DOCTOR OF PHILOSOPHY

Emotion processing in individuals with autistic spectrum conditions and autistic traits the role of stimuli spontaneity and task demands

Walker, David

Award date:
2017

Awarding institution:
Coventry University

Emotion Processing in Individuals with Autistic Spectrum Conditions and Autistic Traits: The Role of Stimuli Spontaneity and Task Demands

By

David J Walker

BSc. (Hons), MSc.

September 2017

Coventry University

A thesis submitted in partial fulfilment of the University's requirements for the Degree of Doctor of Philosophy

Abstract

Perhaps most interesting within autism research is the focus on emotion processing and facial emotion recognition (FER) specifically because difficulties in recognising and responding appropriately to others emotions are part of the diagnostic criteria of autism outlined in the DSM-V (American Psychiatric Association 2013). The research surrounding emotion processing abilities in autism has shown conflicting results (Harms, Martin & Wallace 2010). The thesis presented here aims to explore emotion processing in autism with the use of new stimuli that better reflects the demands of everyday life by simultaneously incorporating tasks that require a greater understanding of socially appropriate information.

Chapter 1 introduces autism in more detail and covers the theories that attempt to explain its aetiology, before briefly introducing emotion processing. Chapter 2 expands into the research area of the thesis covering theories of emotion and emotion processing research in much greater detail, both generally and within autism including a review of current methodologies used to explore FER in autism.

Chapters 3 and 4 report the development and validation of the new stimuli set. The completed stimulus set contains 133 posed expressions and a matching 133 spontaneous expressions captured from 19 individuals in response to seven social prompts. Analysis of expression formation through FACS data with principle component analyses showed consistent display patterns were more frequent across spontaneous expressions than posed. In chapter 4 results showed significantly better recognition of spontaneous expressions than posed, participants could identify the correct answer significantly more than alternate options for six of the seven expressions. Participants also gave systematic emotion state attributions to those responses significantly more than chance would predict.

Chapter 5 reports the results of displaying a subset of expressions with better recognition rates to typically developing children, and recording their visual attention patterns with an infra-red eye tracker. As was the case in chapter 4 differences in spontaneous and posed expressions extended to viewing styles; significantly more fixations were made to posed expressions and significantly more time was spent fixated to posed expressions but this didn't appear to influence recognition rates where no differences

were present between posed and spontaneous expressions. The viewing styles in combination with performance on a retrodictive mindreading task significantly predicted autism traits.

In chapter 6 differences between an ASC sample and typically developing control sample on a retrodictive mindreading task were investigated. No group differences on overall task performance were shown; this was true for both the retrodictive mindreading task and the reading the mind in the eyes task. The previous effect in chapter 4, of spontaneous expressions recognised significantly better than posed was repeated, both groups also made significantly more consistent emotion to retrodiction attributions than a chance model would predict. Investigation of the role of Alexithymia showed no effect of Alexithymia severity on retrodictive mind reading ability. Investigating the role of alexithymia within the ASC sample showed no association between alexithymia sores and retrodictive mindreading ability.

The results are discussed in respect of three themes in the thesis. Firstly the impact of posed and spontaneous expressions are considered in expression production (chapter 3), viewing styles (chapter 5) and recognition (chapters 4 and 6); suggesting that spontaneous expressions elicited during a real life social interchange under the methods outlined in this thesis are quantitatively different to posed expressions, are viewed differently, and have different recognition rates. Secondly the impact of Alexithymia on expression production and recognition was also considered. As an emerging theory that attempts to explain the emotion and social difficulties in ASC, Alexithymia's comorbidity was an important finding throughout this thesis, its role is discussed specifically its influence over retrodictive mindreading performance but not eyes task performance. Finally the results are discussed in respect of FER in autism. The lack of a significant difference between groups could have implications for the topic; many of the inconsistent results rely on different methods some of which are more artificial and lack validity of emotion processing in a real world sense. The discussion continues considering the limitations of the research, potential practical applications and future research directions.

Table of Contents

Appendices

List of tables

List of figures

List of abbreviations

ADHD	Attention deficit hyperactivity disorder
ADI	Autism diagnostic interview
ADOS	Autism diagnostic observation schedule
ANOVA	Analysis of variance
APA	American psychological association
AQ	Autism quotient
AS	Asperger syndrome
ASC	Autism spectrum conditions
ASD	Autism spectrum disorder
AU	Action unit
BAP	Broader autism phenotype
CARD	Cambridge autism research database
CAM	Conceptual act model
CC	Central coherence
CE	Constructed emotion
DSM-V	Diagnostic and statistical manual of mental disorders (5th edition)
EFT	Embedded figures test
EMB	Extreme male brain
Eyes task	The reading the mind in the eyes task
FACS	Facial action coding system
FER	Facial emotion recognition
HFA	High-functioning autism
IQ	Intelligence quotient
JACFEE	Japanese and Caucasian facial expressions of emotion
MANOVA	Multiple analyses of variance
PAM	Perception action model
PCA	Principle components analysis
POFA	Pictures of facial affect
RM	Retrodictive mindreading
RSA	Respiratory sinus arrhythmia
SEM	Structural equation modelling
STEM	Science technology engineering maths
TAS-20	Toronto Alexithymia scale
TD	Typically developing
ToM	Theory of mind
UCDSEE	University central Davis set of emotion expressions
WASI-II	Wechsler abbreviated scales of intelligence 2nd edition
WCC	Weak central coherence

Acknowledgements

I would like to thank my supervisors Dr. Sarah Cassidy and Dr. Laura Taylor for their guidance and support, without which this work would not have been possible. Throughout my Ph.D. their assistance has allowed me the best opportunity to grow and develop. I feel fortunate to have had a supervisory team around me that was consistently supportive, flexible to my needs, and vitally, provided a professionally and emotionally safe space. I would also like to take the opportunity to thank Prof. Simon Baron-Cohen whose supervision as an external advisor was also extremely useful. The assistance of Simon and Paula Smith in recruiting participants through the Autism Research Centre volunteer database was similarly invaluable and I express my thanks.

Similarly I would like to express my thanks to all individuals with and without a diagnosis on the autistic spectrum for taking part in my research, your time and assistance was greatly appreciated. To those Individuals who took the time to contact me with feedback about the experiments and how they could be improved, this was greatly appreciated and I always took the time to reply to express my thanks (except to one individual whose e-mail address returned a non-delivery receipt, sorry!). In short, choosing to take part in my research is a huge compliment and it is not overlooked. Thank you.

I would also like to express my thanks to my dog Poppy. As cliché as it may seem, a furry animal that shows unconditional love and doesn't require justification of unproductive days, is possibly the greatest escape. Many of my issues or problems were solved on walks with my furry companion. Finally, my sincerest thanks go to my wife Catherine, a marital status change that occurred during this process. Before I began my Ph.D. research a previous mentor advised me that undertaking a Ph.D. is better done when single due to the strains it would put on a relationship. Having reached this point I respectfully disagree. This thesis is in part complete due to Catherine's willingness to let me talk *at* her for three years. Not because I was asking for her help (although with administrative aspects she was extremely helpful), but because Catherine understood that most of the time I needed to talk through problems out loud, and she was unfortunate enough to be the closest willing adult. Her support through the often trying times of completing a Ph.D. was second to none. Thank you.

Chapter 1: Autism and Associated Difficulties

This thesis will investigate the often conflicting results of emotion processing in autism. The aims of the thesis are to better understand any difficulties associated with emotion processing by addressing the manner in which this ability is assessed. This is to be achieved by evaluating current methods and conducting an experiment where individuals on the spectrum complete an emotion processing task that uses a more valid assessment of emotion processing and understanding as would be required in truly social situations. The rest of this chapter will introduce the research surrounding autism, what it is, and any difficulties associated with autism. Theories that attempt to explain autism traits are discussed and the chapter will conclude with a brief introduction of emotion processing difficulties in autism.

1.1 What is Autism?

Autism is characterised by stereotyped behaviour, diminished social skills and reduced communication abilities (APA 2013). The social detachment and lack of reciprocity was highlighted in Kanner's (1943) early studies on the subject, and led to the description of autism as difficulties of "affective contact" based on observations of 11 children with high intelligence who displayed a preference for social isolation and rigid adherence to 'sameness'. Similar observations made by Asperger of individuals with social difficulties, empathy issues and clumsiness formed his condition "autistic psychopathy" (Asperger & Frith 1991) which later garnered more attention termed "Asperger syndrome" (AS) (Wing 1981). Research investigating the prevalence of autism according to Kanner's (1943) definition outlined the 'triad of impairments' common between those traits Kanner identified and those Asperger identified (Wing & Gould 1979). The major distinction being that those with AS tend to be of average or above average intelligence, not showing obvious difficulties in communication until complex social situations become more common. This is typically after the observation and diagnosis period of classic autism. A visual representation of the triad of impairments can be seen below in figure 1.1.

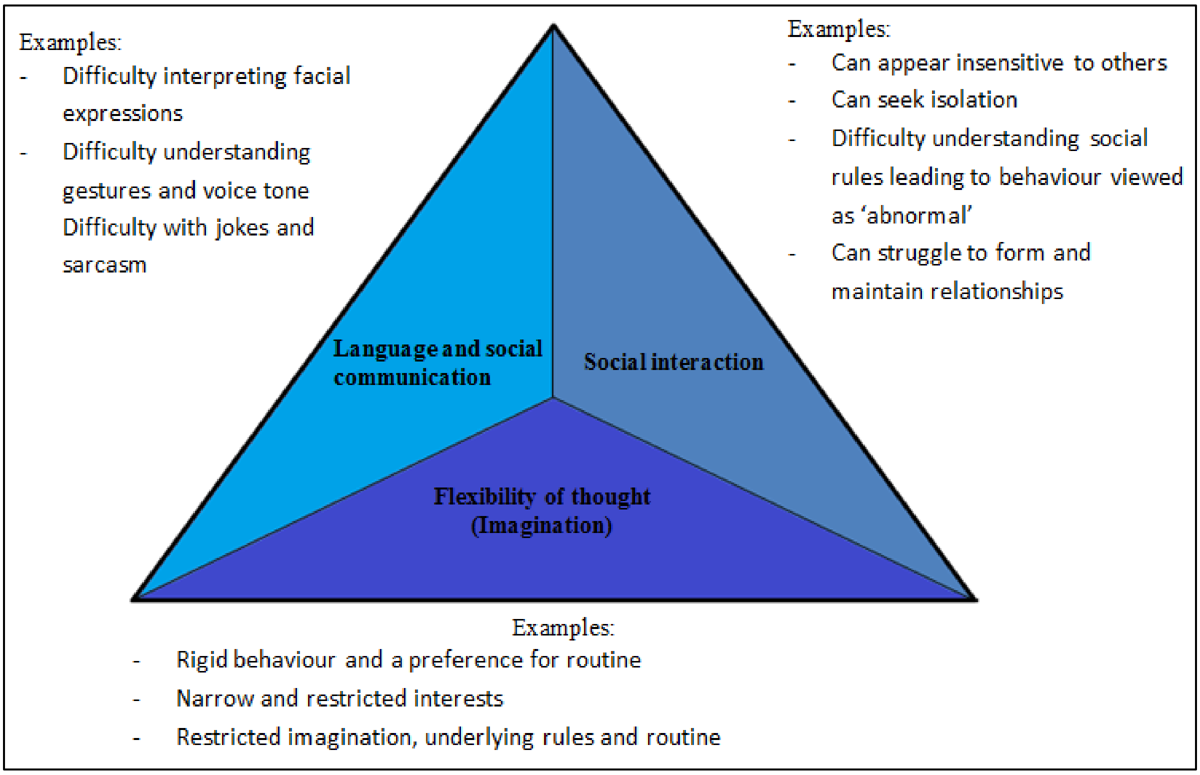


Figure 1.1: *A visual representation of the 'triad of impairments'*

As more research has been carried out the understanding of autism has increased, changing from the outdated label of 'childhood schizophrenia' in the DSM-I (APA 1952) where the symptoms of autism were not outlined in a distinct diagnostic category. This was not changed until the DSM-III (APA 1980) and DSM-III-R (APA 1987), it was the latter revised version which outlined clearly observable criteria and that behaviours must reflect level of development which aided in diagnosis. In the next edition (DSM-IV 1994) several subtypes (Autistic disorder, Asperger Disorder, Rett's Disorders, Childhood Disintegrative Disorder, Pervasive Developmental Disorder- Not Otherwise Specified) were added under the umbrella term 'Pervasive Developmental Disorders', in addition the possible markers had expanded to 16 but requiring only 6 (in specific categories) to meet a diagnosis. These changes reflected the broad spectrum of manifestation in autism which allowed diagnosis with an understanding that individuals will differ in their behaviours, and difficulties.

Currently autism is more commonly referred to as Autistic Spectrum Disorders (ASD) as an all-encompassing term for individuals on the spectrum (Zwaigenbaum 2012). This is partly due to the current DSM-V (APA 2013) diagnostic criteria for ASD which proposes to collapse the autism subtypes e.g. High-functioning autism (HFA) and AS into the singular ASD term to encourage greater specificity of the diagnoses of difficulties faced on a case by case basis (Zwaigenbaum 2012). The introduction of a new disorder, 'Social pragmatic communication disorder', was introduced for those individuals who display social communication difficulties but not stereotyped behaviour or restricted interests associated with ASD (APA 2013), the redefined diagnostic criteria are displayed below in figure 1.2.

Other notable changes in the DSM-V classification is the inclusion of sensory sensitivities within the restricted and repetitive behaviour umbrella, an aspect previously overlooked in autism symptomatology. Similarly there are changes to the period of onset for diagnosis which is now open with symptoms '*being present in early developmental period but may not become manifest until social demands exceed limited capacities*' a change presumed to introduce more flexibility to reflect the abilities of those with HFA and AS within the new collapsed framework. Finally the DSM-V requires that any observed traits bring about '*clinically significant impairments in social, occupational or other important areas of current functioning.*' Such a change is in effort to limit the diagnosis of ASD to cases where individuals require a level of support. This was justified because the application of the existing sub types was inconsistent; however, at a time when there is a strong drive to recognise the strengths of autism as well as the difficulties, restricting diagnosis only to cases where it brings about significant issues in daily functioning or wellbeing undermines this effort. On a similar point, more recently the trend in research is to use the term Autistic Spectrum Conditions (ASC) as this more accurately reflects the strengths, as well as the difficulties displayed by individuals with ASC (Happé & Vital 2009). ASC will also be the term used in this work to refer to individuals on the autism spectrum.

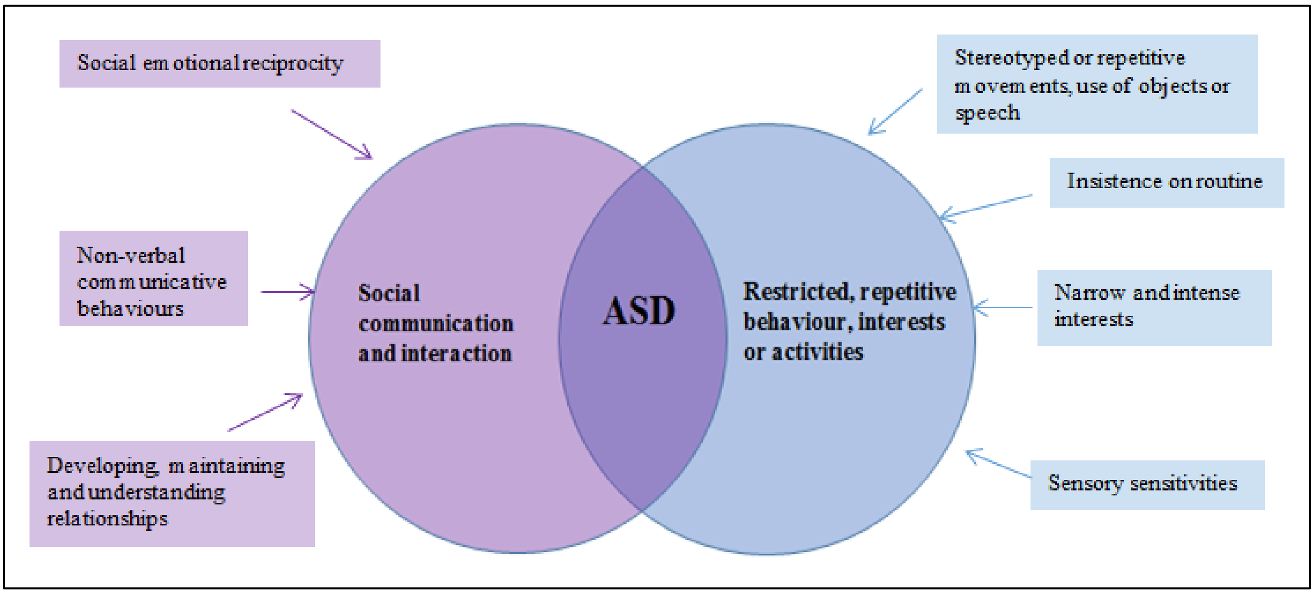


Figure 1.2: *A visual representation of the newly defined DSM-V diagnostic criteria for autistic spectrum conditions*

The prevalence of ASC is estimated to be around 1-2% with 157 cases per 10,000 in the population (Baron-Cohen et al., 2009). Research implicates a biological basis to the condition, with greater probability of ASC incidence in siblings (Jorde et al., 1991) and evidence of a higher concordance rate between monozygotic twins than dizygotic (Bailey et al., 1995). There are also claims of higher foetal testosterone and autistic traits (Auyeung, Taylor, Hackett & Baron-Cohen 2010; Auyeung et al., 2009) such as reduced eye contact (Lutchmaya, Baron-Cohen & Raggatt 2002), social skills and restricted interests (Knickmeyer, Baron-Cohen, Raggatt & Taylor 2005). Alongside the evidence of social difficulties and emotion processing issues there is research demonstrating links between ASC and various quality of life measures such as depression (Stewart, Barnard, Pearson, Hasan & O'Brien, 2006), anxiety (White & Robinson-Nay 2009) and support networks (Renty & Roeyers 2006). Not surprisingly with evidence of lower quality of life in ASC samples there is emerging research suggesting the rate of suicidal thoughts and attempts are more prevalent for individuals on the spectrum (Cassidy, Ropar, Mitchell & Chapman, 2014). These results highlight the importance of a better understanding of the issues associated with ASC as these appear to not only have direct implications for the individuals but also implications for future wellbeing

1.2 The Broader Autism Phenotype

The traits associated with autism are often present in relatives of those on the spectrum but to a lesser degree, this is referred to as the broader autism phenotype (BAP) (Piven et al., 1994). This term encapsulates those that express autistic traits but at a sub-clinical level. There is strong evidence for heritability in autistic traits (Hoekstra, Bartels, Verweij & Boomsma, 2007; Constantino & Todd 2005; 2003), these autistic traits in relatives manifest in specific areas like language (Folstein et al., 1999' Piven, Palmer, Jacobi, Childress & Arndt, 1997a) and executive function (Hughes, Plumet & Leboyer 1999; Hughes, Leboyer & Bouvard 1997). Outside of observing direct abilities that are relevant to autism, it is proposed the subclinical traits of ASC could manifest more broadly as personality traits (Austin 2005). Research that has compared relatives of those with autism to those not related to a family member with autism show personality traits such as rigidness (Losh, Childress, Lam & Piven, 2008; Piven et al., 1997b), impulsivity (Murphy et al., 2000), tactlessness (Losh et al., 2008; Piven et al., 1994) and anxiety (Losh et al., 2008; Murphy et al., 2000; Piven et al., 1997b). The personality characteristics listed above approximate some of the traits associated with autism such as over adherence to routine (rigidness), appearing cold or rude/ lacking social etiquette (tactless), sensitive to change (anxiety).

Investigation of Autism Quotient (AQ) scores (a questionnaire designed to differentiate between autistic and non-autistic individuals) between parents of autistic and non-autistic children significantly differentiated the two groups, the parents of autistic children scoring significantly higher on the AQ and males also scoring higher than females (Wheelwright, Auyeung, Allison & Baton-Cohen, 2010). This increased prevalence of autistic traits in relatives of those with autism typifies the BAP. The prevalence of autistic traits in relatives of those with autism (figure 1.3) and without (figure 1.4) can be viewed below.

Figure 1.3: *Mothers and fathers of children with ASC distributed according to AQ scores taken from Wheelwright* et al.*, (2010)*

Figure 1.4: *Mothers and fathers of children without ASC distributed according to AQ scores taken from Wheelwright* et al.*, (2010)*

As figures 1.3 and 1.4 show, there is a longer tail of higher scores on the AQ in the parents of children with ASC. Scores between 23 and 28 on the AQ fall within the 'BAP' (calculated as scores between 1 and 2 SD above the control sample mean). Scores between 29 and 34 are considered within the range of medium autism phenotype (between 2 and 3 SD above the control mean) and scores greater than 35 are considered within the range of the narrow autism phenotype (scores further than 3 SD from the control mean). The longer tail on the distribution of scores from parents of children with autism suggest a higher percentage of this sample would fall within the broad, medium and narrow autism phenotypes than control parents would. Interestingly the sex distribution seems to show males more frequently fall within the broad and medium autism phenotype but an equal distribution of the sexes in the upper extremities of the narrow autism phenotype.

Further evidence for the BAP comes in the finding that males and those in STEM professions (such as science, engineering, mathematics or computer science) typically present more 'systemiser' traits. Systemiser traits include a stronger grasp of, and reliance on, rule-based systems with predictable outputs based on inputs and knowledge of variables (Baron-Cohen, Richler, Bisarya, Gurunathan & Wheelwright, 2003). Those with higher systemiser traits (males and STEM professionals) also score higher on the AQ than females, or those in professions less aligned with systemiser thinking (Baron-Cohen, Wheelwright, Skinner, Martin & Clubley, 2001b). This finding would suggest systemiser thinking is associated with autistic traits at a subclinical level in the BAP; this can be present in individuals with a relative with ASC or without as evidenced in the research discussed.

1.2.1 Difficulties associated with the BAP

The emotion processing difficulties that are present within ASC also appear in the BAP, for example, there is evidence of distinct processing patterns in the siblings (Oerlemans et al., 2013) and parents (Adolphs, Spezio, Parlier & Piven, 2008) of children with autism. Difficulties in the recognition of expressions were also noted, particularly neutral expressions (Kadak, Demirel, Yavus & Demir 2014) and facial identity recognition (Wilson, Freeman, Brock, Burton & Palermo, 2010). Interestingly the emerging research linking Alexithymia (a condition where individuals struggle to understand, identify and label their emotions) and ASC has also evidenced a greater degree of alexithymic traits in parents of children with ASC (Szatmari et al., 2008). Specifically the ASC children of fathers with higher Alexithymia traits showed more repetitive behaviour traits than those with fathers that had low

Alexithymia traits. The results mentioned above suggest elements of social cognition may be heritable and highlight specific endophenotypes that attribute to the difficulties in ASC. The association of ASC and Alexithymia is present within the BAP, further strengthening the position of researchers highlighting Alexithymia's role in social cognition within ASC.

1.2.2 Summary of the BAP

The BAP shows that differential functioning is present between those high and low in autistic traits, this is present in language (Folstein et al., 1999; Piven et al., 1997a), executive function (Plumet & Leboyer 1999; Hughes, Leboyer & Bouvard 1997) and facial emotion recognition (FER) (Harms et al., 2010). Analysis of relatives of those with autism show personality traits that could be considered associated with autism such as tactlessness, rigidity, anxiety and impulsivity (Losh et al., 2008; Piven et al., 1997b; 1994; Murphy et al., 2000). Relatives of those with autism were also more likely to work in STEM fields, such as engineering or the natural sciences (Baron-Cohen 2012) showing support for a systemising superiority in those with relatives or autism. There is also evidence of altered processing styles (Oerlemans et al., 2013; Adolphs et al., 2008) and performance in relatives of those with ASC (Kadak, Demirel, Yavus & Demir 2014) and links to Alexithymia (Szatmari et al., 2008).

1.3 Theories of Autism

The theories outlined below all attempt to explain autism or specific aspects of autism in some capacity. It is worth noting that of the theories discussed the extreme male brain theory may be the only theory that attempts to explain autism more globally; all subsequent theories address constituent parts of autism, namely social skills or emotion processing. This is most evident with Theory of Mind and the alexithymia hypothesis which specifically relate to the ability to mentalise and assume another perspective or understand and define the affective experience of emotion respectively. Occupying a middle ground is the central coherence theory and amygdala theory, with the central coherence theory still showing a heavy tendency to focus on social skills being impacted by a reduced ability to incorporate masses of information into a coherent whole, while also claiming to explain savant like abilities. Similarly the amygdala theory, while showing a heavy influence on explaining emotion processing and social skills does play a role in threat perception and some evidence suggests hyperactivity is present in ASC which could explain anxiety commonly reported in ASC.

Going forward although titled 'theories of autism' as these theories are often described, it might be more appropriate to view the extreme male brain theory as the closest approximation to a theory of *autism,* subsequent theories explain sub-components of autism. As such, the most discussion will be dedicated to theory of mind and the alexithymia hypothesis which present the most compelling explanations of emotion difficulties in autism, the focus of this thesis.

1.3.1 Extreme male brain theory

The empathizing-systemizing theory later developed into the extreme male brain (EMB) theory (Baron-Cohen 2002; 2010) suggests people with autism are poor empathisers. Broadly, empathy is the ability to understand and share the feelings of another; this can be in multiple domains such as emotional empathy in understanding another's emotional state, motor empathy in mimicking another's motor movement and facial expressions, or in cognitive empathy, imagining another perspective e.g. theory of mind tasks. As the EMB theory predicts reduced empathizing traits in ASC individuals, it also predicts increased systemizing abilities (e.g. embedded figures tasks (EFT)). It is proposed generally females are better empathisers whilst males are better systemisers; this lends itself to a spectrum of empathising and systemising, this may present like the concept of androgyny where one can score highly on both characteristics. However, the EMB theory suggests that autism traits manifest more frequently with increasing 'maleness', this is supported by research linking both foetal testosterone (the male androgen) and age of onset of first menstrual period in girls to autistic traits (Auyeung et al., 2009; 2010; Whitehouse, Mayberry, Hickey & Sloboda, 2011). The concept of EMB is underlined by the BAP, the very nature of the EMB relies on an extreme version of the typical sex distribution of empathising and systemising. With systemizing and empathizing falling on continuums as opposed to a dichotomy, and individuals in STEM fields scoring higher on the AQ (Baron-Cohen et al., 2001b; Baron-Cohen, 2012), it would be expected the prevalence of systemisers would increase within the BAP and subsequent medium autism phenotype and narrow autism phenotype.

The EMB theory with the proposed lower empathising in ASC provides some explanations for the reported social difficulties and emotion processing difficulties in ASC. However the EMB theory fails to account adequately for other reported behaviours in ASC such as narrow interests, sensorimotor difficulties and rigidity to routines. The core of the theory is supported by the higher prevalence of ASC within males, however the presentation of female ASC is still misunderstood (Howe et al., 2015) with evidence suggesting female ASC is often missed in diagnostic criteria if it is not presenting with intellectual disability (Fombonne, 2003; Scott, Baron-Cohen, Bolton & Brayne, 2002). It has been proposed that females with ASC and higher cognitive abilities display ASC traits more subtly or altogether differently (Howe et al., 2015); a stance supported by research showing that ASC children with equal levels of symptoms results in girls less likely to meet the diagnostic criteria (Dworzynski, Ronald, Bolton & Happé, 2012).

Investigation of behavioural patterns of those diagnosed with ASC showed sex differences in multiple domains, females self-reported increased sensory issues, a new aspect of the DSM-V which may now see Female ASC diagnoses rise. There were also less obvious social functioning issues in females that only became apparent through self-report, which lead to the authors suggesting more advanced coping mechanisms in female ASC (Lai et al., 2011). Although in the aforementioned study no significant differences were present between males and females on the empathising quotient or systemizing quotient, which would support the EMB theory of 'maleness' in autistic brains, there is still research needed to better understand female ASC which may yet shed new light on ASC globally. As such the EMB theory is based on the current understanding of autism which is primarily based on research in males and extrapolated to females, a greater body of evidence is required before the theory can be substantiated for autism generally rather than autism in males. One strength of the EMB theory is the ability to explain some savant traits in ASC, due to the proposed systemiser superiority. Some example savant traits include hypercalculia (Pring & Hermelin, 2002) or advanced memories, which can result in extremely accurate memory recollection to a specific date (Kennedy & Squire 2007).

1.3.2 Amygdala hypo and hyper-arousal

The next theory to be discussed points to a neurobiological basis at the root of ASC, with atypical amygdala function purported to drive altered face processing in these individuals (Wallace, Coleman & Bailey 2008; Bachevalier & Loveland 2006; Grelotti et al., 2005). Whilst the amygdala theory is reported as a theory of autism, the amygdala is concerned with the 'social brain' and so the amygdala's role in autism is more specifically concerned with the social difficulties often associated with autism. This is true for much of the theories attempting to 'explain' autism that they focus on social difficulties and so are more accurately defined as theories of emotion in autism. This applies to the amygdala theory as well with the amygdala believed to be linked with the allocation of attention to salient stimuli; specifically the amygdala rapidly responds to stimuli to determine which areas are the most salient and as such need attention. There is also evidence that links the fusiform face area and superior temporal sulcus in this process (Schultz, 2005). Adolphs (2002) isolated key neuronal systems relevant in the processing of emotions and highlighted the amygdala as a key contributor during FER, this appears to be particularly relevant for negative emotions such as fear, disgust and anger (Breiter et al., 1996). This would align with previous research that reports poor recognition of emotions of negative affect in ASC where altered amygdala activity is reported (Harms et al., 2010; Bal et al., 2010; Ashwin, Chapman, Colle & Baron-Cohen, 2006; Wallace et al., 2008; Howard et al., 2000)

The importance of the amygdala is also highlighted in studies on emotion recognition tasks in individuals with amygdala damage. Such research shows significant difficulties when processing fearful stimuli and complex tasks such as attributing trustworthiness ratings to individuals based on facial stimuli (Adolphs, Sears & Piven 2001; Adolphs, Russell & Tranel 1999). Subsequent comparisons were drawn between ASC individuals and individuals with amygdala damage. Similarities were evident in ratings of trustworthiness, for example, both groups rated individuals more trustworthy than controls did (Adolphs, Russell & Tranel 1999). This further implicates the amygdala's role in recognition of emotions, particularly threatening ones likely to play a key role in threat perception and self-preservation of the individual (Adolphs, Russell & Tranel 1999). Of note in the research on emotion recognition competency in amygdala damaged individuals was the intact recognition of happiness, suggesting the difficulty is more localised to negative expressions. In application, these findings could explain some of the difficulties in social skills exhibited by individuals with ASC, potentially accounting for social difficulties.

The amygdala is partly responsible for recognising threats, as discussed this is partly why its function is associated with the recognition of negative emotions which could hold vital information. The amygdala is also responsible for directing attention, isolating the salient stimuli available and focussing attention towards it (Vuilleumier 2005). Evidence in support of the amygdala theory comes from research that has tested the manner in which ASC individuals attend to emotional stimuli. When presented with emotion expressions, individuals appear to prioritise processing the eyes while findings suggest ASC individuals favour the mouth region (Klin, Jones, Schultz, Volkmar & Cohen, 2002). ASC individuals also exhibit atypical saccadic pathways and scan the environment more frequently than controls

(Rutherford & Towns 2008; Neumann, Spezio, Piven & Adolphs, 2006; Klin et al., 2002). However, research has yet to definitively explain why these differences exist. It is proposed that the abnormal visual perusal and regions of interest typical in ASC individuals are a symptom of abnormal amygdala function (Pujol et al., 2009; Schultz 2005). This alteration in development is expressed in such a manner that these regions are not sufficiently activated by typical eye driven stimuli (Grelotti et al., 2005). This lack of arousal causes the individual to seek alternative information from other sources, such as the mouth, verbal context and body language (Piggot et al., 2004; Teunisse & de Gelder 2001).

Recent research is showing an opposite trend in ASC individuals rather than hypoarousal of the amygdala some research is reporting hyperarousal. Crucially research has shown neural habituation (the neural response decrease over time to repeated exposure to the same stimuli) (Thompson & Spencer 1966) in individuals with ASC is lower, simply the rate at which the amygdala becomes less excited by the stimuli is slower. This was also associated with more severe social difficulties (Kleinhans et al., 2010), suggesting the amygdala in ASC individuals does not habituate and reduce activation to social stimuli at the same rate recorded in TD individuals. Lack of neural habituation would keep the ASC individual aroused on the verge of a fight or flight response in social situations longer than would be the case for TD individuals. The interaction of co-morbid conditions in ASC shows that in individuals with high social anxiety the activation of the amygdala is aroused more than in matched controls (Kleinhans et al., 2010, Schumann, Barnes, Lord & Courchesne, 2009) further showing hyperarousal specific to individuals with social anxiety.

Further research has shown some similar results with the amygdala and fusiform gyrus displaying activation upon gaze fixation with eyes (Dalton, Nacewicz, Alexander & Davidson, 2007). This may be related to social anxiety or anxiety surrounding eye contact often reported in the literature. Amygdalae volume was found to be smaller in ASC children (changes in volume are referred to as amygdalae dysmorphia) compared to control; children with the smallest amygdalae were slower to distinguish between neutral and emotional stimuli and displayed the least fixation to the eyes (Nacewicz et al., 2006). This pattern of reduced emotion recognition competency coupled with amygdalae dysmorphia and reduced fixation to the eyes is indicative of an aversion response to social stimuli. This may explain the conflicting results regarding amygdalae arousal; given that individuals with ASC are showing a tendency to avoid the regions of the face that typically result in amygdalae arousal. When attention is paid to these locations, ASC individuals display a slower neural habituation rate suggesting the stimuli is continually arousing the ASC individuals into a fight or flight state. This could potentially explain the aversive scan paths documented

The amygdala theory presents some strong evidence that can account for emotion processing difficulties in ASC with reduced amygdalae volume (Nacewicz et al., 2006), activation (Wallace et al., 2008; Bachevalier & Loveland 2006; Grelotti et al., 2005) and performance patterns in ASC similar to those patients with amygdala damage/lesions (Adolphs et al., 2001; 1999). By extension, the emotion processing difficulties could also contribute to the social traits such as monotone, awkward social prose, and difficulty maintaining social relationships. Abnormal amygdala function does not directly explain the social difficulties reported in ASC but can address these as a knock on effect from emotion processing difficulties. However the Amygdala theory does not address repetitive and stereotyped behaviours in ASC with only potentially contributing to anxiety in shifts from routine where the amygdala may be hyper aroused.

1.3.3 Central Coherence theory

An alternative theory of autism is termed the central coherence (CC) theory. Frith (1989) considered this in terms of a preference for details in ASC individuals due to the use of local as opposed to global processing, resulting in weak central coherence (WCC). It is this tendency in individuals with ASC to focus on details first rather than the stimuli in a holistic manner that can lead to complications in FER (Hill, Varela, Kamps & Niditch, 2014; Deruelle, Rondan, Gepner & Tardif, 2004). This altered method of processing can often result in misinterpretation of emotional stimuli (Kennedy & Adolphs 2012a; Deruelle et al., 2004) and may be one of the root contributors to lower social skills frequently found in ASC individuals (Hill et al., 2014; Pujol et al., 2009). CC theory is typically explored by focusing on a differential preference of attention between ASC individuals and typically developing individuals (TD). Where TD individuals show a tendency to process images in a global manner (Navon 1977), commonly considered as viewing an image or scene in its entirety, the same trend is not present in individuals with ASC which suggests attention is focussed on the local details of an image, this is then not effectively amalgamated into a coherent whole.

Examples of some of the tasks used to explore WCC in ASC include compatible and incompatible stimuli presented across the global and local levels in a variation on the Navon task (1977). In this experiment two paradigms were investigated, a divided attention task where the children had to identify the target in either the global or local level on a trial by trial basis; a second task of selective attention instructed children to focus only on the target at global or local level. With no explicit priming, meaning children relied on whatever processing style was dominant, typically developing children made most errors at the local level whilst ASC children made more in the global level. However, in the selective attention task both groups were faster in identifying the global target. These results suggested the account of WCC in terms of global processing difficulties was not limited by ability to process information globally but rather a preference in processing style towards the local level, potentially due to lack of inhibitory mechanisms around local processing.

Another well-known task used is the embedded figures task (EFT) with target stimuli embedded within them which participants must find. ASD individuals seem to excel at EFT's (Jarrold, Gilchrist & Bender 2005) because their processing style focuses on information in constituent parts rather than part of a whole, supporting the CC theory. Shah and Frith termed this strength for detecting constituent parts and noticing obscure patterns an 'islet of ability' (1983) Examples of the type of tasks used can be seen in figures 1.5 and 1.6.

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure 1.5: *Examples of stimuli compatible at local and global level (1 & 2) incompatible/global (3 & 4) and incompatible/local (5 & 6) (Plaisted, Swettenham & Rees 1999)*

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure 1.6: *Example images from a) the embedded figures test and b) The childrens embedded figures task (Witkin, Oltman, Raskin & Karp 1971)*

In relation to ASC individuals it is suggested some of the emotional difficulties displayed are due to underdeveloped configural face processing a development alongside global processing. Investigating the contribution of contextual information in a configural sense research has demonstrated that ASC individuals are less susceptible to visual illusions (Happé 1996). However further research has failed to demonstrate a robust effect (Mitchell & Ropar 2004). Attempting to investigate configural processing in social contexts, Rosset et al., (2008) tested the recognition rate of ASC children when viewing human faces and cartoon faces. While initially ASC participants were shown to match TD controls on recognition ability, it was later found that the processing technique used differed on the stimuli presented. ASC participants opted to use a local processing strategy for real faces, while they selected a global processing for cartoon faces. Rosset and colleagues (2008) attempt to explain this by addressing the often simplified appearance of cartoons, suggesting that the implementation of a configural processing method was triggered by the exaggerated features of the cartoon stimuli.

Contrary to predictions, Rosset and Colleague's findings showed that both ASC and TD controls performed worse on cartoon faces than human. It may be that cartoon faces prime for a local processing system much like inverted faces do, due to having fewer and more exaggerated features; these features are too locale based to integrate into a coherent whole. If this is the case, that ASC participants opt in to a global processing style with cartoons but not real faces, it would suggest cartoons elicit a reaction in ASC children that they do not in TD children. More importantly, it shows global processing is present and functional in ASC individuals, but possibly underutilised or incorrectly selected and engaged.

This suggestion is addressed in some literature attempting to explore the relationship with ASC individuals employing both global and local processing (Plaisted, Swettenham & Rees 1999). In this research, the condition under which each processing style is employed appears to be dependent upon task demands. Here, ASC individuals tend to opt for a local processing style in tasks dictating a division of attention, yet they opt for a global processing style for tasks that utilise selective attention. To further evidence this relationship, it is found that stimuli presented at the global level, in a forced divided attention task resulted in the worst performance from ASC children. Even in this trend however, ASC children did seem advantaged by attempts to utilise global processing or hindered by its use in a task better suited to local processing (Plaisted et al., 1999). This therefore further supports the evidence of an intact global processing system in ASC individuals, regardless of underutilisation, and supports the weak central coherence theory that global perception is lessened in ASC. The ability of ASC children to perform globally when prompted to do so indicates the difficulty in implementation of global processing may stem from an inability to attend correctly to appropriate facial regions. This difficulty is less pronounced however when those facial regions are externally provided or highlighted (Mottron, Burack, Stauder & Robaey, 1999; Mottron, Burack, Iarocci, Belleville & Enns, 2003; Koldewyn, Jiang, Weigelt & Kanwisher, 2013).

Others suggest that the tendency in ASC individuals to use locally focused processing over global is because this may be the preferred method. Some research stipulates that through the use of local processing, ASC individuals partake in a processing style that is more specialised and efficient (Plaisted, Saksida, Alcántara & Weisblatt, 2003). Here, the ability and potential for global processing is present, but ASC individuals perform better when using a local style of information processing (Plaisted et al., 2003). The specialised local processing is a consistent finding (Hill et al., 2014; Deruelle et al., 2004), and the ability to process globally is found to be regularly demonstrated if it is explicitly designed into a task or instructions prime the individual to do so (Mottron et al., 1999; 2003; Koldewyn et al., 2013). Naturally though, there appears to be a bias towards local processing in ASC, possibly suggesting the perception of features of an image present themselves as more salient to an individual with ASC than would the global context of the entire face. The evidence would point towards an altered salience hierarchy in ASC, where features of an image overpower the global context which would provide a clearer holistic image.

The evidence for weak central coherence in ASC is not undisputed however, with numerous studies citing intact holistic processing or difficulties milder than previously believed (Nishimura, Rutherford & Maurer, 2008; Mottron et al., 1999; 2003; Koldewyn et al., 2013). Rather than an inability to process information globally and configurally analyse faces, it now appears that WCC is more accurately recognised as a biased processing hierarchy than a lack of ability. There is the possibility that these differences are likely due to other aspects not directly addressed within the work, such as differences in clinical subtypes of ASC or substantial variation in task design and difficulty. Therefore, suggestions arise that CC is deficient, or possibly underutilised in ASC populations; this is particularly expressed in tasks where an image is comprised of constituent parts which are singularly salient (Rinehart, Bradshaw, Moss, Brereton & Tonge, 2000; Mottron et al., 1999). Because difficulties are still present in global processing but this appears to be less pronounced than for objects or figures with clear constituent parts, WCC can still account for emotion processing and recognition difficulties in ASC. Much like it can account for certain difficulties due to the attention to detail that WCC would predict it could also provide an explanation for savant like memory and artistic abilities (Treffert 2009). It does not explain particular social difficulties such as the intricacies of turn taking or emotive pitch in conversation, and these cannot be adequately explained by the lack of social context from inaccurate emotion processing. To adequately understand turn taking and further general maintenance of relationships an element of understanding of others internal states would be required which WCC does not address. Similarly, alongside the intricacies of social difficulties, WCC does not account for stereotyped repetitive behaviours, narrow interests or limited imagination.

1.3.4 Theory of mind

Theory of Mind (ToM) (Baron-Cohen, Leslie & Frith, 1985) concerns the ability to attribute mental states to others and use this ability to predict behaviour (Premack & Woodruff 1978). This is the ability of the individual to think or place themselves in such a scenario that they could reasonably assume what another individual's wishes, desires, beliefs and thoughts are. However the process of how this attribution of mental states and causal behaviour to others comes about is at the centre of theoretical disagreements within ToM. Two main approaches dominate; that of Theory-theory and Simulation theory.

1.3.4.1 Theory-theory

Theory-theorists align with the view that a naïve theory of psychology 'folk psychology' is core to understanding and predicting others' behaviour. This naïve theory is continually revised through observation of the world where the child can begin to better predict and apply causal rules to the behaviour of others (Gopnik & Meltzoff 1997). There is debate if this folk psychology is innate (and develops at a set pace) or is learned, Carruthers and smith (1996) argue it is more probable the development of a folk psychology theory is innate given that certain developmental milestone are reached at typically the same age of four (Gopnik & Astington 1988; Perner, Leekam & Wimmer, 1987; Callaghan et al., 2005). This typical developmental milestone would be supportive of the notion that an internal theory develops at a set pace gathering information and revising its model until such a point where enough evidence has been amassed that does not support the current theory and a paradigm shift is required.

In support of theory-theory Gopnik and Wellman (1992) highlight three distinct theories or views that appear at different stages of development, they begin with that of a 2-year-old. They begin by describing 2-year-olds as mentalists that their psychological knowledge is structured in two states, desire and perception. Gopnik and Wellman liken desire and perception to two theoretical constructs 'world-to-mind' and 'mind-to-world' (Searle 1983). These two constructs require an understanding that what's in the mind can influence the world, such as a desire causing a response in the world to fulfil that desire. Further there is an understanding that what is in the world can influence the mind in such a way that the perceptions of the world influence the mind. This early theory builds the foundations that connect the self (the mind) to the world and that these two things can influence each other. This allows the first real opportunity of causal predictive inference.

By the age of three children begin to demonstrate a development to more cognitive mental terms in language such as think, know, remember and make-believe (Shatz, Wellman & Silber 1983). This demonstrates an awareness of mental states with thoughts that are distinct from the world, remembering is the precursor to assuming another mental state (in time) and make-believe has obvious implications for false-beliefs. This developmental stage highlights a transitional period where evidence is accumulating that representations of reality exist, but understanding, or the predictive causal links children are willing to attribute to reality are still grounded in a desire and perception theory. This is evidenced by children's willingness to acknowledge a false-belief but not to attribute causal actions to that false-belief (Moses & Flavell 1990).

By age five in typical development the child has undergone a theoretical transition; at this point they are able to hold mental representations of the world meaning they can hold an understanding of different views of the world than their own. This paves the way to understanding people have a different view to the world than their own and different knowledge of the world than their own. This is best exemplified in the false-belief tasks (Perner, Leekam & Wimmer 1987). These tasks assess an individual's ability to hold mental states different from their own or a previous mental state different from their current one. Example tasks include unexpected contents tasks where the individual is challenged by stating what their original belief was in light of new information about a given scenario. One such example is where a child is shown a smarties container and asked what they believe is inside, the child will usually respond 'smarties' they will then be shown inside the tube is crayons. Once the tube is closed again the child is asked what they originally believed was in the tube, a failure on the task is the child responding crayons; children typically pass this test at 4-5 years of age (Gopnik & Astington 1988).

Another example of a false-belief task is the commonly known Sally-Ann task. In this task the child is told a scenario where Sally has a marble and places it in a basket, Sally then leaves the room Ann moves the marble from the basket to a box, upon Sally re-entering the room the child is asked where Sally will look for her marble. The correct answer is in the basket where she originally left it and believes it to be, however the child with a weak theory of mind will have trouble mentalizing Sally's view of the world and will attribute their beliefs to Sally expecting her to look in the box. Children with representational minds can hold a mental state other than theirs and crucially use this to predict behaviour, there is an understanding that other's behaviour can be directed and governed by knowledge of the world that is not the same as the child's.

It is argued the change from a desire and perception based theory in younger children to the later belief-representation based theory is supported by the use of natural language where children will attribute behaviours to desires when younger, for example 'Jane is looking for her cat under the bed because she wants the cat'. This transitions to belief with development 'Jane is looking for the cat under the bed because she thinks it is under the bed' demonstrating a theoretical shift accommodating the occurrences of behaviours that are not always motivated by desires or perceptions (Bartsch & Welman 1989, Wellman & Banerjee 1991).

1.3.4.2 Simulation theory

Differing from Theory-theory, Simulation theory does not presume there to be theoretical constructs that explain and govern predictive ability, instead it relies on the ability to simulate the current situation or proposed situation in the mind and predict the behaviour of others based on what the self would do (Gordon 1986). This approach relies on the child's interpretation of any given (simulated) event and applying this to others, because of this the theory is egocentric, any simulations made will be an approximation of how the self would behave not how another person would behave. Indeed research has shown the egocentric bias of attributing the states of the self to others (Birch & Bloom 2003; Keysar, Lin & Barr 2003). An egocentric bias does not inherently discredit simulation theory, it may underline certain instances when simulation fails, but through the attribution of the mental state of the self onto others it supports the theory in its claim that to better understand others the state of the self is projected onto others.

The presence of such a bias or failure in simulation may be due to two reasons, a lack of information on the target to make accurate simulations from, or the developmental stage of the simulator where at a young age children are unable to differentiate the knowledge they have which can be objectively true from subjective knowledge others have. The latter is evidenced in the errors children make in false-belief tasks. On such tasks children routinely confuse and over-rely on what they know to be objectively true (for example in the Sally-Ann task the marble is not where sally left it, sally will look where it is now), rather than use the subjective information of the world (that the marble has been moved, sally does not know this and will look where she left it). Simulation theory proposes that until children can compartmentalize knowledge (oftentimes contradictory) they will continue to fail false-belief tasks (Cruz & Gordon 2003). As discussed previously theory-theorists attribute the eventual passing of this task to a theoretical shift allowing mental representations of other perspectives, Simulation theorists believe the ability to pass false-belief tasks lies in the improvements in executive function in development allowing greater compartmentalization of objective and subjective knowledge.

Another distinguishing feature between theory theorists and simulation theorists is the core knowledge that thoughts, desires and beliefs are linked actions by a set of laws or principles in folk psychology. Simulation theorists argue this is redundant when the capability exists to use our own reasoning (and subsequent intentions) to model those of other reasoning beings like ourselves. In this sense understanding the self and having knowledge of our own causal behaviours, we can relate this to many other beings and negate the need for set rules or laws. Simulation theorists argue this approach is more parsimonious and better grounded in evidence (Cruz & Gordon 2003), but are not entirely opposed to generalised rules of thumb developing as a component of simulation.

Some of the evidence provided in support of simulation theory comes from the presence of mirror neurons (Gallese, Fadiga, Fogassi & Rizzolatti 1996; Rizzolatti, Fadiga, Gallese & Fogasi 1996; Rizzolatti, & Craighero 2004). Mirror neurons are a collection of neurons that activate upon seeing an action as well as performing the action, there presence has been noted in humans (Fadiga, Fogassi, Pavesi & Rizzolatti 1995). These mirror neurons or ‘mirror systems’ have been noted in emotion systems (Wicker et al., 2003) and tactile sensory systems (Singer et al., 2004). Such claims of a simulation based model with mirror neuron input are bolstered by research showing impaired recognition of emotional states in those with brain damage (Calder, Keane, Manes, Antoun & Young 2000) or brain legions (Adolphs, Tranel & Damasio 2002).

There is also evidence to support simulation in prospection (future prediction) in that the richness of accounts in the distant past and far future are less than those of accounts in the immediate past and close future (D'Argembaeu & Van Der Linden 2004). Several studies linking episodic memory and prospection to specific brain regions and imagination (see Okuda et al., 2003; Hassabis, Kumaran, Vann & Maguire 2007)_have led researchers to suggest a core network of neural structures that underlines simulation of different time periods (Buckner & Carroll, 2007; Schacter, Addis & Buckner, 2008). There are some that claim this core network also plays a role in mindreading, most notably the core network regions were activated when individuals were asked to consider a reality where someone's belief differed from the current reality, but not when asked to consider the image (viewpoint) of an inanimate object (camera) (Saxe & Kanwisher 2003). This suggests that ToM or mindreading requires some element of imagination likely in simulating a different perspective; such results would support a heavier reliance on simulation rather than theory. It is possible that the activation of core network regions is attributable to retrieving memories to activate theories but this appears to more readily explain a simulation theory account of ToM.

Though the foundation of how ToM is achieved is markedly different between theory-theorists and simulation theorists there is some endorsement of hybrid theories (Shanton & Goldman 2010). These encapsulate the parsimonious and pragmatic nature of simulation theory in using the mind of the self as a working model for others in favour of rules or laws which must be learned at some stage through an ineffectual trial and error process. Similarly the inclusion of some theoretical structure that can incorporate generalizations seems plausible given that simulating the most trivial of responses repeatedly would be wasteful.

1.3.4.3 Theory of mind and autism

It is proposed that many of the social communicative difficulties in ASC stem from a flaw in ToM or 'mentalizing' (Frith 2001). In research, monitoring the ability of traits deemed to be important for ToM such as; following another's gaze, pointing or showing objects of interest and understanding make-believe play are all among demonstrated difficulties in ASC individuals. So strong is the evidence for the importance of theory of mind that a difficulty in these traits at 18 months reflects a high co-occurrence with autism at 3 years of age (Baron-Cohen et al., 1996). Difficulties in these three traits are such a reliable predictor of autism, that they are included as an early indicator for autism in a multitude of tests (Auyeung, Baron-Cohen, Wheelwright & Allison, 2008; Baird et al., 2001; 2000).

The false-belief task reported an 80% failure rate in autistic children (Baron-Cohen et al., 1985), this has led to ToM attracting criticism as a theory of autism difficulties. The finding that 80% of autistic children fail the false belief task whilst at first this seems high it does allow for a 20% pass rate within autism and so the reliability of such a task to detect autism is not robust. Further it opens the discussion that a weak ToM is not preclusive to autism. To this end ToM is now viewed more as a continuum rather than functioning or not functioning, higher difficulty second order tasks were designed to test this and help propose the idea that autism is more indicative of a delay in ToM development (Baron-Cohen 1989). There was evidence to support a developmental delay in ToM development with verbal mental age associated with false belief task success (Happé 1995) although the reported success rate of 73% on second-order false belief tasks in individuals with AS (Bowler 1992) led to developments in assessments shifting away from ToM specifically no longer believing weak ToM was universal in autism.

With the universality of ToM difficulties in ASC under dispute, assessments developed towards advanced tests of ToM such as the reading the mind in the eyes task (Baron-Cohen, Wheelwright, Hill, Raste & Plumb 2001a) with an inherent socio-emotional aspect in their assessment. The inclusion of social information in assessments was later developed with the enactive mind hypothesis (Klin, Jones, Schultz & Volkmar 2003) which suggests neurotypicals attribute social information to all aspects of the world which can be entirely inanimate. The social attribution task (Klin 2000) demonstrated this with the narrative provided by neurotypicals taking on character roles such as a 'bully' and the geometric shapes displaying mental states such as 'scared' or character traits like 'shy' whilst autistic individuals provide a narrative based on purely physical properties and relations. The assessment of ToM had shifted from tasks of false belief to inferring emotional states and attributing emotion to unsocial scenes. This change in assessment reflected the gradual shift from a specifically ToM account of autism, to a more socially based approach with emotion and empathy at the fore.

1.3.4.4 Theory of mind and empathy

The work of Blair (2005) posits that 'empathy' is a blanket term and can be divided into three subcategories of cognitive empathy or interchangeably ToM, motor empathy and emotional empathy. When exploring motor empathy, research has shown that ASC individuals also demonstrate diminished ability to perform tasks such as facial mirroring (Hatfield, Cacioppo & Rapson 1994). Blair (2005) states this difficulty is consistently characteristic of ASC individuals, and may be a fundamental aspect in understanding their struggle in FER and social skills generally.

There is some evidence for difficulties in motor empathy within ASC (Williams, Senior, David, Loughland & Gordon, 2001; Nishitani, Avikainen & Hari, 2004), however the severity and the presence of these difficulties of imitation altogether are refuted (Press, Richardson & Bird, 2010) or the direction is reversed (Spengler, Bird & Brass 2010). Imitation concerns the natural tendency to copy another's motor movements, typically this covers gross motor movements whilst mimicry concerns the copying of one's facial expressions but the two terms are used interchangeably in the literature in some cases (Grecucci et al., 2013; McIntosh, Reichmann-Decker, Winkielman & Wilbarger, 2006). Grecucci and colleagues (2013) demonstrated that imitation abilities are intact but are not modulated by social context as is usually the case in typically developing individuals. While individuals with ASC do not spontaneously respond to emotion presentation in an automatic manner, they can be encouraged to engage in imitation, and perform well (Grecucci et al., 2013; McIntosh et al., 2006). An example of this is the work of McIntosh's (2006) and Stel, van den Heuvel and Smeets (2008) who investigated the effect of instructing participants to mimic and not mimic displayed emotions. As previously suggested the ASC participants were able to accurately mimic emotions when told to do so, whilst their unprompted mimicry was less frequent. This suggests motor empathy is present in autistic individuals, or at least the ability to accurately mimic is, the automaticity to do so is reduced however.

In another interesting finding it was shown that control participants reported a correlative mood to that which they were mimicking, however no such effect was found with ASC individuals, suggesting a break in the semantic processing steps between perception, mimicry (motor empathy) and ToM function (cognitive empathy). There are other potential explanations for such a response such as highly co-morbid Alexithymia in ASC (Berthoz & Hill 2005; Hill, Berthoz & Frith 2004). Alexithymia may mean ASC individuals are experiencing a change in affect but are unable to accurately recognise and label this.

These studies also demonstrated that ASC individuals showed intact voluntary attempts at imitation much similar to typically developing individuals (Grecucci et al., 2013; McIntosh et al., 2006). This would suggest the basic levels of attenuation in response to social stimuli are present but automatic imitation occurs with a difficulty in individuals with ASC. It can then be considered without automatic imitation responses in social interactions, ASC individuals may have adapted to rely on voluntary imitation (McIntosh et al., 2006). Voluntary imitation in this context, addressed the conscious effort of the receiver to attempt to mirror the emotion, to better process and hopefully understand the display. It is further stipulated that the frequency rate at which voluntary mimicry is employed in ASC individuals could be occurring as a result of individual efforts to gradually understand social scenarios and etiquette over long periods of trial and error. This would stand to support the evidence that difficulties of emotion recognition and overall social skills are reduced in higher-functioning ASC individuals (Hill et al., 2014; Dyck, Piek, Hay, Smith & Hallmayer, 2006). This theory is supported by the presence of hyperimitation (e.g. echolalia repeating phrases and echopraxia copying actions) in high-functioning adults with ASC (Spengler et al., 2010).

Much like motor empathy concerns the physical movement of the self in respect of another, Emotional empathy concerns the adaptation of the self in an emotional sense. This is specific to the display of emotions in response to another (Blair 2005). Emotional empathy is primarily in response to displays of emotion, however it can also be invoked by emotionally laden stimuli such as expressive vocabulary. Emotional empathy is then a hybrid of cognitive and motor empathy, this was referred to as 'emotional linkage' in Preston and de Waal's (2002) Perception-Action Model (PAM). In this model the process of empathy begins with perception where a stimulus is presented, this transitions to representation (imitation > emotional contagion > cognitive empathy) the cognitive aspect of empathy is situated towards the latter stages of this chain of events. The individual uses an interoceptive (internal analysis) awareness of the changes in the self from imitation and emotional contagion combined with an assumption of another's mental state to construct a holistic understanding of that state (Preston & de Waal 2002).

As an explanation of ASC difficulties of ToM are more directly referred to as just that, rather than difficulties in a prescribed area of empathy, which may be more applicable. As the literature introduced above showed, there are difficulties in motor empathy in both a hypoimitative (Williams et al., 2001; Nishitani et al., 2004) and hyperimitative capacity (Spengler et al., 2010). The perception-action model places these subcomponents of empathy in a collaborative model, but not always linearly in activation or execution. This model would suggest difficulties could be at any, or multiple stages, of this entire empathy network, indeed there is a body of research showing altered perceptive styles in ASC (Klin et al., 2002; Rutherford & Towns 2008; Neumann et al., 2006; Nacewicz et al., 2006; Pelphrey 2002; Kennedy & Adolphs 2012b; Smith, Montagne, Perrett, Gill & Gallagher, 2010). This might pinpoint perception as the origin of difficulties which impacts accurate imitation and emotion contagion. Similarly in the stages of motor empathy where imitation and contagion are activated, research shows altered physical movements in ASC which are then associated with severity of ASC (Hannant, Cassidy, Tavassoli & Mann 2016); this altered motor control in ASC is reflected in expressions that are less recognisable (Brewer et al., 2016).

Finally the difficulties addressed above in ToM tasks highlight there are also prescribed difficulties in assuming the mental states of others along with any information that may be congruent to this. Tasks such as the unexpected contents and false belief (Baron-Cohen et al., 1985; Leslie & Frith 1988; Gopnik & Astington 1988) do not involve or require emotional contagion or motor empathy and so show isolated difficulties in this domain. ToM difficulties might contribute to other aspects of empathy for example not being able to assume another perspective, would limit the understanding of said perspective and inhibit emotional empathy. However ToM stands alone in not being influenced by separate empathy domains, being unable to imitate should not interfere with assuming another perspective (in time). There is the potential that mental imitation of events in false-belief tasks, for example '*I am sally, I put my doll here. I leave the room, I return. Where is my doll?*' may influence ToM abilities; but the definition of such a process is opaque. Is this still ToM ability or imitation of behaviour? Or a hybridisation of the two? Ultimately there are clear difficulties in assuming others' perspectives in ASC, as of now this would appear to be a stand-alone difficulty (depending on definition and ToM techniques) which may justify its' focus in the literature but it should not overshadow that difficulties in each domain of empathy are just as prevalent in ASC.

In respect of the above it might be better to evaluate the merits of the ToM explanation of ASC as a theory of empathy more globally, given that difficulties are identified in each domain rather than uniquely in ToM. Difficulties of empathy then adequately explain social interaction and communication issues in ASC, difficulties in assuming other perspectives will massively impact social skills and the abilities to appropriately respond to given social situations, this would appear to be more relevant to communication as empathy is particularly in response to a stimulus. Difficulties in empathy do not provide explanations for flexibility of thought or behaviour as this is almost entirely an internal drive and can be maintained in the absence of stimulus to be empathic towards. Only in a small capacity could ToM explain such inflexible behaviour because people often monitor their behaviour in respect of what others may think of them. The inability to assume another's' perspective and employ this self-evaluative step denies potential inhibition of inflexible behaviours, such perspective taking would allow awareness of behaviours seen to be problematic for others and presumably result in altered behaviour. Empathy difficulties provide no plausible explanation for sensory difficulties in ASC.

1.3.5 The Alexithymia hypothesis

As was discussed earlier The Alexithymia hypothesis proposes that the emotion processing difficulties reported in ASC are actually due to comorbid Alexithymia; because of this the Alexithymia hypothesis attempts to explain emotion processing in ASC, not ASC globally. The rest of this section will outline Alexithymia, its origins in the literature, what implications it has for ASC and the emerging research.

Alexithymia first mentioned in 1972, literally meaning "*lack of words for feeling*" (Sifneos 1996), is a condition where individuals struggle to understand, identify and describe emotions in the self. This can extend to the recognition of others' expressions (Nemiah, Freyberger, Sifneos 1976; Parker, Taylor & Bagby 1993; McDonald & Prkachin 1990; Prkachin, Casey & Prkachin 2009), diminished empathic responses with evidence of lower empathic traits (Johnson, Filliter & Murphy 2009; Moriguchi et al., 2006) and reduced neural activity in the anterior insula; a brain region associated with emotional context of sensory input (Bird et al., 2010). Individuals with Alexithymia can be aware they are experiencing an emotion, but struggle to identify the emotion or specific change in affect.

A growing amount of research is investigating Alexithymia as a potential contributing factor in emotion recognition difficulties (Pollatos & Gramann 2011; Pollatos, Schubö, Herbert, Matthias & Schandry, 2008; Cook, Brewer, Shah & Bird, 2013). One of the findings is the reported prevalence of Alexithymia comorbidity with ASC, which is currently estimated between 40% and 65% of autistic adults showing traits of Alexithymia (Berthoz & Hill 2005; Hill & Berthoz 2004). As Alexithymia is concerned with the inability to understand, recognise or describe emotions in the self, it is curious that this should coincide with reduced FER abilities. This is noteworthy because Alexithymia is most commonly associated with internal emotional difficulties of recognition, labelling and understanding. It would suggest a shift in affect in the self (empathic response) is crucial to correctly recognising the emotional states of others (this may be present in individuals with Alexithymia but they cannot accurately label this shift in affect). Thus Alexithymia would appear to be an empathic disorder specific to emotional empathy, and research has supported this identifying that Alexithymia coincides with difficulties in emotional empathy but not cognitive empathy (Moskacheva, Kholmogorova & Garanyan 2015). The presence of difficulties specific to emotional empathy but not cognitive empathy would suggest Alexithymia is separate construct from ASC (although ASC does not universally present with cognitive empathy/ToM difficulties) despite their high co-morbidity.

The unique empathy specificity of Alexithymia to difficulties of emotional understanding, but not ToM, and the reported high co-morbidity with ASC has led to 'the Alexithymia hypothesis' of emotion difficulties in ASC. This hypothesis proposes the emotional difficulties in ASC are attributable to the large amount of individuals with severe Alexithymia within ASC. Figure 1.7 below gives a visual example of the Alexithymia hypothesis within autism. Those in sample A would represent individuals with clear ASC traits and clear Alexithymia traits, this sample would demonstrate emotion recognition difficulties along with autistic traits. Sample C represents those with ASC traits but no co-occurring Alexithymia traits, it is hypothesized those individuals would not present emotion recognition difficulties and less empathy difficulties in a broader sense across multiple domains. The Alexithymia hypothesis centres on the heterogeneous assumption of Alexithymia traits within autism where a sample will comprise of some individuals with ASC with co-morbid alexithymic traits and some without (Sample B). This heterogeneous mix is proposed as the potential explanation of emotion difficulties in ASC, where difficulties emerge the sample has drawn upon more individuals with severe alexithymic traits; where no differences emerge the sample has captured more individuals in the ASC population without Alexithymia traits.

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure 1.7: *An illustration taken from Bird & cook (2013) visualising the overlap o| Alexithymia traits and ASC traits*

Currently it is difficult to appraise the Alexithymia hypothesis in a critical sense, this is because research has neglected to control for Alexithymia severity in control samples and so comparisons are difficult. One such study has shown through matched controls that Alexithymia severity predicted emotional attribution accuracy whilst ASC did not (Cook et al., 2013). In a second experiment Cook and colleagues (2013) demonstrated that Alexithymia does not influence expression variation recognition, limiting the difficulties to emotional content rather than sensory identification.

For Alexithymia to stand up to scrutiny as a potential contributor to emotion processing difficulties in ASC it should be able to shed light on the inconsistent scan paths in ASC. As Figure 1.7 above suggests, these inconsistent findings within ASC could be due to the presence of Alexithymia in some ASC samples. If this is indeed the case, analysing Alexithymia severity should be associated with atypical scan paths to a larger extent than ASC trait severity. Research measuring both Alexithymia and ASC severity supported this, with ASC severity correlating negatively with attention to faces; however Alexithymia severity (but not ASC) predicted the degree of eye fixations (Bird, Press & Richardson 2011).

The Alexithymia hypothesis presents a compelling case for emotion difficulties in ASC, it is important to note that Alexithymia does not attempt to explain the triad of impairments in ASC only emotion difficulties. The highly co-morbid nature of Alexithymia presents a plausible explanation for the difficulties reported whilst also accounting for the lack of findings in ASC. The supposition that empathy difficulties are housed within Alexithymia, rather than ASC, re-introduces the PAM of empathy (Preston & de Waal 2002) that posits the emotional state of the self and others are governed by the same neural networks. The 'emotional linkage' referred to previously which pairs the state of the self and others to arrive at an accurate approximation might also be at the core of emotion recognition difficulties in Alexithymia. Ultimately as a theory explaining aspects of ASC, Alexithymia can only account for emotional and potentially social difficulties that manifest as a knock on effect from emotional understanding difficulties.

1.3.6 Summary

The theories discussed here are but a few a from a broad ranging group, often a consistent and pervasive flaw is that no single theory can account for all or even many of the symptoms associated with ASC. The inability of a single theory to adequately explain the entirety of ASC is evidenced by the breadth of theories currently proposed often citing relevant and compelling work. Rather than continue to propose theories attempting to explain the entirety of ASC, instead there is room for a proposal that the theories need not be all encompassing, or that certain difficulties are distinct but they may be comorbid under ASC. It may be that theories trying to cover all symptoms and difficulties of ASC are instead hindered by trying to accommodate elements into a theory that may not actually coexist in a manner where one difficulty is directly linked in a causal or mutually detrimental relationship with another. Indeed whilst it is important to consider that theories provide compelling evidence for certain difficulties within autism, it should be noted that these theories are also not required to be mutually exclusive. As such strengths from amygdala theory for example, shouldn't by default discount evidence for a weakened ToM or altered processing style.

Such thinking is beginning to gain traction in attempts at understanding ASC aetiology, Happé and Ronald (2009) reviewed evidence from multiple domains (behavioural, genetic, cognitive and neural) to propose the 'fractionable autism triad' the idea that the triad of impairments are due to distinct genetic roots and not so tightly intertwined as previously believed. The face validity of such a proposal comes from the evidence of a triad of impairments; most measures are designed to assess across the triad and factor analytic research has demonstrated multiple factors exist in these assessments rather than a singular ASC factor with high explained variance (Mandy & Skuse 2008). This was further supported by genetic studies evidencing ASC heritability and a BAP, but crucially within the BAP symptoms would often emerge on two or even a single aspect of the triad (Happé & Ronald 2009).

Instead there should be a drive to focus on functionally distinct difficulties (and strengths) within ASC such as emotion recognition and consider the possibility that difficulties in multiple domains and stages of processing contribute to the difficulties measured. Within all of the theories discussed there is scope to explain emotion processing within ASC, thus highlighting the prevalence of the difficulty within ASC. The manner in which the difficulty is explained differs between the theories with some proposing perceptual differences (WCC, Amygdala theory), both in viewing style and emotion classification, and others advocating a delay in mentalizing and empathy (ToM, EMB), or emotional understanding (Alexithymia).

1.4 Autism and Atypical Emotion Processing

Given that the theories discussed above all address emotion processing and understanding difficulties in some way, it is worth briefly considering the research on emotion processing in ASC. Currently the research surrounding FER in ASC is conflicted. Some research shows difficulties of FER exist in ASC individuals (Bal et al., 2010; Corden, Chilvers & Skuse, 2008; Ashwin et al., 2006; Howard et al., 2000; Kennedy & Adolphs 2012a; Smith et al., 2010). FER difficulties in ASC appear to be particularly prevalent in recognition of fear (Humphreys, Minshew, Leonard & Behrmann, 2007; Pelphrey et al., 2002) or negative shifts of expression generally (Corden et al., 2008; Humphreys et al., 2007; Ashwin et al., 2006). On the contrary there is a body of research showing no such difficulties (Tracy, Robins, Schriber & Solomon, 2011; Jones et al., 2011; Da Fonseca et al., 2009a; Lacroix, Guidette, Rogé & Reilly, 2009; Spezio, Adolphs, Hurley & Piven, 2007; Neumann et al., 2006; Piggot et al., 2004). The inconsistencies are hard to pinpoint with such a wide range of methodologies and individuals from different points of the autism spectrum included in the literature (Gaigg 2012; Harms et al., 2010; Uljarevic & Hamilton 2013). What does appear to be emerging is the competency of ASC individuals with average, or above average intelligence, to perform competently on 'simpler' tasks of emotion recognition (Neumann et al., 2006; Rutherford & Towns 2008; Adolphs et al., 2001). These 'simple' tasks are defined as those utilising static, posed stimuli usually involving the basic emotions (Happiness, anger, surprise, fear, disgust and sadness) (Ekman & Keltner 1970; Ekman & Friesen 1971).

Research similarly suggests when the task difficulty is increased through the use of dynamic, and/or lower intensity stimuli, or the use of more complex emotions such as pride and guilt, the FER difficulties in ASC become more pronounced (Baron-Cohen et al., 2001a; Philip et al., 2010; Kennedy &

Adolphs 2012a; Golan & Baron-Cohen 2006; Cassidy, Mitchell, Chapman & Ropar, 2015). Complex emotions which can be subject to display rules (Matsumoto, Olide & Willingham, 2009a; Matsumoto, Olide, Schug, Willingham & Callan, 2009b), such as conveying joy for politeness to hide true feelings, often result in more than one emotion being present in an expression. Considering the findings it is clear the presence of FER difficulties in ASC individuals appear ambiguous because of the variation in tasks employed, and individual differences of the populations tested. These methodological issues, and more, will be discussed in greater detail in chapter 2.

1.5 Summary

This chapter introduced autism and the multiple theories attempting to explain it. These were appraised both in cognitive and biological perspectives, the amygdala theory provides an explanation for poorer recognition of negatively valenced expressions that is not accounted for by other theories. The ToM was considered more broadly as a difficulty in a specific domain of empathy, the other domains were also considered with compelling evidence for global empathy difficulties. The difficulties in emotional empathy overlap with the emerging new Alexithymia hypothesis which proposes the overlap of Alexithymia with ASC as a contributor to emotional processing difficulties. Finally the weak central coherence theory was discussed with evidence questioning the roots of the theory that global processing is reduced in frequency or ability. Multiple findings showed that global processing is intact but is not utilized in the same circumstances as TD samples would employ it. There is little evidence from the theories discussed that adequately explain other areas of difficulty in ASC such as ritualised behaviour, narrow interests or limited imagination. The chapter finished by briefly introducing the literature surrounding emotion processing and the inconsistent literature surrounding emotion processing difficulties in ASC. The next chapter will cover this topic more in depth introducing the function of displays of emotion more broadly, the development of emotion processing ability, expanding on the literature of emotion processing in autism and introducing the concept of attribution as well as recognition.

Chapter 2: Methods in Facial Emotion Recognition Research

The previous chapter introduced autism defining what it is, the diagnostic criteria and any associated difficulties. This was followed with the introduction of several theories that attempt to explain autism which were appraised in their ability to adequately account for the difficulties routinely associated with autism. Also briefly introduced was the conflicting research surrounding emotion processing difficulties in ASC, which was a common theme among the theories discussed. This chapter will expand upon this theme of emotion processing in autism; first the theoretical basis of emotions will be considered, second the function of emotions will be discussed as this is key when adequately appraising any methods that attempt to measure the ability to recognise and understand emotions. This will be followed by a summary of the development of emotion processing abilities and how this may play a role in recognition competencies. This will lead to a more thorough discussion of emotion processing in ASC and the key roles of recognition and attribution whilst simultaneously introducing the RM paradigm as a method that addresses this topic. The rest of the chapter will appraise the stimuli and methods that have been used previously; specifically the stimuli type, complexity, delivery method and task demands as contributing factors to FER competencies in ASC. The chapter will conclude by outlining the aims of the thesis and structure of the subsequent chapters.

2.1 Theories of Emotion

Much as there are theories of autism there are also theories that attempt to explain how emotions come to be. There have been many theories that attempt to explain the phenomenon that is emotion, one of the original theories termed the James-Lange theory proposed that emotions are preceded by physiological reactions which then inform the emotional response (James 1884; Lange 1922). Subsequently the Cannon-Bard theory (Cannon 1927) argued that the physiological sensations and emotional reaction occur simultaneously highlighting some key flaws with the James-Lange theory, most notably that removing the viscera (organs) leaves emotional reaction intact, they also noted that similar physiological changes in the viscera could result in different emotions, among other critiques.

One of the central theoretical turning points in the theories attempting to explain emotion was the two-factor theory of emotion (Schachter & Singer 1962). The two-factor theory argues that emotions are categorised according to two factors, physiological arousal and cognitive label or appraisal. It marked a transition in acknowledging that similar physical states can bring rise to different emotion classifications due to the context that brought about the physiological changes. In a classic study Dutton and Aron (1974) demonstrated that physiological sensations can be misattributed to alternate contextual clues; they provided evidence of such an effect by way of an experiment were male participants had to cross either a highly arousing dangerous bridge over a ravine, or a much safer bridge. Upon crossing the bridge the male participants were approached by an attractive female experimenter and asked to give a description of an ambiguous picture and given the experimenters phone number to call in the case of any questions. The results demonstrated the participants in the highly arousing conditions (dangerous bridge) made more sexual inferences in the description of the picture and were more likely to phone the experimenter than the participants in the safer bridge condition. Dutton and Aron (1974) suggested the highly aroused state of the participants in the arousing bridge condition processed their physiological sensation in the context of an attractive female and thus misattributed their heightened arousal (fear) as attraction due to the contextual clues.

The explanation of emotions has theoretically fallen into two distinct categories, those that acknowledge emotions as distinct functional evolutionary devices and those that view emotions as psychological classifications of the self reacting to the environment. Major differentiations between these two stances is that those viewing emotions as distinct categories (typically credited with evolutionary roots) consider them natural kinds, hard wired and provided by nature, whereas those who believe emotions are part of a psychological construct to categorise the changes in the self, do not require conformation to distinct types with clear boundaries (Barrett 2006).

2.1.1 Darwin-Ekman theory

The Darwin-Ekman theory is based on Darwin's work focussing on emotions in attempt to support his theory of evolution. It was based upon three principles, the emotions as we know them today initially functioned more practically as physiological changes which had tangible benefits, he termed this the 'principle of serviceable habits' (Darwin 1872). Some examples of the baser functions of emotions having serviceable habits include evidence that the widening of the eyes typically associated with fear responses allows a wider visual field and faster eye movements (Susskind et al., 2008). A similar root function can be attributed to disgust which displays with a wrinkled nose and closed mouth, both of these physiological changes assist in closing orifices and reducing harmful bacteria entering the body (Chapman, Kim, Susskind & Anderson 2009).

Darwin's second principle is that of antithesis, He proposed that some displays are not serviceable in functions; they are intended to be without function to display the exact opposite of commitment to any given state or confidence. The proposal of emotional antithesis would only fit in the later stages of Darwin's proposal that emotions primitively initially served functionally adaptive purpos es these were then exaggerated and came to hold communicative meaning for others. Antithetical displays serve no function within the individual to prepare them for any given activity, they are entirely communicative in purpose and so do not hold the same underlying roots as the other emotions and displays. This is potentially problematic because the socially functional explanation of emotions is underpinned by the primitive physiological changes holding contextually communicative meaning for the situation that elicited them. Darwin states that these antithetical displays are originally voluntary displays and become repeated through habit eventually becoming involuntary and inherited which as Black (2002) noted is problematic due to its contradiction of the s elective pressures that underpin Darwin's first principle.

Darwin's third and final principle is that nervous discharge from the nervous system gives rise to specific reactions, such as increased verbal responsiveness in animals when experiencing intense p ain, fear or excitement. This proposal reflects the theories discussed previously from James -Lange and Cannon-Bard in that physiological sensations give rise to emotions reactions. The specific functionality by which these nervous discharges come to be might only be applicable to very select instances of displays rather than the stereotypical emotion responses we know today.

Darwin's view of emotions is best supported by Ekman's work on FER. Ekman among many other researchers, believes the display and recognition of emotions is universal across cultures and has conducted and presented much research in support of this (Ekman & Friesen 1971; Juslin & Laukka, 2003; Elfenbein & Ambady, 2002; Russell, 1994 Kirouac & Doré, 1984; Izard 1971; Scherer, Banse & Wallbott 2001). Such a Vast amount of research was conducted investigating the universality of emotion recognition that Elfenbein and Ambady (2002) conducted a meta-analysis, concluding that emotions could be recognised across cultures to a significantly better degree than chance alone would expect, they reported an average recognition rate of 58%. In the same Meta-analysis Elfenbein and Ambady (2002) investigated the prevalence of the in-group advantage, a phenomenon where individuals recognise expressions better when they are displayed by someone from their own ethnic or regional group. They found an overall significant effect of the in-group advantage across 16 studies equivalent to 30.2% improvement within an in-group.

The presence of an in-group effect is problematic if emotions are to be universal across cultures, performing better at recognising emotions from individuals the same ethnicity as you suggest some cultural variation is present. The nature of how that variation exists is not compatible with a natural kind explanation of emotion. However it is acceptable that being particularly attuned to faces of your own ethnicity would be advantageous to aid in recognition of faces one was more likely to encounter, but the means by which such subtle variation arises is not clear.

Evaluating the natural kind theory proposed by Darwin and supported by Ekman's research has tried to correlate emotions with response patterns, such as self-report state, facial display, physiological response and behavioural change. There is strong evidence that correlates facial activity and subjective reporting of emotional states, this is true for anger and sadness (Bonanno & Keltner 2004), and happiness and sadness (Mauss, Levenson, McCarter, Wilhelm & Gross 2005). However there are criticisms that state the correlations of specific emotion categories to states pale in comparison to the correlations between such measures and affective properties of arousal and valence (Lang, Greenwald, Bradley, & Hamm, 1993).

Such criticisms have resulted in alternate attempts to explain the origin of emotions, perhaps most radical of these is the work of Russell and Barrett (1999) because it appears diametrically opposed to the Darwin-Ekman theory stance of emotions that evolution provided emotions in distinct categories to govern behaviour when appropriate. The Barrett-Russell approach considers emotions to be better explained by locations across two properties of activation and pleasure or arousal and valence.

2.1.2 The theory of constructed emotion

In a shift from the natural-kind stance that underpins the essentialist Darwin-Ekman theorists of emotion, 'the theory of constructed emotion' is predicated upon the belief of (in earlier works) a state of 'core affect'. Core affect is described as "*the most elementary consciously accessible affective feelings…examples include a sense of pleasure or displeasure, tension or relaxation, and depression or* *elation*" (Russell & Barrett, 1999 p 806). The catalyst for a shift in paradigm was the lack of consensus in research to report correlate emotion subevents with resultant changes in areas such as self-report affective state, physiological response, emotional display *etc.* (Russell & Barrett 1999). This lack of evidence for a clearly defined natural-kind emotion structure can be seen in the high correlations between subjective reporting of negative emotions such as sadness, anger, fear, and disgust (Feldman, 1993; Watson & Tellegen, 1985; Watson & Clark, 1984).

This lack of specificity between the emotions has led to some claiming the reports of negative emotions appearing related to one another is better represented as a circumplex structure (Russell & Barrett 1999). A circumplex relies on the objects (emotions) being varied and situated along basic properties. One such example of a circumplex is provided below in Figure 2.1, this particular example varies along two basic properties 'valence' ranging from pleasant to unpleasant and 'arousal' ranging from highly activating or highly deactivating. The labels inside the circle represent affective changes in approximate locations; the labels outside the circle represent the likely locations of the prototypical emotions in respect of valence and arousal.

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure 2.1 *A circumplex of affect across two basic properties, valence (horizontal) and arousal (vertical) taken from Russell & Barrett's work on core affect (1999).*

It is worth noting the affective states in figure 2.1 such as 'stressed',' nervous', tense' and 'fatigued' (among others) hold some connotation for the physiological state of an individual. For example being stressed often has implications for one's health such as blood pressure (Hassoun, Herrmann-Lingen, Hapke, Neuhauser, Scheidt-Nave & Meyer, 2015) much like being nervous or tense has an association with cardiac change and muscle tension. This idea that affective states appear alongside physiological changes has links to the idea of embodied cognition where the physiological changes in the body might influence the mind. The key premise in embodied cognition that the mind may be influenced by the body is at work in Barrett's Conceptual act model (2006; 2014) of emotion. The conceptual act model (CAM) theorizes that emotions exist in the conceptualisation of incoming sensory input and prior experience (Barrett, 2014), that is the emotion is real in a constructed sense when prior knowledge and incoming sensory input categorize the event under an emotion term.

Expanding on the CAM, Barrett (2017) proposed the theory of constructed emotion (CE) as an amended model where interoception (the sense of physical condition of the body) and allostasis (the delicate balancing act of ensuring adequate resources for functioning) were introduced. The theory of CE once again has roots in embodied cognition, with even more reliance on changes in physiological states recognised through interoception impacting allostasis. It is the constant drive to achieve allostasis that drives the CE theory. It is proposed an internal model of concepts (past experiences) is continually evaluating the world and predicting "*what is about to happen in the sensory environment, what the best action is to deal with impending events, and their consequences for allostasis (the latter is made available to consciousness as affect).*" (Barrett, 2017 page 12). These predictions are designed to minimise allostatic change, and when predictions are correct allostasis is maintained (or change is minimised), however when the predictions are wrong (prediction error) the allostatic change is high and the resulting affect experienced is greater. Once the prediction error is minimised it becomes an experience, the prediction then explains the cause of sensory events and directs action through categorizing the sensory event (Barrett 2017) in this way the brain categorizes the concepts as emotions.

Some of the evidence provided in support of the CE theory is in the form of decorticated cats (cerebral cortex surgically removed) which resulted in reflexive actions that lacked the affective component. Given that affect forms a core part of the predictive model in governing behaviour to manage allostatic change it was important to note that although the cats appeared to still react emotionally this did not appear to be for survival purposes the allostatic purpose of the emotion was missing (Woodworth & Sherrington, 1904 in Barrett 2017). There are also many studies that show neuronal degeneracy, where structurally distinct brain regions perform similar functions or one function is mapped to numerous regions (Clark-Polner, Johnson & Barrett 2016; Herry & Johansen, 2014; Becker et al., 2012; Mihov et al., 2013) supporting the domain general approach outlined in the CE theory.

2.1.2.1 Prediction and retrodiction

Barrett (2017) also notes the brain functions in a predictive fashion rather than reactive, stating the brain runs simulations on incoming sensory input (Deneve 2008; Bastos et al., 2012) to best match the current situation to any previously categorised (Gallivan, Logan, Wolpert & Flanagan 2016). Each prediction is a concept and when completed they are categorizations that govern physiological regulation, action, and perception (Barrett 2017); this is contradictory to standard appraisal models (Lazarus 1991; Scherer 2009). However this approach is not without issues, the evidence for prediction which Barrett uses to underpin the theory relies on a feedback loop (prediction error) built in to accommodate the inevitability of predictions being incorrect. But the model cannot sustain itself on prediction alone, no model can, it requires flexibility and re-evaluation to accommodate conflicting information.

At this point there is the issue that the theory of CE appears to be built on the foundations of prediction that all predictions serve to govern the maintenance of allostasis. With these foundations it is accepted that prediction would be portrayed as more important than retrodiction (the explanation of past events through use of the event) but the model can only improve and so allostasis can only be achieved (with accuracy) through the continual process of retrodiction. Similarly the CE theory portrays emotions as the very last step, seemingly reduced to a conscious labelling exercise of the multitude of physiological and affective information that arises in prediction error. But if the categorization of that physiological and affective episode into an emotion allows effective implementation of that episode then the emotion governs future behaviour and retrodiction is the key that incorporates the information into the model. It would appear in the theory of CE the predictions are only as reliable as the retrodictions allow them to be.

The importance of retrodiction is evident in research suggesting there is no inherent specialism on prediction that eclipses retrodiction ability (Jones & Pashler 2007). Similarly retrodiction has been shown to be a reliable method in the past of assessing emotional understanding (Cassidy et al., 2014; Pillai, Sheppard, & Mitchell 2012; Pillai et al., 2014). The nature of the retrodictive tasks does not allow prediction to factor into the causal event categorisation process, this is because the causal event has already happened only the result is observable and from this information is deduced. Because of this prediction knowledge is always limited by what is known prior to the event and retrodiction includes the information of the event itself.

Prediction and retrodiction work in tandem, particularly in social situations where one must adapt quickly to the complex nature of communication and display rules. To assume one prediction governs an entire social interaction is too simplistic and so retrodiction must bridge the gap between predictions within social interactions. The purpose here is not to argue that predictions are less valuable than retrodiction, after all no amount of information is useful if it serves no function to better understand and govern appropriate behaviour. What is the aim is to highlight predictions can only be as accurate as the sum of prior knowledge and retrodictions in explaining prediction error, prediction is of limited use without prior information on error to temper subsequent predictions and retrodiction is no use without the ability to apply that information to future scenarios.

2.1.3 Theoretical criticisms

In summary the natural kind theory and the theory of constructed emotion each have limitations. The belief that emotions are natural kinds appears to lack research supporting correlate actions and causal evidence, there is also a resurgence in cross cultural universality research that questions the original findings (Gendron, Robertson, van der Vyver & Barrett 2014; Crivelli, Russell, Jarillo & Fernandez-Dols, 2016; Nelson & Russell 2013). In much the same sense there have been claims that the phenomenological experience of an emotion and the subsequent action, such as facial displays or vocal response, is quite narrow and restricted to the most stereotyped of expressions (Russell, Bachorowski & Fernandez-Dols 2003).

There does also appear to be cultural in-group effects (Elfenbein & Ambady 2002) in recognition which should not be the case if emotions are truly universal, although such an advantage could be attributed to familiarity to in-group facial morphology, although this is a tenuous explanation at best. The rigid adherence to emotions as natural kinds is essentialist as Barrett (2006) claims; such views quarantine emotion research to the basic expressions. Treating natural kind emotion as fundamental to all understanding only achieves shoehorning research into a corner, chasing the clear boundaries of specific emotion types; instead research should acknowledge that emotions may be hardwired and may serve specific functions but to have these appear in mutual exclusivity is unrealistic and would be evolutionarily counterproductive.

The theory of CE however, relies on core affect quite heavily and though there is strong evidence for prototypical emotions falling along valence lines and inter-relatedness between these expressions, it is worth noting that in a functional sense the prototypical expressions that appear similar in a circumplex design all fall towards a negative valence requiring action (Russell & Barrett 1999). There is sense in phenomenological experiences that require action having some instances of cross-over, given that any highly activating negative stimulus is better responded to with one of many negative expressions than not at all; a much larger concern would be an overlap in the correlate measures of the phenomenological experience of happiness and fear, for example. Touched upon previously and another potential issue with the CE theory is that 'emotions' in the theory, appear relegated to a lesser role, marginalised to a category system at the tail end of an allostatic change (Barrett 2017). The reasoning or justification for this appears only to serve the claim that emotions are real and do exist, but functionally do very little. This is further suggested in the claim that animals do not experience emotion but do experience a change in affect, but it is the change in affect that is ultimately categorized in humans as an emotional episode (Barrett 2017).

It is this lack of explanation as to what makes an emotion (or is required) that is absent, this leads to some questions: 1) how do animals maintain their allostasis without emotions to help categorise events and inform predictions? 2) If animals do this without emotions what is the purpose of emotions in humans? 3) What trait do humans have that allows us emotions but not animals? Ultimately the theory of CE appears to undermine the very importance of emotions with its explanation of them, which is reduced to deviation from the allostatic norm. If such deviations require classification under emotion labels to better reduce allostatic change in the future, then this process (or ability) by Barrett's own admission does not extend to animals which would suggest they have evolved an entirely separate system to govern their survival instincts, or alternatively, emotions are functionless.

2.1.4 Summary

There is merit in Barrett-Russell's theory of constructed emotion, the very basic assertion that emotions are not entirely distinct (as argued in this thesis) and range in intensity, supports the core components of the theory. Believing that the distinct emotion categories exist, with evolutionary adaptive purposes, is also the stance in this work; it is such that emotional expressions without display, physiological, and behavioural changes would serve no purpose whatsoever. However, requiring expressions to be heterogeneous in their resulting correlate output behaviour and physiological manifestations requires independence in occurrence of expression, which is not the belief in this current work. It is instead believed the evidence for universality of expressions is supported in their widespread recognition, although see (Gendron et al., 2014; Crivelli et al., 2016; Nelson & Russell 2013) but this does not preclude or prohibit the stance that in actuality expressions are far more likely to be complex blends. Even when recognised as the basic six they are still likely to include some qualitative overlap of the boundaries. It is such that human perception of expressions (and self-report) of particularly high intensity will likely show adherence to basic prototypical kinds but presentation and measurement through various methodological approaches will show a rich blend of multiple emotions.

2.2 Emotion Processing and the Function of Emotions

When investigating the ability to correctly process and recognise emotions the focus should also be on the function of emotions, why is it important that we recognise them? If someone shows poor emotion recognition abilities what is this likely to mean for them in real terms? If there were no detrimental impacts on everyday life then there would be no need to investigate the ability. Unfortunately difficulties in recognising emotion are usually manifested in mental health conditions where there is evidence of difficulties in individuals with eating disorders (Bydlowski et al., 2005), schizophrenia (Gur et al., 2002; Hooker & Park 2002; Mueser et al., 1996), depression (Bourke, Douglas & Porter 2010), attention deficit hyperactivity disorder (Yuill & Lyon 2007) and Alexithymia (Roedema & Simons 1999). There are also marked difficulties in individuals with Alzheimer's disease (Cadieux & Greve 1997; Bucks & Radford 2004), dementia (Miller et al., 2012) or those on the autistic spectrum (Harms et al., 2010).

The prevalence of emotion processing difficulties in many different areas from mental health issues that can be periodic, to diagnoses of Alzheimer's or ASC that will stay with the individual indefinitely highlights the important association between emotion processing and mental wellbeing. The consistent presence of FER difficulties across the conditions listed above suggests that the ability to correctly recognise emotions is either: A) required for good health and typical development or B) the inability to do so is a negative side effect of atypical development as is the case in ASC; or health issues in the cases of Alzheimer's or depression. The nature in which FER difficulties emerge in different conditions suggests there is not a single 'poor performance' style, but that this alters according to the issue experienced. For example in depression, sufferers have a tendency to overly recognise sadness and view neutral expressions as more negatively valenced (Bourke et al., 2010). Whereas individuals diagnosed with schizophrenia show a general difficulty in specificity often confusing emotions (with a slight improvement in happiness relative to other emotions) (Schneider et al., 2006), whilst those diagnosed with ADHD express reduced N170 (electrophysiological markers of emotion processing) density in the fusiform gyrus; a brain region associated with face and emotion recognition (Ibáñez et al., 2012).

The differential presentation of emotion processing difficulties across various conditions or health issues underlines the communicative function of emotions. By displaying social information to others emotions can aid in social cohesion (Shariff & Tracy 2011), when that social information is not accurately recognised problems can emerge in social skills. For example the aforementioned emotion processing negative bias in depression patients, whether this pre-empts the origin of depression or is a symptom of depression, highlights the importance of correct recognition as this negative bias can reinforce the depressive state. Thus if there are functionally different communicative intents for each expression type, then difficulties in specific types of expressions can result in specific social difficulties.

One such case is individuals with diagnoses of ASC. These individuals often have marked difficulties in recognising emotions of negative affect such as fear, anger or disgust (Harms et al., 2010; Bal et al., 2010; Ashwin et al., 2006; Wallace et al., 2008; Howard et al., 2000). Considering this we can question what are the social difficulties likely to be faced in individuals who present specific difficulties in processing negative expressions? Well to answer this we need to consider the function of those negative expressions.

Unanimously anger, fear and disgust would convey some need to alter behaviour; that things in the current environment are not okay. Anger is typically a threat, designed to convey that whatever you, or someone in the current environment are doing, is not well received (Averill 1982). The intent of the expression is dependent upon the intensity, mild anger communicates displeasure that you may have been rude, intense anger is approaching physical intervention or at the very least threat of such an intervention (Graham & Wells 2001). Disgust can be very similar in meaning something offensive has elicited this reaction but it specifically centres on revulsion and has evolutionary roots in behaviour adaptation (Wicker et al., 2003). Disgust can be classified into three domains; Pathogen disgust intended to avoid infectious substances for example rotting food, Sexual disgust designed to govern mate choice in avoiding costly mates with potentially poor genes, the final domain is moral disgust which mediates social behaviour and helps to maintain social cohesion (Tybur, Lieberman & Griskevicius, 2009). Fear is fairly obvious in its communicative intent, it conveys immediate danger. Typically the social circles we keep are those we have a vested interest in; these could be family, immediate and distant, and friends. These people have a social alliance, sometimes with kinship investments and so signalling when immediate danger is near serves to help those who would also help us.

Understanding the communicative function of negative affect expressions, we can now begin to hypothesize what personality characteristics would be present in individuals who show difficulties in recognising these emotions. Those who struggle to recognise disgust might make social faux pas, as they misunderstand social etiquettes and violate certain subtle moral disgust taboos. They may also struggle to pick up on subtle anger that would be displayed to allow an opportunity to rectify previous social gaffes. Similarly difficulties in recognising fear might result in individuals who do not adequately recognise threats and appear overly trusting of others (Adolphs et al., 2001). Individuals diagnosed with ASC are often described as being socially awkward with lack of understanding of social rules such as personal space and reciprocal behaviour (Happé 1994; Baron-Cohen et al.,1999); they also present flat and inflexible speech (Muskett, Perkins, Clegg & Body 2009) although this may be a function of the flexibility provided by the individual they are interacting with. Characteristics such as those would be guided by the recognition of negative expressions such as anger or disgust which convey that the communication behaviour is not to be expected. The inability to correctly recognise fear often presents in individuals with ASC (Caulfield, Ewing, Burton, Avard & Rhodes, 2014).

Having outlined the communicative function of emotions, and what difficulties in recognition can mean, it is now worth considering the development of emotion processing throughout age; specifically how the communicative nature of emotions develops and is not fully formed at birth. Investigating this developmental trend will question how emotion processing should be assessed and if one task is appropriate for all age ranges, or if this inadvertently presents a bias to certain age demographics because of developmental stages. These issues are addressed in the next section.

2.3 The Development of Emotion Processing from Childhood to Maturity

The ability to correctly process emotions follows a developmental trajectory from birth through to adulthood. This trajectory is underpinned by several shifts in processing style and ability at certain developmental milestones. These milestones will be discussed in relation to how research typically assesses emotion processing and if the conclusions drawn can be considered valid in respect of the emotion processing ability at any given developmental time point.

Orienting to face like stimuli appears innate at birth (Johnson & Morton 1991; Morton & Johnson 1991), with new research even demonstrating foetus' preferentially orienting to face like stimuli in the womb (Reid et al., 2017). The presence of such abilities so early in development underlines the adaptive benefits of face orientation and emotion processing. These abilities develop in line with needs, for example orienting to faces post-natally appears to be less communicatively functional but more bonding focussed, this is because new-borns have very limited communicative ability. The extant of new-born communicative ability is limited mostly to crying and some facial gestures, with premeditated gesturing not developing until around nine months (Iverson & Goldin-Meadow 2005). New-borns do show emotional mimicry (Meltzoff & Moore 1977; 1983) but this is likely an involuntary response to facilitate bonding with care-givers. The lack of ability to communicate needs in new-borns means they are entirely reliant upon care-givers to meet their survival needs, the best way to ensure this is achieved is to recognise a face when one is present and orient towards it. This ensures the caregiver can see the new-born and is best positioned to meet any needs.

Contextual understanding of expressions does not develop until approximately five years old, when children begin to understand emotions match certain situations (Philippot & Feldman, 1990; Boyatzis, Chazan & Ting, 1993). This is matched by an improvement in language ability within this age group demonstrating that as emotional understanding improves it matches the abilities and comprehension to use such abilities (Pons, Lawson, Harris & Rosnay, 2003). Of note is the improvement in recognition of emotions with negative affect such as fear and disgust (Herba & Phillips, 2004) this may be partly due to the increasing need to recognise emotions that pose a threat to the individual as development increases the ability to react to such expressions appropriately. New-borns would have no benefit in being able to recognise emotions such as fear and disgust because they are physically unable to act on the information conveyed.

The improvement in ability after the age of five coincides with the improvement of configural processing styles, where children begin to show the ability to place an aspect of a face into the correct whole (known as the part-whole paradigm) (Tanaka, Kay, Grinnell, Stansfield & Szechter, 1998). This holistic processing is key to accurate emotion recognition where attention is directed to multiple areas of the face, most notably the eyes and nose. This attention is fluid transitioning between the eyes and mouth continually which requires the ability to interpret the information as a coherent whole. This could be linked with executive function development which also controls working memory (Ozonoff, Pennington & Rogers 1991) possibly playing a part in holistic processing. Although holistic processing is developed at around age six, second-order relations (the distance between facial features) are still under developed (Bruce et al., 2000; Gilchrist & McKone 2010). Because second-order relation configural processing is not fully developed, there are implications for the type of task that can be used to assess emotion recognition abilities. Using static images that do not show any changes in facial structures during development lack these second-order relation components that would be present in natural real world expressions. This could result in research identifying performance above what would be representative in a real world situation. Using dynamic expressions is more likely to capture any difficulties as it reflects small changes in the face, such as the scrunching of the nose in disgust or unilateral slight upturn of the lip in contempt. Further still using spontaneous expressions can be even more subtle with shorter display periods and less intense presentations (Dibekglioğlu, Salah & Gevers, 2012; Dibeklioğlu, Valenti, Salah & Gevers, 2010).

Deviation from the typical viewing pattern outlined above is often associated with difficulties; one such example is in ASC. Evidence suggests individuals with ASC spend less viewing the eyes, and more time viewing the mouth and body regions than typically developing controls (Klin et al., 2002; Pelphrey et al., 2002). These viewing patterns also appear to translate to recognition of emotion categories and intensities (Kennedy & Adolphs 2012a; Smith et al., 2010). The importance of the eye region is further highlighted with evidence in ASC of a reduced ability to infer mental states of others from images of the eyes only (Baron-Cohen et al., 1997; 2001). These atypical patterns are also accompanied by a general difficulty in recognising negative shifts in affect (Humphreys et al., 2007; Pelphrey et al., 2002; Corden et al., 2008; Ashwin et al., 2006) likely due to atypical amygdalae function (Adolphs 2002; Adolphs, Baron-Cohen & Tranel, 2002; Breiter et al., 1996).

However, these viewing patterns are not always the case and do not necessarily occur with differences in recognition between autistic individuals and typically developing individuals (Van Der Geest, Kemner, Verbaten & Van Engeland, 2002; Tracy et al., 2011; Jones et al., 2011; Da Fonseca et al., 2009; Lacroix et al., 2009; Spezio et al., 2007; Neumann et al., 2006; Piggot et al., 2004). In some cases research has only highlighted differences between those with and without autism when the stimuli used was dynamic, more natural in presentation, and allowed social context (Speer, Cook, McMahon & Clark, 2007). Another factor that influence the likelihood of group differences is using stimuli of a higher complexity (Cassidy et al., 2014), although this did not appear to be governed by visual search strategies.

As emotion processing abilities develop the task that would be appropriate in assessing those abilities also needs to differ. A task used with adults should incorporate natural dynamic stimuli, to reflect the fact that typically developing adults should have a fully developed configural processing style that is able to differentiate between very subtle facial movements. A task in young children might want to consider still utilizing natural dynamic stimuli, but limiting the complexity of any expressions that may be mixed or blended (Hoque, Morency & Picard 2011; Hoque & Picard 2011) which could increase complexity beyond children's recognition range and executive functioning. With the previous evidence introduced above, it questions whether such viewing patterns will still be present in those with ASC or autistic traits when presented with stimuli that more accurately represents typical social interaction.

2.4 Emotion Attribution and Recognition in ASC

As is clear by now, successful recognition of others' emotion expressions and appropriate responses to these are key to successful social interaction and relationships. One need only look at the difficulties faced by individuals on the autistic spectrum (Harms et al., 2010), to see how difficulties interpreting others emotional responses and responding appropriately can impact social and communication skills. Previous research has typically employed stimuli sets that are static in display and consist mainly of the six basic expressions; happiness, sadness, disgust, anger, fear and surprise (Tottenham et al., 2009; Martinez & Benavente 1998; Matsumoto & Ekman 1988; Ekman & Friesen 1976). Research utilising such stimuli have presented conflicting results, with some studies showing differences in emotion recognition ability between groups, such as men and women (Hall 1984, 1978; Hall & Matsumoto, 2004; McBain, Norton & Chen, 2009), and those with and without autism (Harms et al., 2010). Whilst other research shows no differences between these groups (Loveland et al., 1997; Gepner, Deruelle & Grynfeltt, 2001; Castelli 2005). However, research has tended to more consistently produce group differences when using stimuli of differing intensities, with more subtle expressions presented at low intensity being more likely to reveal group differences in emotion recognition ability (Hoffmann, Kessler, Eppel, Rukavina & Traue, 2010).

What is emerging and was briefly introduced in section 1.4 is the need for an experimental approach to develop ecologically valid stimuli that reflects the challenges of realistic social interaction. Without the use of such a stimulus set the field would struggle to accurately measure FER competency. This is particularly true of ASC individuals who are believed to have difficulties in FER, but the current stimuli fail to uncover these difficulties consistently.

The need for more realistic, subtle, and complex displays of emotion is further supported by previous work suggesting that expressions posed on command do not accurately convey the emotion pattern entirely (Carroll & Russell 1997). The widely reported 'Duchenne smile' as an indicator of genuine happiness is distinguishable from non-Duchenne smiles by the upturn in the edges of the lips and eyes causing 'crow's feet'. The ability to distinguish between the two proposes the use of non-Duchenne smiles serves as an illegitimate display of happiness (Ekman & Friesen 1982; Ekman, Friesen & O'Sullivan 1988). The purposes of non-Duchene smiles are usually to conceal embarrassment, or attempt to mask negative expressions (Ekman & Friesen 1976). The documented use of both genuine (Duchenne) and non-genuine smiles in social interactions, further emphasises the need for stimuli that addresses emotions can occur in multiple scenarios beyond what may be typically expected, and the root cause of those emotions can be multiple antecedent 'feelings'. The underlying theory to this approach is that emotions have a 'formal object', the cue which elicits the emotion (Kenny 1963). Focussing on the formal object as a recognition task and later identifying the emotion could serve as a better test of FER competency transferrable to real world social competencies.

Approaching FER in this manner would assess emotion processing on two fronts; the first being the ability to accurately recognise facial stimuli much like previous FER tasks have done (Tracy et al., 2011; Smith et al., 2010); the second aspect would measure the ability to recognise the antecedent scenario or formal object that incited the response in the individual. The ability to accurately recognise facial emotions as described in the first aspect, has in previous approaches, been considered to reflect the overall ability of FER in a social sense (Kleinhans et al., 2010, Hill et al., 2014; Pujol et al., 2009). What may be the case is the recognition competency of facial emotional stimuli is assessing the ability to solely match those stimuli to a bank of pre-defined emotions.

The previous tasks of FER do not measure effective implementation of the emotional information, what would cause such a response, or how that response is likely to alter the individual's behaviour or mood. A task focussing on implementation of the semantic information associated with the stimuli shown would be a greater measure to assess social skills, distinguishing between recognition of emotional stimuli and effective social implementation of the information. In light of this it is important to consider that tasks of FER, even tasks of a greater difficulty, should be rightly classified as assessments of emotion recognition and not of understanding or social skills although one may pre-empt the other. To assess understanding, an acknowledgement of appropriate formal objects would be required; similarly in the case of social skills there would need to be a greater focus on implementation of the information available in FER tasks and how this influences corresponding understanding and or behaviour. Previous research has focussed on difficulties of FER assuming difficulties in that area are the underlying catalyst to general social difficulties. Research should consider the possibility of some ASC individuals' abilities to recognise emotions in a matching sense, through having learned the standardised expressions of emotions. The learned expressions do not however effectively apply the information from those expressions into their social repertoire; it may be that this effect is more pronounced with complex expressions which are less immediately recognisable and categorical.

As has been introduced above in the concept of formal objects and understanding appropriate root causes to any given response, it is required that future tasks should effectively emulate the entire social episode of emotion presentation this includes both attribution and recognition. Many of the tasks previously used have focussed on viewing an image or video of an emotion and attempting to label this; this is problematic because emotion recognition in the real world more accurately encompasses the process of observing a reaction and trying to understand the cause of that reaction. In this sense observing a reaction and placing it in social context forms an attribution (for example Jane returns home to find her house has been burgled, Jane is angry). This attribution, aids in correct recognition because it provides social context. Attributing emotional states to others helps in the process of understanding other people's internal emotional states and potential subsequent actions, this process requires ToM and so it is important to consider the link between ToM and emotion recognition.

2.4.1 Theory of mind and emotion recognition

Within the literature there is often confusion between ToM difficulties and emotion recognition difficulties, whilst these areas are related they are not synonymous. For example research has shown that ASC individuals struggle when presented with tasks that encourage them to relate to others on an advanced level such as determining from someone's expressions how trustworthy they are (Adolphs et al., 2001). ASC individuals demonstrate an ability to identify the emotional displays of others, with little difference in success rates compared to TD (Tracy et al., 2011);however, when prompted to consider why the individual felt as they did, or what could have induced that reaction, ASC individuals struggled when attributing likely scenarios that preceded complex emotions (Cassidy et al., 2014). The research in the literature would suggest that the ability to recognise emotions is not as impacted as previously believed, at least not universally among ASC individuals. However, incorporating that information into higher order tasks, such as attributing mental states or tasks requiring retrodictive mindreading (RM) where the participant is tasked with determining the scenario that preceded an emotional expression (Gallese & Goldman 1998; Goldman & Sripada 2005) results in difficulties within ASC individuals.

Some evidence suggests autistic samples and control samples can be differentiated on measures of first-order and second-order ToM tasks as well as emotion recognition tasks (Buitelaar, Van Der Wees, Swaab-Barneveld & Van Der Gaag 1999); although these group differences only appeared on collapsed composite scores. When individual measures were evaluated, group differences were only present for two of the first-order ToM tasks (concept of brain and picture sequencing) and none of the emotion recognition sub tasks. The authors concluded large effects for expression complexity and context matching expressions but noted this was similar across all participant groups. They also noted that second-order false-belief tasks differentiate the participant groups more than first-order, or emotion recognition tasks, and corroborated this with discriminant function analysis (Buitelaar et al., 1999).

To consider ToM as a key contributor to difficulties in ASC, particularly those of a social nature like emotion recognition there would be an expected relationship between ToM and emotion recognition. However as mentioned previously, first-order ToM tasks do not categorically identify those with ASC in a fail or pass manner (Baron-Cohen et al., 1985); because of this there needs to be an acknowledgement that ToM abilities may be present to a certain degree, allowing success at first-order tasks but potentially failure at second-order tasks. Such a pattern appears to be present with difficulties reported more often in second-order tasks than first (Buitelaar et al., 1999; Ozonoff et al., 1991). With second-order false-belief failure more commonly reported in ASC individuals (but not AS see Bowler 1992) it would be expected if ToM abilities were essential to emotion recognition the requirements of second-order false-belief tasks would reflect some requirements of emotion recognition tasks.

Although the work of Buitelaar and colleagues (1999) did not differentiate groups when highlighting the importance of complexity and contextual matching, these two characteristics of expressions will present some challenges that match second-order ToM tasks. For example complex emotions such as guilt, surprise, and shame require context matching and an understanding of belief in another person (e.g. for guilt they have done wrong) that is simultaneously predicated on the social expectations of that person (people expect better of them). Correct recognition of such a state requires the understanding that an individual feels the way they do because they believe other people hold a social judgement of them.

The reported ASC difficulties on emotion recognition tasks would appear to fall along two types of tasks with differing demands. On 'simpler' tasks which rely on basic expressions and label matching, the difficulties are less pronounced (Neumann et al., 2006; Rutherford & Towns 2008; Adolphs et al., 2001). However, when difficulty increases with more realistic stimuli, delivery, and task demands some difficulties are noted (Baron-Cohen et al., 2001a; Philip et al., 2010; Kennedy & Adolphs 2012a; Golan & Baron-Cohen 2006; Cassidy et al., 2015). To better understand the relationship between ToM and emotion processing these two types of tasks should be considered. In the 'simpler' tasks which less reliably show ASC difficulties there are demands such as 'label the emotion you see' (whilst correcting for guessing) which allows a direct measure of the ability to correctly recognise an emotion. However the amount of mentalizing required in completing these tasks is minimal. There is no contextual information to simulate, there is indeed nothing to simulate beyond matching the expression of the target to the self physically. This may give rise to affective feedback which aids in correct recognition but the point remains the amount of mentalizing required is quite basic. Considered from a theory-theory perspective the same can be said that the amount of information available for the model is sparse. This could lead to predictions that theoretical conclusions of the emotion would be incorrect, due to the little data available. It is also a possibility that the lack of data for a basic expression leads to little conflicting information in the model and so conclusions are easier to be made.

Contrasting the demands of the simpler tasks with those of the research which do show difficulties in ASC (Baron-Cohen et al., 2001; Philip et al., 2010; Kennedy & Adolphs 2012a; Golan & Baron-Cohen, 2006; Cassidy et al., 2015), it is clear that the amount of mentalizing or ToM required is notably increased. For example, when inferring the trustworthiness of individuals (Adolphs et al., 2001) to best complete this task one would have to recognise the emotional expression on the face and then make an attribution of behavioural intent to that person based on their emotion. Even in description it is clear this process requires the mental consideration of another perspective to predict behaviour. The same can be said for similar tasks such as the retrodictive mindreading tasks (Cassidy et al., 2015) which require the ability to understand socially appropriate responses to given situations and the eyes task (Baron-Cohen et al., 2001) where individuals are asked to infer what a person is feeling from their eyes alone. These tasks require more than the categorical ability to match physical facial features to a label; instead, success on these tasks requires the ability to determine mental states and desires from limited information.

This leads to the issue of where does ToM and emotion recognition meet? As briefly suggested when recognising basic emotions there is little mentalizing required, the amount of simulation or theory consultation employed is minimal because the amount of information presented is minimal. It is difficult to then consider ToM integral or vital to emotion recognition when the methods used reduce emotion recognition to categorical labelling. It might be for those that consider emotion recognition a more holistic process beginning with correct labelling that includes understanding of others mental states and attributing appropriate emotional states to others, that ToM is centrally ingrained in such a process. This is an important point to make because where one decides to draw the line and conclude 'emotion recognition ends at this stage' will constitute what needs to be measured; and with basic tasks the literature is increasingly showing that many people with ASC do not in fact have difficulties. A discussion is appropriate to consider the roles of emotion attribution, recognition and if these form part of one particular skill.

2.4.1.1 Emotion attribution

By placing the reaction viewed in context the task more readily allows the application of ToM, the more information available the easier it should be to assume another perspective and come to a correct conclusion as to their mental state and behaviour. So by providing context of the emotional episode the task should, in theory, be easier whilst simultaneously more realistic. However, this would only hold true if there is an intact understanding of what socially appropriate emotional displays are, i.e. what would be expected in a given situation. If this understanding of socially appropriate displays is reduced, as would appear to be the case in ASC where children do not mediate joint attention with positive affect (Kasari, Sigman, Mundy & Yirmina, 1990; Loveland & Landry 1986; Mundy, Sigman & Kasari 1990) or recognise social faux pas (Baron-Cohen et al., 1999), there are two possibilities. The added context is of no use and performance on such a task will still be below that of controls. Alternatively there is intact understanding of emotional context and ability to attribute emotional states, which may or may not present with appropriate social behaviour as a result of that correct attribution and understanding.

The social difficulties within ASC are well documented (Kasari et al., 1990; Loveland & Landry 1986; Mundy et al., 1990; Baron-Cohen et al., 1999; Dawson, Finley, Phillips, Galpert & Lewy, 1988), their prevalence prompted research to focus specifically on social attributions (Klin 2000). Yet their importance in social contexts was only recently incorporated into emotion processing tasks (Pillai et al., 2012; Cassidy et al., 2014). Such inclusions are long overdue, but provide a deeper understanding of emotion processing in the manner in which previous research intended to hold weight. By measuring attribution of emotion states to a given reaction the task assesses emotional functioning in a real world sense, rather than basic labelling.

2.4.1.2 Emotion recognition

Many of the tasks that currently exist rely solely on recognition, rather than attribution. The distinction is that to correctly recognise an expression one is only required to know the correct label for what they are seeing; such a task requires no understanding of social context or appropriateness. As mentioned this can result in individuals developing a pre-defined bank of expressions that are matched on expression appearance with no consideration to how or why that expression has been evoked. This is particularly likely in samples such as ASC where the research suggests that a high co-morbidity of Alexithymia (section 1.3.5) could result in little understanding of affective states in the self or others. Such methods with an ASC sample assumes recognition in the sense of social understanding is being assessed, in reality the task is more akin to asking individuals to discriminate between shapes. This is because many of the tasks rely on images that are devoid of social context consequentially the discrimination employed also lacks social consideration.

2.4.2 Retrodictive mindreading

The emerging research paradigm 'retrodictive mindreading' (Gallese & Goldman 1998; Goldman & Sripada 2005) tests individuals ability to discern from behaviour what series of events are likely to have caused the response viewed. This task, although simple in design, is actually a far greater test with broader implications for social skills. In order to accurately infer what happened to someone from their reaction requires the ability to; a) understand what emotional responses typically occur in a variety of social situations; and b) accurately recognise and attribute the appropriate emotion to the person. This is particularly relevant to individuals with ASC who not only exhibit FER difficulties, but also difficulty with Theory of Mind, and understanding what emotions and behaviours are appropriate to social situations (Cassidy et al., 2014; Pillai et al., 2012; 2014).

By introducing a range of complex emotions such as shyness and guilt, or emotions subject to display rules, the validity of the assessment improves. Viewing a more complex or blended expression which is more likely to be present in natural social interaction is already an improvement closer to what would be expected in real world interaction. Supplementing this with being asked to infer what caused that reaction, the task then becomes even more representative of everyday social interaction where a constantly changing environment requires a fine tuned understanding of s ocially predictable responses to a given situation. A reduced ability to match socially appropriate emotions to reactions could have serious implications for overall social ability, which is inherently separate from perceiving an emotional expression and applying a label to it. If the aim of research is to measure emotion recognition abilities there must be some inherent interest in how that information is used, if recognising emotions had no impact on behaviour there would be no need to measure the ability to do so. Recognising an emotion should only be the first step in a chain of events that should govern behaviour in a reciprocal social situation. The aim of any task should also address the understanding of social situations, not just what expression is seen. This can be achieved in the form of RM.

By incorporating RM into stimuli development, naturalistic expressions are captured in response to specific prompts and the resulting reactions are recorded covertly. Such a method allows the capture of expressions that are closer to truly spontaneous and governed by social display rules (Wagner 1990; Wagner, Lewis, Ramsay & Krediet, 1992). The expressions created are in direct response to a specific prompt, and so there is an objectively correct answer to an inherently spontaneous reaction more natural than any before. Using these expressions in an emotion recognition/understanding task means more advanced questions can be asked; Such as: 1) what event happened to cause the reaction in the video? And 2) how does the person in the video feel? This added step of emotional inference results in a task measuring beyond basic emotion matching. The emergence of this technique in recent literature is producing naturalistic expressions with good recognition rates (Cassidy et al., 2014; 2015; Pillai et al., 2012; 2014).

In the newly available assessment style, research has highlighted the importance of identifying an appropriate emotion to the situational context when trying to identify the correct antecedent cause of the reaction seen (Cassidy et al., 2014). Typically developing participants demonstrated an average increase of 26.43% in matching consistent emotions to context when they correctly recognised the causal event compared to incorrect. The increase in ability of matching emotions to causal events was larger in an ASC sample, which showed a 55.63% increase from incorrect to correct recognition of the causal event. Such an improvement demonstrates that correctly recognizing the causal event of the emotional reaction has an effect on the perceived emotional state of the individual. This research suggests understanding what could cause an emotional reaction influences correct recognition of appropriate emotional states; when paired, these abilities could inform the responses in reciprocal social interaction.

The importance of the RM method becomes apparent when considering that ASC individuals can distinguish between basic emotions (with varying competency), but do not necessarily acknowledge or respond appropriately to others emotions compared to controls or children with a learning disability (Sigman, Kasari, Kwon & Yirmiya 1992). In a study designed to observe ASC children's responses to an adult displaying emotions during play, the ASC children showed physiological acknowledgment of the emotion expressions from the adults (distress, fear and discomfort). However in response to the emotion the children failed to physically attend to the adult, and rarely ceased play to investigate further. The issue then is that ASC individuals have a basic catalogue of emotion labels, but this is not complimented with semantic information of what those expressions mean, or how they should be responded to.

What appears to be the case is that individuals with ASC, particularly HFA individuals who have well learned compensatory responses, are able to list a range of basic emotions and some complex given more time and prompts. When prompted to give examples of what would cause such emotions, clear difficulties emerge and there appears to be a semantic gap between the emotional categories and what those emotions serve in individuals, the affective change they bring about, and any associated behavioural changes. Further, the tendency for the ASC children to not orientate to the source of expressions, (Sigman et al., 1992) means they miss vital information relevant to what may have caused that reaction initially. Similar perceptual pattern difficulties exist with ASC individuals opting to pay more attention to the physical details of an image, such as the proximity of characters, objects in view and colours rather than the emotionally primed content that the individuals are close friends playing together (Bauminger & Schulman 2001). Employing the RM method tests the ability of ASC individuals to effectively use the information available in deciphering likely social events that preceded the event. ASC individuals who do not frequently engage others emotions, should in theory perform worse on a RM task, and so the method can be considered a greater test of social skills rather than simple emotion labelling.

2.5 Introduction to Methods in FER Research

The measures and techniques used to assess emotion recognition competency are often based upon the ability to assign a standard expression to a given display. This method is somewhat basic as it removes the social context from emotion recognition and requires individuals to simply identify the expression rather than understand it. This is particularly true considering research suggests the ability to process emotions is related to social functioning (Hooker & Park 2002) and social judgements (Adolphs et al., 2001). Such methods that lack elements of social understanding may have unfounded implications of difficulties in certain populations, or at least question the basis of those claims in relation to what performance would be under more valid circumstances. One such example is the mixed results in the literature surrounding emotion processing competencies in individuals with ASC discussed briefly in chapter 1; the inconsistencies suggest there is a need to re-evaluate the methods employed. Particular attention should be paid to the stimuli itself, questioning if it accurately portrays a range of emotions broad and complex enough to be accepted as a test of emotion processing competency that is valid. The delivery methods of the stimuli currently active in the literature need to be evaluated considering if these could be improved to be more representative of naturalistic expressions. Finally there should be consideration of the tasks administered and if they effectively measure engagement and understanding of the emotional information available beyond label based recognition.

Currently multiple stimuli sets exist to assess emotion recognition competency such as the AR face database (Martinez & Benavente 1998), the NimStim face set (Tottenham et al., 2009), UC Davis set of emotion expressions (UCDSEE) (Tracy, Robins & Schriber, 2009), the gold standard; Pictures of facial affect (POFA) (Ekman & Friesen 1976), and the later revised Japanese and Caucasian Facial Expressions of Emotion (JACFEE) (Matsumoto & Ekman 1988). These stimuli sets, with the exception of the UCDSEE, focus primarily on expressions of the basic six emotions (happiness, surprise, sadness, fear, disgust and anger) found to be universally presented and recognised across cultures (Ekman & Keltner 1970; Ekman & Friesen 1971). Both the NimStim and JACFEE include all six of the basic emotions captured, from a multiracial participant group, to ensure recognition validity across a range of ethnicities. One of the larger stimuli sets that covers both the basic and complex expressions is the Cambridge mindreading face-voice battery (Golan, Baron-Cohen & Hill, 2006; Baron-Cohen, Golan, Wheelwright, & Hill 2004; Baron-Cohen, Hill, Golan & Wheelwright 2002). The mindreading face-voice battery includes 412 different emotions, each with six different displays and verbal responses enacted by a wide range of actors/displayers from male to female, young to old and multiple ethnicities. Aside from these large validated stimuli sets, research has designed smaller sets of stimuli for specific purposes; some examples include variation in presentation rate of dynamic stimuli (Tardif, Lainé, Rodriguez & Gepner 2007), the ability to match static and dynamic emotion expressions (Gepner et al., 2001) and investigating the multi-modal delivery of emotion expressions (Loveland et al., 1997). The differing avenues of research being employed, each addressing potential variables in stimuli type and delivery method that could influence recognition, demonstrate the need for a stimuli set more advanced than those currently being used in the literature. Ultimately the literature (until some of the most recent work Pillai et al., 2012; 2014; Cassidy et al., 2014; 2015) has neglected to address these issues with serious concern as to how they may affect performance in recognition, the very purpose of their creation.

The remainder of this chapter will address aspects of the stimuli and methods currently in use in the literature highlighting the need for the creation of a stimulus set that addresses these key issues:

I. The stimuli need to be social, elicited in response to a social situation under conditions as natural as possible to ensure spontaneity.

II. The stimuli should be presented in a manner that reflects how social skills have developed, in response to real-time dynamic expressions.

III. Expressions should be open to variations in complexity, referring to the expression types available beyond the basic six.

IV. Similar to dynamic delivery and complexity the expressions should be multi-modal in their information streams; they should incorporate visual information, auditory information and allow enough context for body posture and language to be incorporated.

V. The method of assessment should address correct understanding of socially appropriate responses as well as recognition, to separate the assumption that perceiving a display and being able to label it correlates with understanding of the emotional content.

2.6 Expression Creation and Delivery

This section will specifically address the creation and delivery of emotion expressions in research. This is because the task used to assess emotion recognition should be as close as possible to emotion recognition in a real world setting. Some of the issues most important are how the expressions used in the task are created, do they manifest naturally like they would in typical social interaction? And does this natural manifestation effect recognition? Alongside the creation of the expressions, how these are displayed to participants in the task is also an important factor; is the expression displayed within context? Or is it presented as a standalone piece of information? These issues will be addressed in following sections.

2.6.1 Spontaneously evoked and posed expressions

Research involving spontaneous reactions does not come to a clear definition to differentiate posed from spontaneous, not until Matsumoto and colleagues (2009a; 2009b) where a clear definition outlined that spontaneous expressions are not produced in response to a direct request like posed. Until this work a definition is distinctly absent mostly implied that such a distinction should be obvious, differentiating "*posed*" and "*evoked*" (Gur et al., 2002) or between "*felt*" and "*unfelt*" emotions (Gosselin, Kirouac & Dore, 1995). In the effort for clarity a definition will attempt to be deduced from the method of elicitation used, the distinction between *posed* and *evoked* is that something (a memory or event) is the catalyst for an emotional change when *evoked*, but when *posed* there is no such internal change. Whilst *felt* and *unfelt* is clear, suggesting a change of internal affect should be present. What has been deduced from these two classifications then is a similar approximation of natural expressions, albeit if not spontaneous. A natural expression should be the result of some external catalyst and should result in some change of emotional state.

Outlining such a distinction is important because spontaneously evoked expressions can hold multiple root causes, which posed expressions are not likely to effectively capture in their creation. This could result in a singular expression of higher signal clarity (Signal clarity concerns the emotional content available and how readily recognisable it is) from posed than evoked expressions (Matsumoto et al., 2009a). Ekman and Friesen (1976) alluded to this highlighting the multifaceted use of the basic emotions in different situations across cultures; the smile is typically an indicator of happiness, but can also be used as a mask in situations of embarrassment or politeness. Creating stimuli of posed expressions, particularly basic expressions, does not address the way emotions manifest in typical social situations. A higher quality dynamic delivery will provide more information surrounding the elicitation of the smile showing it to be a far more complex mixture of emotions. The difference between posed and naturally evoked expressions could ultimately result in an entirely different emotional categorisation.

2.6.1.1 When is an emotion reaction spontaneous?

To come to a definition of a spontaneous emotion reaction, it might be easier to first define a posed emotion. This definition will vary according to the theoretical stance of how emotions come about, those aligning with the Darwin-Ekman stance will view emotions as evolutionary adaptive constructs that served behaviourally practical benefits but came to be exaggerated and communicative over time. The Darwin-Ekman stance is strongly underpinned by universality in presentation and recognition of basic natural kinds, thus it would be expected that any emotional change would fall into one of the six identified basic expressions (happiness, sadness, anger, fear, surprise, disgust). Two things are worth noting from this; an emotion should comprise some shift in affect towards one of the identified basic expressions and being behaviourally adaptive, the shift should be attributable to some external influence; this is due to the origins of emotions in evolutionary terms where changes in facial expressions are thought to be in response to the environment. By contrast those that align with a constructed view of emotions would consider emotions to be a product of a change in core affect and a subsequent categorization of the brain trying to make sense of instances where allostasis was not adequately maintained. Importantly, it is clear both of these views of emotion require a change in response to something.

The points above illustrate that regardless of the theoretical stance on emotions, there is agreement that emotions manifest as an anticipation of, or response to, external stimuli/events. The methods with which posed expressions are usually created involve asking individuals to match their faces to prototypical expressions (Ekman 1993; Beaupré, Cheung & Hess 2000; Tracy et al., 2009) often with coaching for specific AU activity (Ekman & Friesen 1978). Under these methods, posed expressions are not re-creating emotions *per se*, they recreate physical changes that are associated with emotions. As a result, posed expressions do not result from a change in affect and are only in response to a request. The request may serve as an external influence but if this were true, the instruction to raise the lip for example, is affectively no different from an instruction to widen the eyes. These two instructions are unlikely to produce an affective change; if they do it is unlikely to produce different affective change from each other. Therefore in extrapolation from a definition of what traits posed expressions contain it can be deduced that spontaneous emotion responses should rely on affective change that is linked to external events; this premise is at the core of theories attempting to explain emotions.

2.6.1.2 Methods of evoking emotion expressions

Of the previous methods that have been used in an attempt to capture naturalistic expressions, many have been subject to limitations. In some cases, individuals are asked to re-live a past memory with strong emotional ties (Gosselin et al., 1995; Gur et al., 2002). Consulting our previous definitions as exclusion criteria, we can agree that reliving a memory will most likely result in a change in affect. Being asked to do so is artificial and so falls short of our criteria of natural and spontaneous. There are also issues around the accuracy of those expressions; for example, memories are often re-appraised over time (Ellsworth, 1991); meaning the original classification of the event could have changed. In this way, something that was once considered an extreme cause for distress, could be reconsidered and viewed positively as a challenge. This changing of the valence of the emotional memory could potentially alter the portrayal of the expression. Re-living a memory relies on the assumption the expression produced will result in the same emotional content of the initial expression, which is not guaranteed if re-appraisal has occurred. Similarly it requires the physical production is representative of spontaneous emotions as they occurred in real time amplitudes, duration and intensity.

Other attempted methods have captured real time spontaneous reactions to images or video cues (Lang, Bradley & Cuthbert, 2008; Valstar & Pantic, 2010). These expressions would meet the criteria to be considered spontaneous; the emotion reactions are not directly requested and arise in response to some stimulus, likely bringing about some change in affect. However, given that the purpose of emotional facial expressions is partly to display social information to others (Shariff & Tracy 2011), there is doubt that expressions gathered under isolated non-social conditions are representative of those in social interaction (Schmidt, Cohn & Tian, 2003). When attempting to create expressions we must consider spontaneity relative to posed but also the naturalness of those expressions relative to truly typical. By truly typical it is meant their closeness to what we would expect to encounter in a typical day to day interaction.

The demand for more representative expressions has resulted in research attempting to develop stimuli of naturally evoked expressions. Considering the previously discussed research monitoring the development of spontaneous smiles in social interaction and isolation (Schmidt et al., 2003), there are concerns to the validity of the smiles generated in both conditions; in the interview condition participants were aware of their recorded reactions and were also under instruction to actively deceive the interviewer. The instructions to actively deceive the interviewer are likely to have produced smiles lower in ecological validity than those produced under a natural interview setting. During the isolated condition the individuals recruited for the research were part of an experiment investigating risk of depression. There is research suggesting expression evocation during depression can be atypical (Berenbaum & Oltmanns 1992; Rottenberg & Vaughan 2008). Analysing expressions presented by individuals who may have depressive traits or diagnoses of depression and comparing these to a separate group of individuals without such traits, prompts questions regarding the validity of the results being due to situational context or group differences.

The comparisons of posed to evoked expressions and questions surrounding the efficacy of using posed expressions has resulted in research attempting to create evoked expressions to more accurately measure expression recognition competency. Certain designs such as Wagner, MacDonald and Manstead (1986) and earlier work from buck and colleagues (1972; 1978) attempted to create spontaneous expressions in individuals using emotionally loaded stimuli and covertly recording the expressions. The method of recognition used in these studies is commendable, tasking individuals that viewed the emotional expressions to feedback what slide the individual was seeing. Such a task is similar in design to the RM tasks where the response of the individual is used to retrodict what scenario is likely to have caused the expression (Gallese & Goldman 1998; Goldman & Sripada 2005). The method of expression evocation employed is still subject to scrutiny; the participants used to evoke emotions viewed static images of varying scenes to elicit expressions (Wagner et al., 1986).

Further Attempts at producing evoked expressions have tasked individuals to try and relive memories that are congruent to the expression required (Gur et al., 2002; Gosselin et al., 1995).This method is designed to more accurately reflect emotion expressions whilst still maintaining experimental control. While this technique is a marked improvement to relying on solely posed expressions, it still applies a reductionist view to the production and defining of an evoked expression. This is because reliving a memory is an entirely new event from when the memory occurred, this can lead to distinctly different reactions; asking someone to reflect on their late spouse is just as likely to elicit happiness as they revisit memories of their time together as it is to produce sadness. More likely is some amalgamation of the two will appear but this is still an entirely different reaction from the intended emotion of grief. Reliving memories as a method to evoke emotions would be okay if the captured emotion was accurately labelled and classified upon reliving, but it appears the method specifically aimed to coax distinct emotions from memories assuming they would be relived in the same way as initially experienced. It is worth noting that controls were employed such as autonomic measures and mood readings, so it is likely the emotions evoked affectively achieve what was aimed, but there is still concern if these emotions manifest in the way they would upon initial experiencing.

Expanding on the point above, there is a further confounding variable in the likelihood that the emotion requested can be recalled to a contextually acceptable degree even if the original categorical recollection is appropriate. For example depending on the context of the request, individuals may be asked to relive an experience that made them angry. This would most likely result in the production of the correct affective response but its accuracy is entirely open to the individual due to which type of memory to recall. There are undoubtedly varying levels of intensity within the same emotion category (Fujita, Diener & Sandvik 1991), these are influenced by sex (Diener, Sandvik & Larsen, 1985) and age (Diener, Sandvik & Larsen 1985; Fujita, Diener & Sandvik 1991). As mentioned previously this would be less problematic if the stimuli were presented with full context of evocation method. E.G. "has this person just relived experience X?" rather than "has this person just relived a memory that once made them angry?" This distinction is small but significant; the context of the specific memory relived would prove a particularly novel task and arguably engage ToM abilities to a higher degree, forcing the participant to consider that perceptions of specific memories can change over time. Of course this is only possible if the emotions are presented as relived expressions rather than as current expressions.

By asking individuals to retrieve emotional memories related to a target emotion, there is room for discrepancy between the emotion desired and the memory used to retrieve it. Such discrepancy could lead to individuals retrieving memories of a lower or higher intensity than desired with some research suggesting the kind of memories people are likely to retrieve (those important to their life) are higher in intensity (Talarico, LaBar & Rubin 2004). With inconclusive findings surrounding emotional events improving or hampering recall (see Christianson 1992) there are once again validity issues with this method of emotion evocation. There is little control to mediate the appropriate level of intensity of emotion recalled to aid in expression evocation, this is ultimately due to the subjective nature of affect; what may make one person angry, can make another laugh. Resultantly conveying the correct affective state desired and having the actor relive a memory of the correct intensity is restrictively complex. Ultimately the method of recalling memories associated with emotions preselects a range of emotions far higher in intensity than would be expected of typical day to day emotion evocation, this is due to typical day to day events not likely intense enough to form long lasting memories where recollection would be necessary.

The issues raised around intensity may seem trivial, after all the drive for spontaneous methods proposed in this thesis by capturing real time emotions at the moment of experience allow no control over how intense each individual expression might be. However, there is consistency in the event that is used to illicit said emotion, which allows more control than reliving expressions which can leave the range of memories available skewed towards more intense instances. The question then is what do relived expressions add that spontaneously evoked expressions can't achieve? It would appear very little; in the context of the studies mentioned the reliving was not framed as a relived expression when viewed by participants, it was a method used to achieve spontaneous expressions of target emotions. Their application in a RM task as discussed might pose new and novel questions forcing consideration that perceptions of events can change over time, but this specific ability is beyond the scope of real time recognition as discussed in this thesis.

By opting to use posed stimuli of the basic emotional expressions as a measure of emotion processing competency, the rigour of the assessment is drawn into question. Failing to accurately replicate the array and complexity of emotional stimuli that would be on display in typical social environments means many of the current stimuli and methods employed lack validity in a capacity that holistically assesses emotion recognition. More accurate would be to consider a level of basic emotional processing has been established and further tests could be used with stimuli of a higher complexity to expand upon this. Similarly there is room for developments in the range of spontaneously evoked stimuli that exist, particularly in the advancement of stimuli that demonstrate expressions more accurately reflecting day to day expressions produced at the volition of the individual.

2.6.1.3 Presentation differences between spontaneous and posed expressions

Whilst the critiques of previous spontaneous stimuli sets are outlined here and the case is made for greater validity, is there currently any research to suggest expressions captured spontaneously differ from those posed? Most well researched are the differences of posed and genuine smiles, with evidence of less muscular contraction around the eyes for posed smiles (Dibekglioğlu, Salah and Gevers, 2012; Dibeklioğlu, Valenti, Salah and Gevers, 2010), in tandem with more accelerated eyelid movement in posed smiles and overall shorter expressions in posed smiles (Dibeklioğlu et al., 2010). With differences in display patterns, is there any evidence that expressions produced upon request may contain less social information than those that occur naturally in social interaction? The inherent socially communicative nature of expressions leaves them open to display rules (Wagner 1990; Wagner et al., 1992) an accepted social filter that informs what expressions are socially appropriate. Display rules dictate how we might portray a certain emotional response; for example, pretending to portray happiness upon receiving an unwanted gift, the true emotion is likely one of disappointment but display rules would require this response be concealed with a masking emotion of happiness/gratitude. This lack of social filters in posed expressions suggests there is less communicative information in posed expressions than spontaneous as a result the expressions created are narrow and do not contain the depth that display rules provide.

Traditionally, research has shown better recognition of posed expressions (Ekman & Friesen 1982) with recognition levels mostly at chance for 'genuine' emotions (for the purposes of this work spontaneous expressions are considered genuine, there are undoubtedly non-genuine spontaneous emotions this will be discussed briefly in the later paragraphs but is primarily beyond the focus of this work) (Manstead, Wagner & MacDonald, 1986; Motley & Camden, 1988). By genuine and non-genuine emotions it is meant expressions that convey the true internal state are genuine, those that do not are non-genuine (sometimes referred to as deceptive and unfelt). The previously discussed display rules underpin this idea that expressions are frequently shown that do not match the internal state. If the claim is that posed expressions do not convey the information that would be in spontaneous expressions (genuine or non-genuine) we should expect to see differences in the production of those expressions and subsequent recognition of posed and spontaneous expressions.

Early work quantifying differences in expressions of posed compared to spontaneously evoked expressions have demonstrated subtle differences in facial muscle action (Cohn & Schmidt 2004; Valstar, Pantic, Ambadar & Cohn 2006). Spontaneous smiles appear to be lower in amplitude (intensity in associated facial regions), longer in duration and have delayed onset and offset times when compared to posed smiles (Cohn & Schmidt 2004). Findings also demonstrate altered brow activity in spontaneous expressions, displaying altered intensity, duration and the action units appear in altered occurrence when compared to posed expressions (Valstar et al., 2006). Analysis of recognition of spontaneous expressions in medal winners at the Athens Olympic games (Matsumoto et al., 2009a) found no evidence to support the phenomenon of ingroup advantage recognition (where individuals are more likely to correctly identify emotions presented by individuals of the same ethnicity as themselves) reported in posed expressions (Elfenbein & Ambady 2002). This finding implicates the difference between spontaneous and posed expression production with posed expressions being subject to 'cultural dialects' (Elfenbein, Beaupré, Lévesque & Hess, 2007). The cultural dialects are permutations exclusive to specific ethnicities which allow more effective recognition within cultures than across (Elfenbein et al., 2007). The failure to replicate this effect in spontaneous expressions (Matsumoto et al., 2009a) suggests evoked expressions supersede posed in their production urgency and are likely to have less social filtering applied considering subtle cultural dialects are omitted.

The subtle distinctions between posed and spontaneous expressions outlined above appears to impact the overall authenticity of posed expressions where previous research has demonstrated the production of posed expressions, even those of professionally trained actors, are not representative of those expected by natural expressions (Caroll & Russell 1997). More subtle aspects of the stimuli may also vary between posed and natural expressions, one such potential factor is the length of the stimuli, with varying lengths possibly compromising the recognisability of the stimuli (Cassidy et al., 2015). Previous research has attempted to address this by limiting the exposure time of stimuli more in line with that which would be expected in natural expressions (Kirouac & Doré 1984). This is problematic when considering the rate of expression development could vary across posed and naturally evoked expressions. The lack of research investigating expression development over time, particularly regarding posed stimuli compared to spontaneous, questions how effective a solution it is to simply cap expression viewing time to shorter intervals. This approach assumes expression formation and dissipation is uniform when spontaneous or posed but research has shown this not to be the case (Cohn & Schmidt 2004) and is simply likely to result in expressions being cut short.

When tasked with identifying non-genuine emotions (where an actor displays an emotion contrary to their internal state) participants showed particularly poor discrimination between posed and genuine emotions (Hess & Blairy 2001; Naab & Russell 2007; Ekman & Friesen, 1974; Ekman & O'Sullivan 1991; Manstead et al., 1986) and a bias towards rating expressions as authentic (Zuckerman, Koestner, Colella & Alton, 1984). Such a bias may be because the non-genuine/posed expressions are of a high quality that accurately replicates natural expressions. But the previous research shows this is not the case with noticeable differences (Dibeklioğlu et al., 2012; Dibeklioğlu et al., 2010; Ekman, Davidson, & Friesen, 1990; Valstar et al., 2006; Williams et al., 2001). But if there are clear observable differences between posed and spontaneous (genuine and non-genuine) emotions, a bias towards rating expressions as spontaneous (genuine) may be more due to a social requirement than lack of perceptive ability. A possible reason for such a pattern could be the social ramifications for stating distrust of others emotions may be far more severe than any manipulation incurred for being 'duped'.

2.6.1.4 Summary of spontaneous and posed expressions

The definition of posed expressions included in this work is that any expression produced upon request is posed, any other displayed change in affect would be considered spontaneous. There is also a distinction between felt (genuine) and unfelt (non-genuine) expressions. For example trying to hide frustration in response to a rude comment, the expression may be one of happiness but this is non-genuine. In the given example the non-genuine happiness is posed at the volition of the displayer, in the context of this thesis such an expression would still be considered spontaneous as it has occurred naturally in social interchange. The example given above is designed to highlight the complexity of posed and spontaneous distinctions as even spontaneous expressions can be non-genuine designed to hide affective states. The distinction between posed and spontaneous expressions has been validated with evidence of altered display styles, amplitudes and onset/offset times (Cohn & Schmidt 2004; Valstar et al., 2006). These differences appear to translate into recognition rates with improved recognition of posed expressions (Ekman & Friesen 1982), however as this chapter addresses such results are based on stimuli sets that do not accurately recreate spontaneous expressions. This section has made clear the observable differences in posed and spontaneous expressions production and display. It is paramount that these differences are reflected in the stimuli used to assess FER competency; particularly in populations with suspected difficulties.

2.6.2 Static and dynamic display

Research specifically comparing the use of dynamic stimuli vs static stimuli when recognising emotions in an ASC sample, showed that recognition was significantly improved for static images compared to dynamic, when the stimuli was less complex and towards a single end of the valence spectrum (Cassidy et al., 2015). Whilst recognition of genuine vs feigned positive shifts of expression was improved for static relative to dynamic stimuli, recognition of the emotion blend of smiling and confusion was significantly less accurate in the static compared to the dynamic condition. The finding of a complex emotion such as blended smiling and confusion being better recognised via dynamic delivery is more likely due to the nature of the expression rather than dynamic stimuli being easier to interpret. This can be explained in the manner of the expression, the mixture of happiness and confusion is unlikely to be presented in even proportions at any one static point of the expression. Therefore the static condition conveys less information and is likely conveying either more of happiness or confusion and so is categorised that way. The results highlight the need for dynamic expressions in instances where the expression is more complex, isolating a single frame is not representative of the emotion label (Cassidy et al., 2015.)

Much like the work from Cassidy and colleagues (2015) research shows ASC individuals may struggle processing dynamic stimuli suggesting that interpreting dynamic stimuli is a considerably harder task than interpreting static ones (Gepner & Feron 2009). However early findings demonstrate improved emotion recognition in intellectually disabled individuals from dynamic stimuli compared to static (Harwood, Hall & Shinkfield 1999). Similar findings from low functioning ASC individuals suggest a slow presentation of dynamic stimuli to be the most beneficial to FER (Gepner et al., 2001). Somewhat similar is the evidence that in ASC individuals mental state inferences to dynamic expressions showed a mild non-significant improvement, suggesting that the increased social information is not a hindrance to those with ASC (Back, Ropar & Mitchell 2007). Conversely, recognition of complex emotions (e.g. guilt, shame, pride) is improved in static stimuli compared to dynamic (Roeyers, Buysse, Ponnet & Pichal 2001). Although this difficulty in dynamic recognition is complex, with evidence of improved anger recognition from dynamic displays compared to static but decreased sadness recognition suggest the individual expressions may each have optimum delivery methods and intensities (Enticott et al., 2014).

The mixed results highlight that the difficulties are complex and likely unique to the type of stimuli viewed, with prototypical emotion recognition showing a general improvement (Harwood et al., 1999; Gepner et al., 2001; Enticott et al., 2014), but difficulties appear for recognition of some complex emotions (Roeyers et al., 2001; Back et al., 2007). The differences in static and dynamic stimuli extends to the visual perusal patterns employed, with analysis of eye tracking data outlining differences in gaze direction to dynamic but not static stimuli (Speer et al., 2007) which may account for haphazard improvements, due to altered visual perusal and the differing regions of interest across emotion expression and valence.

2.6.2.1 Summary of static and dynamic presentation

The effects of differing stimuli delivery methods on emotion processing demonstrates that for complex blended emotions, there is a need for these stimuli to be displayed in a more holistic natural manner. When complex emotions are delivered via static images, it assumes the emotional expression is a uniform process with the blend of emotions showing equal clarity at any given moment. In reality the expressions of emotions are fluid and initial smiles and perceived happiness can morph into confusion or hesitance (Cassidy et al., 2015). By presenting a complex blended emotion in a static manner, the stimuli do not accurately reflect the emotion as it is elicited. It may be that complex emotions are series of shorter expressions that collectively form an overall episode. Research typically opts to isolate the point at which the expression appears most intense and uses this as an indicative emotional expression. By selecting the frame at which the expression appears most intense, tests of recognition provide a far easier task than displaying a dynamic delivery of the emotion inception to termination. This is particularly true of basic expressions, whereas the difficulty of interpreting complex emotions is more than likely aided by the extra contextual information dynamic stimuli provides compared to static images (Cassidy et al., 2015; Ambadar, Schooler & Cohn 2005). This in turn means the expressions used are too intense to be displayed in a static manner for a prolonged period of time and still be considered an effective measure of emotion recognition competency. This effect is compounded when the stimuli is used in a population of individuals with ASC, where the results surrounding FER competencies are conflicting.

Providing a task easier than typical everyday social emotional presentation serves no purpose for measuring an individual's competencies and instead provides a glass floor by not fully engaging any difficulties which may or may not be present resulting in an inflated performance of emotion processing due to testing via ill equipped measures. On the contrary as demonstrated in Cassidy and colleagues work (2015), the extra contextual information may also aid FER for complex expressions. This suggests for tasks that include complex expressions but do not present the expressions in dynamic multi-modal formats the opportunities for correct recognition are artificially reduced.

2.7 Expression Complexity in FER Research

Complexity in research is an open term and can refer to multiple factors, it can mean the type of expression shown, if it is one of the universal basic six or expressions defined as 'complex'. Complexity can also be used to differentiate the amount of information available in the expression if this is delivered over multiple modalities; this section will address differing levels of complexity in the literature both in expression types and the amount of information available.

2.7.1 Expression types

2.7.1.1 Basic expressions

The stimuli in the literature includes some, if not all of the basic expressions (happiness, sadness, anger, fear, disgust, surprise) with mixed results in emotion processing competencies, particularly in ASC populations (Martinez & Benavente 1998; Matsumoto & Ekman 1988; Tracy et al., 2009; Ashwin et al., 2006; Bal et al., 2010; Teunisse & De Gelder 2001). More recent developments have begun to include emotions outside of the basic six (Tracy et al., 2009; Pillai et al., 2013; 2014; Cassidy et al., 2014). The classification of 'basic' and 'complex' emotions is convoluted, but what can be agreed is the basic six expressions are widely accepted as the foundational emotional responses and this is supported with cross cultural evidence (Ekman & Keltner 1970; Ekman & Friesen 1971).

2.7.1.2 Complex expressions

Classifying complex emotions is more ambiguous, indeed there have been calls from Ekman that the basic six expressions should be expanded to sixteen (Ekman 1999); which highlights the need for a classification system outside of the basic six. The distinction for the purposes of this work is that basic emotions are reactionary responses that can vary in intensity but are often not tempered according to social or cognitive appraisal. Complex emotions however, are belief based (Harris 1989), concerning reflection of the change in affect in response to a situation. Complex emotions can also be social in their roots (e.g. guilt, shame, pride) (Kasari, Chamberlain & Bauminger 2001) leading to a mental state change (Baron-Cohen et al., 1996; Griffiths 1997).

Interesting research has demonstrated complex expressions in the form of mental states can attract a broad range of identifications (Back & Jordan 2014), questioning the method that using a proportion of responses to a predefined mental state as a 'correct' measure may be potentially simplifying the process of identification. Just as important a result was the finding that on repeat presentation, raters occasionally attributed different words to the same stimulus; Back and Jordan (2014) hypothesized this may be due to the preceding stimuli and individual differences in their label use. This has important implications, it suggests that individuals' perceptions of mental states are not bound by a rigid classification system but are more fluid in response to their own mental state. One explanation for this is that the subtlety of mental states in realistic social interchange requires more information from less overt ques such as voice pitch, body pose, gestures and contextual information. This is in line with the findings of Jones and colleagues (2011) which demonstrated other sources of information such as verbal and non-verbal vocal expressions explained larger variance in emotion recognition than visual input.

Evidence suggests the eye region holds important information for identifying complex emotions and mental states (Baron-Cohen, Wheelwright & Joliffe 1997; Baron-Cohen et al., 2001) particularly within dynamic expressions (Back, Jordan & Thomas 2009). There are difficulties recognising complex social situations not specifically limited to visual perception, with evidence of reduced understanding of social faux pas, irony and sarcasm in descriptions of social situations in ASC (Happé 1994; Baron-Cohen et al., 1999). As complex emotions include aspects of mental states of the individuals in relation to context, and that these are often based in social interchanges or contexts, E.G. "this person is friendly" or "I shouldn't have worn this I feel embarrassed" there is once again the need to highlight the importance of spontaneous natural emotions that can capture this degree of complexity. Posed expressions tend to lack the self-regulating social filter of display rules (see section 2.6.1.3), where the internal felt emotion may not match the externally displayed one, it is then also possible they may not accurately portray complex expressions which are based in appraisal of context often socially based.

2.7.1.3 Mixed and blended expressions

Complex emotions can also frequently be blends of two or more basic emotions (Humphreys et al., 2006; Hoque & Picard 2011), which may not accurately convey the emotional state of the individual when shown via static image. Regarding complex emotions and the potential of blending or combining of basic emotions, Ellsworth (1991) notes that often the transition from one emotion to another is due to a reappraisal, where the root cause of the emotion has been altered. This reappraisal poses the question that when emotions shift is it merely a change from one basic emotion to another or is the emotional episode as a whole experienced as a complex emotion? To present isolated stimuli of an individual pre and post reappraisal would most likely result in two completely different emotion labels, but presentation of the entire episode would display the emotional transition and provide overall greater context. Another consideration is that expressions can, and do, appear simultaneously when blended (Hoque & Picard 2011); presenting such an instance via a static image may not provide the signal clarity required for recognition. Well standardised stimuli sets such as the POFA and JACFEE have high signal clarity in their expressions (Ekman & Friesen 1976; Matsumoto & Ekman 1988) this is partly because the nature in which the JACFEE and POFA stimuli were designed allows for higher signal clarity with coaching and posing of expressions. More natural stimuli sets developed through spontaneous methods do not allow for coaching of expressions to achieve higher signal clarity. This may result in more ambiguous expressions but these are likely a truer representation of social interchange.

2.6.1.4 Summary of expression complexity

The stimuli in use in the literature has been a consistent majority of static basic expressions (Hobson 1986; Braverman, Fein, Lucci & Waterhouse, 1989; Macdonald et al., 1989; Tantam, Monaghan, Nicholson & Stirling, 1989; Prior & Hoffmann 1990; Fein, Lucci, Braverman & Waterhouse, 1992 Adolphs et al., 2001; Loveland, Steinberg, Pearson, Mansour, & Reddoch, 2008; Neumann et al., 2006; Ogai et al., 2003; Rutherford & Towns, 2008; Spezio et al., 2007). The presence of complex expressions is more limited (Baron-Cohen et al., 1997; Baron-Cohen et al., 2001; Happé 1994; Baron-Cohen et al., 1999; Tracy et al., 2009) but more recent studies have incorporated better methods that are more likely to effectively capture and display these expressions (Pillai et al., 2013; 2014; Cassidy et al., 2014). The inclusion of mixed and blended expressions is more a type of complex expressions and may actually be a series of complex expressions in rapid succession that come about when processing an event. In summary natural emotion expressions appear in far more variety than the basic six. Whilst the basic six are a good universally recognised starting point in assessment, the field should be aiming to better recreate the type of expressions that would be expected in typical social interaction.

2.7.2 Unimodal vs multimodal delivery

Complexity, not only a variable in the emotional content available in expressions, can also be expanded to the method of stimuli delivery and the amount of social data available. Delivering static images can be considered to be less complex than dynamic; similarly, stimuli with no audio input can be considered less complex than stimuli with visual input and auditory input. It is worth note at this point to clarify that complexity does not equate to difficulty in recognition, complexity concerns the amount of social data available, if this data is subtle or overt and if it is expressed in multiple modalities. It is possible that more complex stimuli are more difficult to correctly identify, but for the sake of clarity, complexity in this instance relates to the delivery and content of the stimuli. A unique design by Jones et al., (2011) conducted a factor analysis of individual emotion recognition across modalities (facial expression/visual, verbal vocal expression/auditory and non-verbal vocal expressions/auditory). Their findings demonstrated across all six basic expressions that facial expressions (i.e. visual input) never occurred as the strongest factor loading to recognition. For every emotion either verbal vocal expressions or non-verbal vocal expressions were a stronger contributor to emotion recognition than visual input. An example of their factor analysis loading is shown below in figure 2.2.

Figure 2.2: *Six-factor (happiness, sadness, fear, anger, surprise and disgust) emotion recognition model of 3 emotion modalities (facial expressions, verbal and non-verbal) taken from Jones* et al., *(2011)*

The work by Jones and colleagues (2011) outlines the importance of the multimodal nature of emotion expression and the pitfalls of omitting other modalities than visual input. The limited amount of research that has investigated vocal expression recognition in ASC has demonstrated difficulties also exist in this modality (Lindner & Rosén 2006; Mazefsky & Oswald 2007). Although the difficulties appear to exist simultaneously across modalities evidence suggests the multimodal nature of emotion processing is underpinned by a general processing ability which would be better addressed by a higher quality stimuli set of multiple modalities (Borod et al., 2000).

This shift towards the complex side of emotion expressions more accurately reflects the nuanced nature of emotion expression and should be continued in future research attempting to measure emotion processing competency. Tracy and colleagues (2009) included alongside the basic six emotions the complex emotions embarrassment, pride and shame. The inclusion of a broader range of stimuli with dynamic delivery is equally important for research involving individuals with ASC, where the reported competencies are inconsistent, and appear sensitive to variations in stimuli complexity (Dalton et al., 2005; Macdonald et al., 1989; Baron-Cohen et al., 1997; Homer & Rutherford 2008). This development towards more realistic and complex emotional stimuli has expanded to the delivery method, where research is now including the use of dynamic stimuli as well as static, to more accurately measure emotion processing competency (Rump, Giovannelli, Minshew & Strauss, 2009; Pillai et al., 2012; 2014: Cassidy et al., 2014).

2.7.3 Validity and specificity

The points made thus far in sections 2.6 and 2.7 have highlighted the importance of the stimuli type, the expression type (basic, complex or blended), delivery style and modality. The stance in this work is that methods and tasks moving closer towards ecological validity allow a more complete assessment of abilities as they would be used in everyday interactions. However, it is important to acknowledge that with improved validity there is a cost of specificity. When more information is included in a task and its complexity (or validity) increases to better reflect typical social interaction, the amount of control afforded is decreased. This is problematic because through increasing validity one might get a better assessment of abilities, but it becomes increasingly harder to identify exactly *what* has been assessed.

Because of this delicate balance between validity and specificity, psychometric instruments often focus on very specific areas, Intelligence quotient (IQ) tests for example have low ecological validity with many of their sub-measures seemingly alien to everyday life, but they have particularly high construct-specificity. In this particular example the high specificity at the cost of ecological validity is beneficial because it allows IQ tests to be somewhat more generalizable across cultures because the sub-measures are less likely to be assessing learned or practiced abilities given their abstract nature. However, in cases such as emotion processing particularly in ASC samples, emotion processing tasks (historically with low ecological validity) are believed to have implications for the overall social functioning of the individual. This is partly because emotion processing is considered part of overall social and communication difficulties in the DSM-V classification, but the ability to infer mental states to eyes, or label high intensity instances of prototypical expressions does not adequately address social or communication skills. In this case the specificity does not translate to the overall ability assessed. For this reason, as previous sections have discussed, there is sufficient justification to sacrifice specificity for greater validity; this is because the inconsistencies in the literature suggest the specificity currently in use is not displaying particularly reliable causality or associations to certain mechanisms,

It is acknowledged that the creation of a task with the level of ecological validity proposed in this thesis will lack the ability to highlight specific mechanisms. However, much like Jones and colleagues (2011) displayed in their work, there are multiple contributing factors in the correct recognition of an emotion, to create a task that focuses only on one lacks not only the validity in assessing the whole ability, but also specificity across other modalities. The methods proposed in this thesis allow an assessment that contains much more information across multiple modalities; this can then be engineered towards specific mechanisms. For example, the visual information can be removed assessing recognition through only verbal and non-verbal (non-word vocalisations) recognition. By beginning with a task that has richer ecological validity the researcher can control how much information is afforded to the participant by limiting what is included in the stimuli. This extra control the researcher has means specificity is added back into the assessment through the option of how much information to include across multiple modalities.

2.8 Assessment in Emotion Recognition Research

Past research focussing on the recognition of emotions has been dominated by stimuli that are static and display only the basic six emotions (Calder et al., 2000; Elfenbein and Ambady 2002; Hall and Matsumoto 2004; Kessler et al., 2008; Matsumoto et al., 2002; Shioiri, Someya, Helmesta & Wa Tang, 1999). Stimulus sets such as the POFA (Ekman & Friesen, 1975) and JACFEE (Matsumoto and Ekman, 1988; Biehl et al., 1997) have been widely used. Although these stimuli sets represent some of the highest quality examples of basic emotion expressions in a static format, their validity as a comprehensive and realistic measure of emotion recognition is debateable.

The expressions themselves are one part of assessing emotion processing abilities; they need to accurately depict the situation in a way that is valid. How they are used and the questions that can be presented with these expressions are the next part of getting an accurate understanding of abilities. If the question or task is too simplistic ceiling effects may emerge (Adolphs et al., 2001; Loveland et al., 2008; Neumann et al, 2006). This ceiling effect may be partly due to the type of task that is frequently employed, the emotion matching or labelling task (Ashwin, Baron-Cohen, Wheelwright, O'Riordan & Bullmore, 2007; Bormann-Kischkel, Vilsmeier & Baude, 1995; Gross 2008; Riby & Hancock., 2008; Rosset et al., 2008; Wallace, Coleman & Bailey, 2008). In emotion labelling tasks participants are shown an emotional face (historically static, but gradually increasing in frequency to dynamic) and must match an emotional label to this face. A task such as this, usually with forced choice options, of typically the basic six emotions is too simplistic. It results in little avenues for confusion, mostly limited between anger and disgust, and fear and surprise; happiness is consistently well recognised and stands alone as the only clearly positively valenced expression whilst sadness is rarely confused with other expressions unless displayed at lower intensities (Hoffmann et al., 2010).

In respect of the previously discussed points of posed and spontaneous expressions, the long-time gold standard POFA and JACFEE expressions are posed in their creation, they are also static in their presentation. Static expressions do not appear in the same manner that is to be expected in realistic social interchange where expressions form and dissipate naturally, something that cannot be conveyed in a static image. For the purposes of assessing emotion recognition competencies, the stimuli displayed should be a true reflection of realistic social interaction. The distinction between showing a static expression and a dynamic one is ultimately that dynamic expressions convey change from one point in time to another; the benefit of which is better context of the expression development. This context allows greater recognition of complex emotions (Cassidy et al., 2015) where multiple emotions may be present or blended (Hoque et al., 2011; Hoque & Picard 2011). Whilst the format expressions are displayed in can influence how they are perceived, the expressions themselves also need to be considered in their complexity and the way they are elicited.

2.9 Aims and Outline of the Thesis

The overall aim of the thesis is to investigate emotion processing difficulties in those with a diagnosis of ASC, as well as typically developing adults and children. This is to be achieved with a new stimuli set and the RM research paradigm that allows the capture of spontaneous naturalistic expressions in direct response to a social scenario. The thesis also aims to evaluate the Alexithymia hypothesis of emotion processing difficulties in ASC. There is a growing section of research that links Alexithymia to ASC, Using a RM task with the proposed stimuli could potentially provide evidence for or against this theory given the more ambiguous nature of the task which requires correct understanding of what would be socially appropriate behaviour and expressions. With Alexithymia believed to impact emotion labelling and understanding in the self there is less information available of emotions in response to past events to attribute, this is likely to have effects on the ability to infer socially appropriate behaviour to others. The results could have important implications for the use of the RM paradigm as an intervention that can better work with ASC individuals to more effectively consider what emotions expressions would be expected in certain situations and crucially why. This kind of intervention could be useful in improving overall social skills and reduce anxiety in social interactions.

If there is evidence to suggest strong comorbidity of Alexithymia with ASC which affects RM performance, this has important implications for the clinical focus of ASC. Much like the DSM-V now collapses communication and social skills, this research may highlight the importance between the two that recognition of expressions *combined* with appropriate semantic understanding may be a more appropriate method of assessing ASC traits and influencing any subsequent intervention. For example, if there is intact recognition but poor emotion understanding there is a need to focus on the semantic understanding of emotions rather than perception and labelling.

2.9.1 Outline of the thesis

In chapter 1, autism was introduced outlining the historical development of understanding ASC and the changes made to the diagnostic criteria. The concept of autism was expanded into the BAP evidencing the presence of ASC traits in relatives of those with ASC. Several theories of ASC were discussed from both a biological and a cognitive perspective with their strengths and weaknesses appraised. Finally the inconsistent results regarding emotion processing in ASC were introduced with certain key points raised such as the inconsistent methods in the literature and the broad range of sample used where difficulties appear less pronounced in HFA individuals (Neumann et al., 2006; Rutherford & Towns 2008; Adolphs et al., 2001).

In Chapter 2 theories of emotion were introduced and the literature surrounding emotion processing was discussed, explaining the functions of emotions as adaptive displays of intent that are designed to a) govern behaviour in the self and b) signify information to others to alter their behaviour. The importance of the functions of emotions via correct recognition was highlighted through research showing difficulties of recognition in depression (Bourke et al., 2010), Schizophrenia (Schneider et al., 2006), ADHD (Ibáñez et al., 2011), and specific to this thesis ASC (Harms et al., 2010; Bal et al., 2010; Ashwin et al., 2006; Wallace et al., 2008; Howard et al., 2000). The developmental trend of emotion processing was then examined demonstrating an improvement throughout age in typical development that coincides with developmental milestones where processing styles develop from orienting to face stimuli (Reid et al., 2017) to understanding emotional context (Philippot & Feldman, 1990; Boyatzis, Chazan & Ting, 1993) developing configural processing (Tanaka et al., 1998) and finally second order relations in configural processing (Bruce et al., 2000; Gilchrist & McKone 2010). The differences between emotion attribution and recognition in ASC were discussed followed by the introductions of the RM paradigm.

The methods used in emotion stimuli creation, delivery, and tasks were then appraised, there was an argument for an improvement in the stimuli that is considered 'spontaneous'; the improvements identified where that spontaneous reactions should be in response to a real social situation and not produced upon request. Where possible the expressions should be captured in naivety of the displayer to ensure valid production, the expressions should also be directed to another individual due to their communicative nature. Critiques of task methods highlighted the need for stimuli to be more complex presented in dynamic format (Cassidy et al., 2015) with multiple modalities (visual and audio feed) (Jones et al., 2011). Finally the requirements of the task need to better match emotion processing in real world situations where more inferences are made retroactively about information gleaned in social interactions. This should take the form of tasks that require an understanding of socially appropriate responses (pillai et al., 2012; 2014; Cassidy et al., 2014; 2015) and understanding of emotional states rather than label matching with no semantic element.

Chapter 3 introduces the process of stimuli development and investigates the morphology of expressions when posed and spontaneous to identify if: a) the expressions generated conform to typical patterns across participants and b) if typical display patterns are similar for posed and spontaneous expressions. The results of a FACS based analysis of expression development in posed and spontaneous expressions in response to seven social prompts are reported through factor analysis. 266 expressions (133 posed, 133 spontaneous) are captured from 19 participants in response to 7 social prompts. The results from this study are discussed in relation to prior research that investigates differential display patterns and intensities in spontaneous expressions and how this might have implications for FER research.

In Chapter 4, the expressions created in chapter 3 are validated with a typically developing sample of adults (n=141). This research aimed to investigate the validity of the stimuli in a typically developing population whilst also investigating if the display patterns identified in chapter 3 translated to recognition; the research also investigated the impacts of perceptions of expression intensity and valence on recognition rates. Finally the free response emotion state attributions provided in this study were thematically coded to allow analysis of emotion state inference to prompt situation in this study and subsequent studies. The results from this study are discussed in consideration of previous literature on spontaneous expression recognition rates and those reported in chapter 3.

The research outlined in Chapter 5 used eye-tracking equipment to investigate the viewing patterns of typically developing children (n=32) to both posed and spontaneous expressions. This was to investigate if differential viewing patterns would be present based on the results from chapter 3 and 4. As a secondary aim, the research also investigated the contributions of RM ability and viewing patterns in predicting autism traits. The results are discussed in relation to previous viewing styles, specifically considering the validity of previous research based on viewing styles to posed stimuli previously considered standard.

In Chapter 6, the stimuli created in chapter 3, validated in chapter 4 and used to investigate viewing styles in chapter 5, is used to investigate the inconsistent emotion recognition performance scores in ASC. Participants (n=137) with ASC (n=53) and controls (n=84) will complete the RM task utilised in chapter 5 to determine if there are indeed group differences in RM performance, a measure of both emotion recognition and social understanding. As a further aim Alexithymia will be measured to investigate the links between Alexithymia and ASC co-morbidity and to investigate the Alexithymia hypothesis of emotion processing within ASC. The results will be discussed in light of previous FER research, RM research and the Alexithymia hypothesis.

Finally in chapter 7, the results from Chapters 3, 4, 5 and 6 will be summarised and discussed in relation to each other and other results in the literature. The results will be discussed in relation to: A) the theories of ASC and associated emotion recognition difficulties, B) the conflicting literature regarding FER in ASC, C) the effects of stimuli type on recognition and D) the effects of Alexithymia on FER. The practical applications of the work will then be considered and future directions of the research in light of findings will be discussed.

Chapter 3 Developing a FACS Verified Stimuli Set of Spontaneous and Posed Expressions

This chapter will follow on from the previous by addressing the issues raised in chapter 2 around stimuli validity. This will culminate in the creation of a new stimulus set that aims to overcome many of the shortfalls in current methods. This is to be compounded with analysis of the physiological features of the expressions created, investigating if there are justifications for a drive towards spontaneous stimuli closer in validity to socially typical expressions.

3.1 Introduction

As discussed in chapter 2, the recognition of emotion expressions is an important part of social communication, relationship formation, and maintenance. This is all the more important when individuals are diagnosed on the autistic spectrum where there are some difficulties in these areas. This ability is typically assessed by showing people the emotional faces of others and tasking them with matching an emotion to the face. This method is limited as an approach to measuring emotion recognition abilities for a number of reasons. Firstly, research has tended to use posed expressions, largely ignoring any differences there may be between posed expressions and those that spontaneously occur (section 2.6.1) (Calder et al., 2000; Elfenbein & Ambady 2002; Hall & Matsumoto 2004; Kessler et al., 2008; Matsumoto et al., 2002; Shioiri et al., 1999). Secondly, the methods used in questioning recognition can be overly simplistic, often relying on basic expressions (section 2.8) (Calder et al., 2000; Elfenbein & Ambady 2002; Hall & Matsumoto 2004; Kessler et al., 2008; Shioiri et al., 1999) and presuming an intact understanding of socially appropriate emotional states (Section 2.4.1). Thirdly the act of recognising an emotion expression is only one small part of the social skillset that ultimately dictates social communication and competence, one that would be better addressed through a method such as RM (section 2.4.3) (Izard et al., 2001; Leppänen & Heitanen 2001). The ability to understand appropriate responses and recognise root causes of emotions from examples can be assessed by RM (Cassidy et al., 2014; Gallese & Goldman, 1998; Pillai et al., 2012). This ability is just as important as correctly recognising the emotion and has been shown to be linked with correct recognition (Cassidy et al., 2014). The issues discussed here and in more detail in chapter 2, make the argument that although some previous measures have high specificity in focussing on individual mechanisms; their application is limited in what can be deduced about emotion recognition as a whole given that verbal information, gesture and voice tone can all provide valuable information. Subsequently, the implications for social skills generally are somewhat limited because the tasks do not measure social skills; very little of the abilities tested focusses on understanding appropriate social emotions. Attempting to create a spontaneous stimuli set, this research will use the RM paradigm, which allows objective assessment of reactions in context, across a range of expressions higher in complexity than those previously used.

3.1.1 Towards a new method of assessment

For research looking at expression development or recognition, a stimuli set is required that can be considered accurate, the gold standard is to have expressions that have been analysed according to the facial action coding system (FACS) (Ekman & Friesen, 1978; Ekman, Friesen & Hager, 2002; Hjortsjö 1969). The FACS allows an objective assessment of what morphological aspects of the face are present and what these typically infer; part of the FACS is identifying 'action units' (AUs) which are the building blocks of facial expressions. The movement of individual muscles or groups of muscles make up AUs which can be rated on a five point scale from: A – trace, to E - maximum. The early work on codifying expressions by Hjortsjö (1969) identified 23 facial action units which was subsequently expanded upon in the work of Ekman and Friesen (1978) and later updated again (Ekman et al., 2002). The FACS system now consists of 46 main AU codes relating to facial muscular movement and further codes for gross motor movement, eye and head movement, and face visibility.

The current research aims to create expressions that are more representative of those that would be expected in typical social interactions. This can be summarised into three characteristics: 1) Expressions should be spontaneous as a direct result of some social cue which produces fundamentally different display patterns (Schmidt et al., 2003) that can be subject to display rules. 2) Expressions should be dynamic displayed in real time, as research has shown dynamic expressions allow greater recognition of socially complex emotions (Cassidy et al., 2015). 3) Expressions should be open to more types and blends of emotion than the basic six which would better reflect the open ambiguous nature of social interactions (Hoque et al., 2011; Hoque & Picard 2011). Separately from expression type, more advanced questioning of recognition and social understanding should be paramount, employing the RM paradigm allows this.

This research will incorporate the RM paradigm (Cassidy et al., 2014; 2015; Gallese & Goldman 1998; Goldman & Sripada 2005; Pillai et al., 2012; 2014); expanding upon previous work by incorporating seven reactions building upon the smaller ranges used previously. The reactions cover more of the emotion spectrum from positive to negative, confusion, frustration, relief, feigned positive and hesitance. The experimental design enables all potential reaction types to be collected from each participant; this is an improvement upon previous research (Cassidy et al., 2014; Pillai et al., 2012), where a single prompted reaction was collected from each participant. By collecting all possible reactions from each participant, further analyses can be conducted on the intensity and attributed valence of the reactions without individual differences confounding a single expression type, addressing some of the issues of displayer depth and holistic expression understanding raised in previous research (Back & Jordan 2014). Asking participants to pose expressions after capturing spontaneous reactions allows comparisons to be explored between posed and spontaneous expressions.

As screening measures, the research will also incorporate the autism quotient (AQ) (Baron-Cohen et al., 2001) and Toronto Alexithymia scale (TAS) (Bagby, Parker & Taylor 1994; Bagby, Taylor & Parker 1994). These are included as early research indicates expressions from those with autistic traits are less recognisable than typically developing individuals, and this effect is still unclear specific to Alexithymia due to its highly comorbid nature (Brewer et al., 2016; Macdonald et al., 1989; Volker, Lopata, Smith & Thomeer, 2009). To the author's knowledge this is the first screening of this kind employed in stimuli development; measuring the prevalence of these traits will allow for extra confidence in the recognisability of the expressions, and open the door to new research avenues wanting to investigate the impacts of emotional responsivity in those with ASC or Alexithymia traits.

In order to capture naturalistic responses, seven specifically designed social prompts were used to elicit a reaction which would be recorded without the participant's knowledge (renewed consent gained upon debrief). The seven social prompts included: Being given positive feedback, being given a reward of monopoly money, being asked a difficult maths question, being given negative feedback, being told the audio recorder had not been recording (wasting the participants time), being asked to repeat the experiment, and being told there was no need to repeat the experiment. This selection of prompts allows a range of social responses that were likely to span from positive (positive feedback) to negative (negative feedback), with a range of complex reactions such as confusion/feigned gratitude (monopoly money), shock/surprise (maths question), concern/irritation (told the audio recorder has not been recording), hesitance/frustration (asked to repeat the experiment) and relief/suspicion (told there is no need to repeat the experiment).

These expressions were identified to best reflect a range of emotional experiences in a controlled environment. Although the basic emotions would seem ideal targets, the aim of the thesis is to better assess emotion recognition in a more valid way. To achieve this, target expressions focussed on obscure situations, this should allow more varied responses likely higher in complexity, with the potential of display rules in effect. The reasoning for this is because the adherence to basic emotions as the only type of emotions that warrant investigation is considered too narrow a focus. This argument was highlighted previously in section 2.1 specifically 2.1.4, that the labelling of emotions phenomenologically would appear to align with simple basic expressions. This might be because tasks require such categorizations whereas free recall would allow divergence into more complex blends or social emotions. By targeting obscure situations across the emotional spectrum it is possible whatever reaction is elicited adheres to simple categorical structures or alternatively, more nuanced blends are evoked.

Creating spontaneous examples of the basic expressions would be useful in testing the Darwin-Ekman theory that specific kinds of emotions exist and that under better methods (more natural evocation for example) results may support this. However, this thesis is not attempting to explain the aetiology of emotion, it is attempting to investigate recognition; to assert that emotion display and recognition is limited to 6 (or 7 if contempt is included) distinct kinds of expressions reduces human experience to only those 6 (or 7) emotions which would seem wholly inaccurate. The use of more obscure emotions in this thesis attempts to capture more realistic displays of emotions that might not align with the defined structures of basic expressions; instead presenting with blends or altogether different emotions such as confused or sceptical. It is believed this presents a more realistic assessment of emotion recognition in practical terms.

In order to provide detailed data of the expressions captured, the most expressive frame identified by human raters will be analysed with FaceReader software (Noldus, Wageningen, Netherlands). This will provide an overview of the AUs present per prompt and condition. The FACS coding system allows a fine-grained analysis of the facial activity within expressions; this is particularly useful to investigate the underlying AU's that are present within displays. These can allow a better understanding of how individual expressions types differ and if there are differences between posed and spontaneous expressions that may not be obvious to naïve raters. Individual AU activity can be associated with specific expressions using the FACS manual, for example AU 9-nose wrinkler is associated with disgust while AU-26 jaw drop is associated with surprise (Ekman & Friesen 1978).

Given that the analysis of facial structures from the expression types is exploratory there is no a priori hypothesis around the patterns that may emerge

3.2 Method

3.2.1 Design

The research employed a within participants design where all potential expressions were captured from each participant. Analysis of expression composition for each condition and prompt type was conducted through principle component analysis (PCA) where the ratings of the 20 most frequent AUs on a 6 point scale ranging from A/0 (not active) to E/5 (fully active) were provided per image from the Facereader analysis. Separate PCA were conducted for each prompt type and stimuli type, totalling 14 in all, analysing the data in this way allowed a data reduction technique to suggest which AUs are most activated for specific expression types. This is possible because PCA reduces a set of observations to a singular value (Factor/component) that combines separate but similar observations to more simply convey patterns present in the data. Any possible clustering onto factors could also indicate important sequences of AUs that hold semantic information.

3.2.2 Participants

Nineteen participants (9 males Mean age = 22 SD = 2.79, 9 females Mean age = 23 SD = 4.03, 1 participant who identified as non-binary aged 37) were recruited via opportunistic sampling predominantly from Coventry University undergraduate and postgraduate populations with six overseas students visiting the University as part of ‘summer school’ for potential students.

3.2.3 Materials and Apparatus

Two cameras were used in the research; a SONY HANDYCAM DCR-SR58 was used to capture the participants’ facial expressions and body posture positioned on a tripod. A second SONY HANDYCAM DCR-SX15 was used to capture the profile view of the interaction between the researcher and participant also positioned on a tripod. The research was conducted in an observation laboratory at

Coventry University. The researcher sat directly opposite the participant with a desk between them, with the camera positioned over the researchers left shoulder to match participants' eye level (see Figure 3.1)

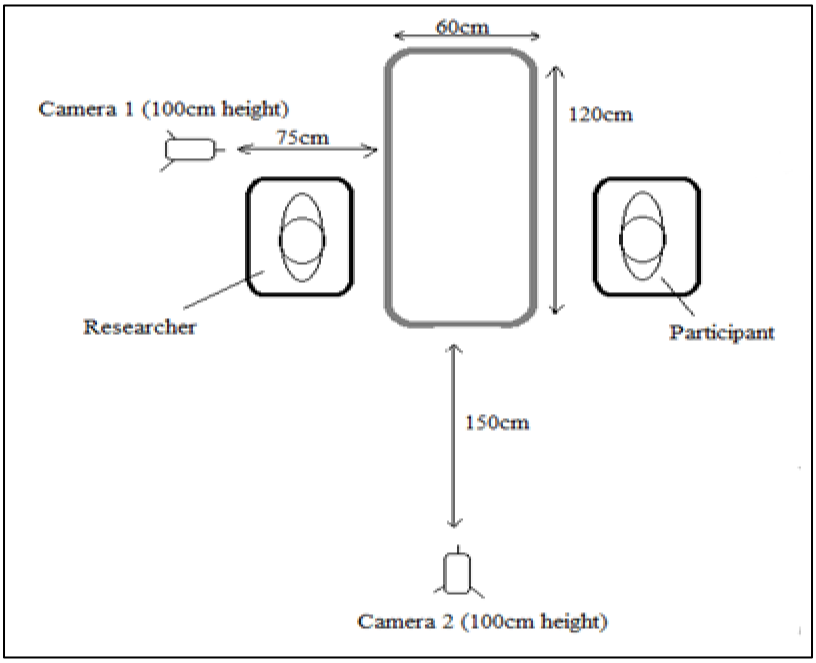


Figure 3.1: *Layout of laboratory*

The Autism quotient (Baron-Cohen et al., 2001) was used as a measure of autistic traits due to recent research suggesting individuals with high autistic traits do not display emotions easily recognised by others (Brewer at al., 2016). It was selected for its reliability evidenced by good internal consistency scores (Cronbach's Alpha =.71 (general population) .81 (student sample) and test-retest reliability ($r = .78$ $p<0.1$) (Hoekstra, Bartels, Cath & Boomsma, 2008). The AQ also demonstrates good face validity as 80% of the adults tested with AS or HFA scored above the threshold for clinical traits compared to only 2% in the control group (Baron-Cohen et al., 2001).

The Toronto Alexithymia Scale (TAS-20) (Bagby, Parker & Taylor 1994; Bagby, Taylor & Parker 1994) was chosen as a self-report measure of Alexithymia. The TAS-20 is considered the gold standard measure of Alexithymia and presents good internal reliability (Cronbach's alpha = .81) and test-retest reliability ($r = .77$ $p<.01$) (Bagby, Parker & Taylor 1994; Bagby, Taylor & Parker 1994). The block design subtask of the Wechsler abbreviated scales of intelligence 2nd edition (WASI-II) was used to simultaneously uphold the legitimacy of the fake experimental aims and was also used as a measure of performance from which participants could be given feedback to illicit a reaction. The results of the block design subtask were not part of the experiment it was used specifically as a device to facilitate experiment legitimacy and allow prompt delivery in the form of feedback.

3.2.4 Procedure

Ethical clearance for the research was obtained from Coventry University ethics board (see appendix A). Due to the deception involved, renewed written informed consent was obtained upon debriefing with explanation of the deceptive recording which was required to capture natural spontaneous emotion reactions. Part of the renewed consent gave optional levels of consent for participants to have their expressions altered, used in future research and made available for use in others research.

Participants were told the aim of the research was to investigate the effects of feedback on task performance with a recorded portion at the end to discuss how the feedback made them feel. It was made expressly clear to participants the video cameras in the room were not yet turned on and the recording would begin after the tasks were complete, participants were unaware cameras were recording from the beginning of the experiment to capture their reactions. After they were seated, the deceptive version of the research explained to them, and consent provided, the experiment began with completion of the AQ and TAS-20. Once completed, the experimenter delivered a scripted series of social prompts as the participant completed different tasks. Participants were presented with all of the following seven social prompts in the order outlined below (see appendix B for full details):

Positive feedback: Participant was told they performed above average on the WASI-II block design sub-task.

Monopoly money: Participant was told because they had performed well they were to receive a reward, they were then handed some monopoly money.

Maths questions: Participants were asked five maths questions the first four were notably easier (what is 20-7) followed by a much harder last question (what is 616/7).

Negative feedback: Participants were told performance on the maths was poor and that they were expected to perform better.

Not recording: The participant was informed the audio recorder used in the experiment had not been working with emphasis that this was problematic to the researcher.

Repeat experiment: The participant was asked if they would be willing to repeat the experiment again as the audio recording was a vital part of the experiment.

No repeat: The participant was informed there was no need to repeat the experiment.

Upon completing the series of scripted prompts the participant was informed the experiment was complete and that the cameras had been recording the entire time. The cameras were turned off and the participant asked to report how they felt in response to each social prompt via a questionnaire, they were provided with example emotional states to facilitate this (see Appendix C). The participant was then debriefed as to the true aims of the research and an additional stimuli consent form presented outlining the research, deceptions involved and purposes of the stimuli obtained. Optional levels of consent were provided that allowed: A) modification of the stimuli such as shortening of clips; it was made clear to participants that modification would not involve artificially changing the content that would be damaging to themselves, it would only involve removing audio or changing audio across expressions to create incongruent information streams or physically restricting the image clarity. B) Presenting the stimuli in published research/ at conferences, C) making the stimuli available for use in future research; this included the explanation that the expressions would be available for use in others research provided it was not edited in a way that breached the ethics outlined and explained to participants in the present research (see Appendix D for debrief and renewed consent)

Upon completion the participant was informed the second aspect of the research would involve posing the expressions that were previously obtained spontaneously. The responses the participant provided on the emotional state feedback questionnaire were used to coach participants to pose the expressions they stated they felt during the spontaneous elicitation. Once all the expressions had been posed to the best of their ability and recorded the participant was thanked for their participation and the experiment ended.

3.2.5 Stimuli editing

The videos clips were edited with Final cut pro X video editing software (Apple, Cupertino, California, USA), removing all cues that would make the objectively correct answer obvious (e.g. researchers voice, monopoly money in the frame). For the purposes of this research the most expressive frame in each video was isolated by the lead researcher, 50% of the stimulus set was verified by independent raters to check reliability. Each rater coded exactly half of the stimulus set (133 expressions) there was 79.70% (106 out of 133) agreement between rater 1 and the lead researcher, and 73.68% (98 out of 133) agreement between rater 2 and the lead researcher. To check reliability Krippendorff's Alpha (Krippendorff 2011) was calculated between rater 1 and rater 2 as including the lead researcher would cause a singularity, the percentage of agreement between rater 1 and rater 2 was 71.43% which resulted in $\alpha = 0.203$ $p=0.032$. Given the percentage of agreement between the lead researcher and each rater and that between the two raters being >70% the lead researchers frame selections were used for the analysis. The resulting 266 static images were analysed using FaceReader software.

3.3 Results

3.3.1 Data screening

Analysis of missing data showed that Facereader could not accurately map the face for three images out of the 266 total. The specific prompts and stimuli types that could not be mapped were: posed negative feedback, spontaneous not recording and spontaneous positive feedback. Two of these images were from the same participant but overall there appeared to be no patterns of difficulty in Facereader recognising a specific prompt type or stimuli type of individual participants. The 3 images that were unable to be analysed represented 1.13% of the overall dataset.

3.3.2 Were participants self-report emotions consistent with FaceReader?

To investigate if the self-reported emotions matched those that FaceReader identified in the images the qualitative emotions needed to be coded into one of the 6 basic expressions or neutral. In total 126 emotion reports were coded, in five cases of the total 133 expressions participants did not report an emotional state to accompany their reaction, in two cases as previously mentioned FaceReader could not map the facial structure of spontaneous expressions. The agreement between the lead researcher and an independent rater was high, measured via Krippendorff's $\alpha=.91$, $p<0.001$ with agreement on 119 out of the 126 reported emotions.

Facereader provides an estimation of the activation of basic expressions in any given image; this is provided on a 0 to 1 scale with 0 signifying the emotion is not active at all and 1 indicating full activation. To investigate if there are consistencies between the self-reported emotion (after coding) given by participants and the strongest basic expression identified present in the image by FaceReader the two were compared. Results showed that in 42 cases of 126 (33.33%) the coded self-report emotion matched that identified as the strongest expressions by FaceReader. The consistency between self-report emotions and the most active basic expressions identified is underwhelming but it is important to note that this is still over two times as likely as chance would expect (14.29%), a binomial distribution shows the probability of 42 successful trials over 126 total trials with 14.29% chance of success to be $p<0.001$. The results of percentage consistent emotion match for individual prompts can be viewed below in figure 3.2

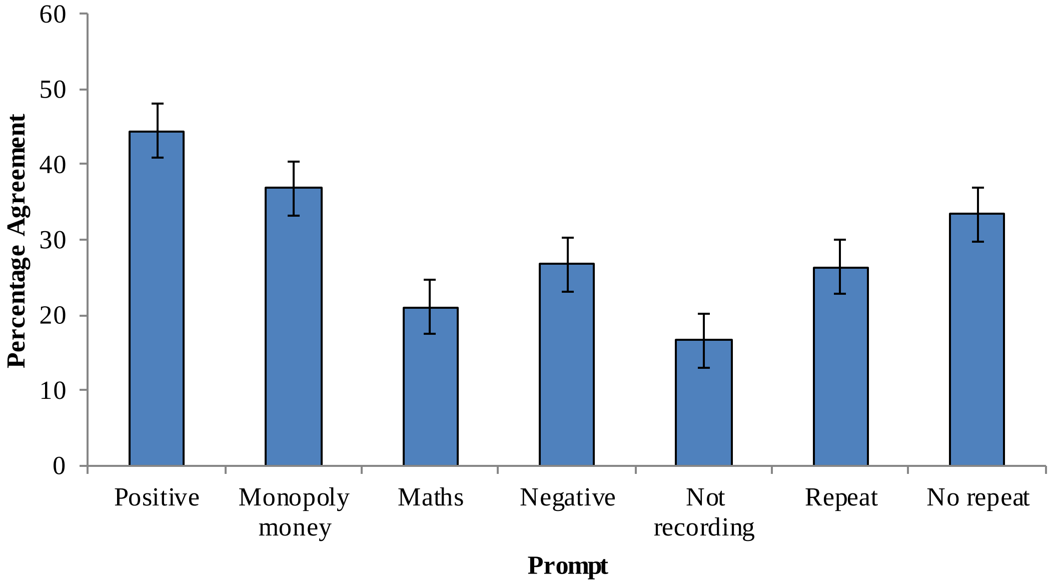


Figure 3.2: *Percentage agreement of self-report emotion to FaceReader most intense emotion identified with error bars ± 1 SE.*

The overall trends on how participants reported their emotional states in each situation after coding to reflect the basic 6 is displayed below in table 3.1. It can be seen that positive feedback, monopoly money and no repeat appear to have the most consistent emotional state reported across the sample with all three showing happiness as the most frequently reported emotion. The repeat experiment prompt also presented happiness as the most frequently reported emotions but this was less pronounced with responses in each of the other emotion categories suggesting the individual differences to this prompt were larger. The maths question and negative feedback prompt showed mixed responses with fear and surprise reported for the maths question and sadness and surprise equally as prevalent for negative feedback. The mixed responses suit the context from which the expressions were gathered, for example the maths question was a surprisingly difficult maths question after four much easier questions this is as much likely to cause surprise due to its unexpected difficulty as fear towards the idea of tackling the question. Equally the negative feedback provided was designed to criticise the participants ability to better illicit a response, it is understandable some individuals would report feelings of sadness to this news whilst others would be surprised at the nature of the comment.

Table 3.1: *Frequency of coded emotion response provided for each prompt category*

		Prompt category						
		Maths	Monopoly	Negative	No repeat	Not recording	Positive	Repeat
Self-reported emotion	Happiness	2	**10**	2	**10**	2	**15**	**7**
	Sadness	1	1	**5**	0	**8**	0	1
	Anger	2	0	0	1	1	0	1
	Fear	**7**	2	1	1	0	1	3
	Disgust	0	0	0	0	0	0	1
	Surprise	5	6	**5**	5	6	2	3
	Neutral	2	0	2	1	1	0	3

Note: Bold items indicate most frequent emotion reported

3.3.3 Are the pattern of action units for each prompt and condition different?

The data for each image consisted of an activation rating for 20 of the most frequent AUs ranging from 0 (not active) to 5 (fully active). Table 3.2 below shows the mean activation of all AUs per prompt type when posed and spontaneous. It can be seen that the AUs: 43-eyes closed, 25-lips part and 12-lip corner puller were the most active AUs across the entire stimuli set being the three most active AUs in all prompts in both conditions except the posed repeat experiment prompt. AUs that were notably less active included: 9-nose wrinkler, 15-lip corner depressor, 23-lip tightener and 26-jaw drop.

Table 3.2: *Average action unit intensity (0-5) between prompt types when posed and spontaneous*

	Maths		**Monopoly**		**Negative**		**No repeat**		**Not recording**		**Positive**		**Repeat**	
	Posed	Spont	Posed	Spont	Posed	Spont	Posed	Spont	Posed	Spont	Posed	Spont	Posed	Spont
1 - Inner Brow Raiser	0.05	0.37	0.05	0.32	0.11		0.21	0.26	0.16					0.16
2 - Outer Brow Raiser	0.26	0.21		0.11		0.26	0.26	0.37	0.16	0.39	0.32	0.11		
4 - Brow Lowerer	0.16	0.89	0.58	0.84	**1**	0.58	0.84	0.74	0.58	0.56	0.32	0.22	0.32	0.79
5 - Upper Lid Raiser	0.21	0.16	0.05	0.11		0.16		0.05		0.44	0.05	0.06	0.05	
6 - Cheek Raiser	0.68	0.63	**1.53**	**1.53**	0.78	0.42	0.95	**1**	0.84	0.5	**1.32**	0.89	**1.05**	0.79
7 - Lid Tightener	0.53	0.26	0.68	0.63	0.61	0.42	0.68	0.32	0.58	0.06	0.16	0.67	0.63	0.37
9 - Nose Wrinkler					0.06									
10 - Upper Lip Raiser	0.37	0.21		0.53	0.17	0.68	0.37	0.53	0.11		0.68	0.5	0.32	0.32
12 - Lip Corner Puller	**1.42**	**2.26**	**3.05**	**3.53**	**2.11**	**1.89**	**2.63**	**1.89**	**2.95**	**2**	**2.95**	**2.56**	**2.37**	**2.58**
14 - Dimpler	0.84	**1.05**	0.42	0.11	0.67	0.58	0.37	0.84	0.32	0.72		0.39	0.95	0.63
15 - Lip Corner Depressor	0.16	0.16		0.05	0.39		0.05	0.05		0.44			0.05	0.16
17 - Chin Raiser	0.32	**1.16**	0.37	0.47	0.56	0.68	0.32	**1**	0.32	0.17	0.21	0.28	0.79	0.26
18 - Lip Puckerer	0.16	0.26		0.16	0.39	0.21		0.37	0.21	0.44	0.11	0.17		0.21
20 - Lip Stretcher	0.42	0.21		0.16		0.32	0.05	0.05		0.17	0.21		0.05	0.68
23 - Lip Tightener	0.16		0.26	0.05	0.22	0.16		0.11		0.06			0.21	0.21
24 - Lip Pressor	0.68	0.11	0.63	0.05	0.61	0.32	0.53	0.37	0.68	0.28	0.37	0.44	0.63	0.37
25 - Lips Part	**1.32**	**1.53**	**1.58**	**2.16**	**1**	**1.42**	**1.89**	**2.32**	**1.11**	**1.06**	**2.21**	**1.61**	**2**	**1.63**
26 - Jaw Drop		0.16									0.21	0.11		0.16
27 - Mouth Stretch	0.21	0.21	0.05	0.21		0.26	0.32		0.21	0.39		0.06	0.58	0.11
43 - Eyes Closed	**1.47**	**1.79**	**1.79**	**2.37**	**1.56**	**2.32**	**1.95**	**1.63**	**1.11**	0.78	**1.37**	**2.22**	0.79	**2.21**

Note: where AU's did not appear in a reaction the cell is left blank to aid interpretation, bold cells indicate AU activation >1

In order to effectively measure the contribution of AUs to peak expression, Principal Component Analyses (PCA) were carried out on each individual prompt type. PCA is a statistical analysis that uses orthogonal transformations to reduce observations to singular components which capture related observations that may present in a pattern. In the case of this research, the observations are the presence of the AUs and their intensity that might appear in a single expression. In this way PCA can highlight specific reaction patterns that are occurring throughout the stimuli set to different prompts. PCA will also identify if there is more than one type of reaction and if this is consistent across the posed and spontaneous conditions. The results of the PCA will be presented for the posed expressions first followed by spontaneous.

Although factor analysis is typically quite demanding in the number of participants required for reliable dimension reduction and convergence, literature has investigated the amount of variance that can be explained with smaller sample sizes. Specifically smaller sample sizes and the contributing effects of communalities and variables per factor (*p/f*). Such work has shown that dimension reduction can be reliable with N<50 and in some cases N<10 (de Winter, Dodou & Wieringa, 2009). Their simulations showed

"When λ (loadings) = 8, f (factors) = 1, p (variables) = 24, and the structure was simple, N = 6 was adequate. A small sample solution (N = 17, λ = 8, f = 3, p = 24) was markedly robust against single small distortions." (de Winter et al.*, 2009 p168).*

The parameters outlined above are not dissimilar to those in the current study, helping support the use of PCA to identify underlying patterns of AU in expressions; particularly as the analyses are exploratory in nature.

3.3.3.1 What is the clustering of action units within posed expressions?

In order to ensure the correct number of factors was used to explain the variance in the data parallel analyses were used rather than relying on Eigen values greater than 1, as this can be liberal in factor retention (Ledesma & Valero-Mora, 2007). By using a parallel analysis with the same parameters, it allows comparisons of the amount of variance explained within the data to multiple iterations of random datasets. Any factors with Eigen values that were not greater than parallel analysis were rejected or the simplest structure interpreted.

For the maths question prompt a parallel analysis showed random data would achieve a greater Eigen value (3.29) than the actual data did for the strongest loading factor (3.05). Due to no factors in the actual data explaining greater variance than a random data set a second PCA forced the data into the strongest single factor structure (see table 3.3 below for factor structure and item loadings) to explore the AUs that best characterise the prompt. The single factor model that best measured expression prediction had strong loadings (>0.5) for items: 5-upper lid raiser, 6-cheek raiser, 10-upper lip raiser and 25- lips part. These AUs when combined present an image of surprise or shock, the presence of cheek raiser would suggest squinted eyes as can be expected in complex thought.

The monopoly money prompt was best described in a one-factor model (Eigen value 3.35) incorporating two factors reduced the Eigen value in the actual data (2.04) below that of a parallel analysis (2.18). The strongest loading items were: 14-dimpler, 24-lip pressor, 27-mouth stretcher and 43-eyes closed. The presence of dimpler, eyes closed and mouth stretch would portray Happiness and joy, whilst lip pressor is a sign of frustration.

The negative feedback prompt was best explained in a one-factor model (Eigen value 3.97) with the variance explained by a two factor model (2.34) less than a parallel analysis (2.42). The single factor model showed strong item loadings of: 6-cheek raiser, 9-nose wrinkler, 10-upper lip raiser and 25- lips part; All strong indicators of a negative reaction akin to disgust.

The no repeat prompt was poorly fit in the data (2.64) when compared to a parallel analysis (2.93), a single-factor model provided the strongest Eigen value and was fitted for exploratory purposes. The strongest loading items were: 20-lip stretcher and 27- mouth stretcher there were also items that showed strong negative loadings these were: 1-inner brow raiser, 2-outer brow raiser and 43-eye closed. These loadings do not indicate a clear image, mouth and lip stretcher would indicate a degree of surprise or hesitance but this is not supported by negative associations with inner and outer brow raiser. Results are consistent with a wide array of AUs across expression with no clear pattern, as such it would be expected the no repeat prompt would be poorly recognised in the posed condition as the AUs do not appear to arrange in any readily identifiable pattern.

The not recording prompt once again showed a lower Eigen value (2.63) for a single factor structure than a parallel analysis (2.74). Subsequently as the simplest model a one factor structure was forced and explored. The strongest loading items where: 4-brow lowerer, 7-lid tightener, 18-lip puckerer and 24-lip pressor. All of these items are indicative of frustration or anger and match the prompt.

The positive feedback prompt was best explained by a three- factor model as the fourth factor presented a lower Eigen value (1.53) than a parallel analysis (1.58). The first factor (Eigen value 2.98) presented strong loadings from items: 10-upper lip raiser, 17-chin raiser and 20-lip stretcher, suggesting this factor measures mild approval. The second factor (Eigen value 2.59) was strongly loaded with items: 5-upper lid raiser, 25-lips part and 26-jaw drop, suggesting this factor is measuring an element of shock or surprise. The third factor (Eigen value 2.25) had strong loadings from items: 6-cheek raiser, 10-upper lip raiser and 25-lips part; there was also reasonable loading from item 7-lid tightener. Together these AUs hint a measure of suspicion is present in certain positive feedback images, but three distinct factors highlight the presence of three distinct ‘types’ of posed happiness.

The repeat experiment prompt was best explained by a four-factor model, inclusion of any factors beyond these yielded better results from a parallel analysis (1.39) than actual data (1.19). The first factor (Eigen value 3.19) had strong loading from items: 4-brow lowerer, 27-mouth stretch and 43- eyes closed. The second factor (Eigen value 2.95) had strong loadings from two items 18-lip stretcher and 24-lip pressor. The third factor (Eigen value 2.14) had strong loading from 6-cheek raiser, 7-lid tightener, 10-upper lip raiser and 17-chin raiser. The fourth factor (Eigen value 1.70) only displayed a strong loading from item 12-lip corner puller but was also negatively loaded with items: 14-dimpler and 15-lip corner depressor. Between the factors there is a clear measure of some form of disgust, frustration and anger being detected in no repeat images. Example images that best depict the factor structure for each expression type can be seen below in figure 3.3.

Table 3.3: *Factor structures and loadings for posed prompts*

	Maths*	Monopoly*	Negative	No repeat*	Not recording*	Positive			Repeat			
Action Units	Factor 1	Factor 1	Factor 1	Factor 1	Factor 1	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 4
1 - Inner Brow Raiser	-0.28	0.27	-0.21	-0.59	0.02							
2 - Outer Brow Raiser	-0.30			-0.66	0.02	-0.20	-0.17	0.17				
4 - Brow Lowerer	-0.24	-0.15	-0.26	-0.15	**0.56**	-0.15	0.06	0.20	**0.91**	-0.08	0.03	0.04
5 - Upper Lid Raiser	**0.79**	-0.17				0.14	**0.90**	-0.20	-0.24	-0.20	-0.35	0.29
6 - Cheek Raiser	**0.57**	-0.71	**0.86**	0.11	-0.43	-0.57	-0.13	**0.66**	0.01	0.27	**0.78**	0.36
7 - Lid Tightener	-0.04	-0.49	**0.45**	0.25	**0.59**	-0.34	0.12	**0.48**	0.38	-0.24	**0.63**	-0.43
9 - Nose Wrinkler			**0.80**									
10 - Upper Lip Raiser	**0.74**		**0.80**	-0.19	**0.45**	**0.59**	-0.20	**0.57**	-0.17	-0.28	**0.87**	0.08
12 - Lip Corner Puller	0.28	-0.76	**0.58**	-0.05	-0.45	-0.59	-0.47	0.08	-0.10	-0.08	0.17	**0.81**
14 - Dimpler	-0.26	**0.83**	-0.25	**0.59**	0.39				-0.20	**0.49**	-0.06	-0.71
15 - Lip Corner Depressor	-0.15		-0.41	-0.19					-0.15	-0.09	-0.03	-0.64
17 - Chin Raiser	0.15	0.14	-0.40	**0.49**	-0.06	**0.90**	-0.18	0.30	-0.32	0.20	**0.64**	0.34
18 - Lip Puckerer	-0.09		-0.12		**0.57**	0.01	-0.17	-0.42				
20 - Lip Stretcher	-0.10			**0.60**		**0.90**	-0.18	0.30	-0.10	**0.78**	0.20	0.17
23 - Lip Tightener	-0.18	-0.19	-0.13						-0.07	0.32	-0.08	-0.34
24 - Lip Pressor	-0.37	**0.54**	-0.34	0.18	**0.65**	-0.16	-0.34	-0.32	-0.12	**0.92**	0.08	-0.07
25 - Lips Part	**0.87**	-0.15	**0.82**	0.21	-0.56	-0.34	**0.58**	**0.53**	-0.05	-0.65	0.21	0.29
26 - Jaw Drop						0.14	**0.90**	-0.20				
27 - Mouth Stretch	0.34	**0.49**		**0.60**	-0.27				**0.86**	-0.09	-0.08	0.16
43 - Eyes Closed	-0.29	**0.77**	-0.31	-0.55	0.33	0.04	-0.30	-0.61	**0.84**	-0.04	-0.07	0.00

Blank cells denote cases where the action unit was not active and not eligible for inclusion in analysis.

Where more than one factor better describes the variance in the data orthogonal rotated (Varimax) loadings are given.

* indicates prompt types where the strongest factor was less than parallel analysis

Items in bold indicate loadings >0.4

Figure 3.3: *Example images that best depict posed prompt types based on AU loadings*
Note: images best depict the factor structure in a single participant. They may not completely capture the factor structure which accounts for all images.

3.3.3.2 What is the clustering of action units within spontaneous expressions?

The maths question prompt showed a four-factor model best explained AU activity (see table 3.4 below for full factor structures and item loadings), including more factors beyond this would result in greater variance explained by parallel analysis (1.63) than the actual data (1.48). The first factor (Eigen value 3.91) showed strong loadings (>0.5) with items: 7-Lid tightener, 10-upper lip raiser, 18-lip puckerer and 43-eyes closed; these AUs would indicate the presence of disgust or discomfort. The second factor (Eigen value 2.69) was strongly loaded with items: 1-inner brow raiser, 5-upper lid raiser and 27 mouth stretch this is concurrent with surprise and fear. The third factor (Eigen value 2.51) loaded strongly with items: 2-outer brow raiser, 14-dimpler and 15 lip corner depressor; these AUs are indicative of positive surprise. The fourth factor (Eigen value 1.98) showed strong loading with items: 6-cheek raiser, 12-lip corner puller, 17-chin raiser and 24-lip pressor; these AUs displaying narrowing of the eyes raising of the chin and tightening of lips suggest mild discomfort and complex thought.

The monopoly money prompt was best explained by a single factor structure, adding more factors resulted in better explained variance in parallel analysis (2.66) than the collected data (2.44). This factor (Eigen value 4.88) was loaded strongly with items: 14-dimpler, 15-lip corner depressor, 20-lip stretcher and 23-lip tightener. These AUs suggest an element of confusion in this prompt with the lips tightened but this is masked by dimpler and stretchers portraying happiness.

The negative feedback prompt was best explained with a three-factor structure, including further factors beyond this yielded less explained variance (1.67) than a parallel analysis (1.74). The items loaded most strongly on the first factor (Eigen value 3.47) were: 7-lid tightener, 17-chin raiser, 20-lip stretcher and 23-lip tightener; this factor is indicative of disgust or anger. The second factor (3.05) was most strongly loaded with items: 4-brow lowerer, 6-cheek raiser, 12-lip corner puller and 27-mouth stretcher; this sequence of AUs would suggest frustration tapered with scepticism. The third factor (2.20) was strongly loaded with the items: 10-upper lip raiser and 25-lips part, as the only strongly associated items with this factor the theme of the factor is not clear.

The no repeat prompt was best explained by a single factor structure, including further factors would reduce the amount of variance explained by the data (2.57) to that in parallel analysis (2.60). The single factor (3.69) was strongly loaded with the items: 1-inner brow raiser, 2-outer brow raiser, 5-upper lip raiser and 18-lip puckerer; these AUs are representative of a surprised response.

The not recording prompt was best explained by a single factor structure, a parallel analysis showed including more than one factor provided less variance in the data (2.46) than a random data set would provide (2.51). The items loading most strongly onto the single factor (Eigen value 3.49) were: 6-cheek raiser, 12-lip corner puller, 25-lips part and 43-eyes closed. In combination these AUs present a face of frustration with the eyes closed and scrunched, and the lips part.

The positive feedback prompt was not well explained by the collected data with an Eigen value of 2.56 compared to a parallel analysis of random data showing an Eigen value of 3.00. Because no factors structures present greater explained variance than random chance the data was forced into the simplest one factor structure to explore any loadings present. Only one item loaded onto the single factor structure above 0.5 (lip pressor). As such no clear theme emerges from this factor structure which would be expected to be clearly positive.

The repeat experiment prompt was best explained by a three-factor structure, parallel analysis showed including more factors than this provided less explained variance (1.64) than random data (1.82).

The first factor (Eigen value 3.16) was strongly loaded by items: 6-cheek raiser, 7-lid tightener, 10-upper lip raiser and 12-lip corner puller; these AUs would suggest an element of disgust with the wrinkling of the nose pulling of the lips. The second factor (Eigen value 2.65) was strongly loaded by items: 12-lip corner puller, 17-chin raiser, 23-lip tightener and 24-lip pressor; these items in combination are very clear indications of frustration with lip pressing. The third factor (Eigen value 2.26) loaded strongly with items: 4-brow lowerer, 7-lid tightener and 10-upper lip raiser; these AUs suggest disgust tempered with anger is present in images of repeat experiment. Example images that best depict the factor structure for each expression can be seen below in figure 3.4

Figure 3.4: *Example images that best depict spontaneous prompt types based on AU loadings*
Note images best depict the factor structure in a single participant, they may not completely capture the factor structure which accounts for all images.

Table 3.4: *Factor structures and loadings for spontaneous prompts*

	Maths				Monopoly	Negative			No repeat	Not recording	Positive*	Repeat		
Action Units	Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 1	Factor 2	Factor 3	Factor 1	Factor 1	Factor 1	Factor 1	Factor 2	Factor 3
1 - Inner Brow Raiser	-0.07	**0.91**	-0.05	0.23	-0.12				**0.66**			0.24	-0.14	-0.10
2 - Outer Brow Raiser	-0.06	0.27	**0.84**	-0.07	-0.11	0.12	-0.49	-0.14	**0.78**	-0.57	-0.62			
4 - Brow Lowerer	0.16	-0.09	-0.20	**0.45**	-0.22	0.12	**0.59**	-0.31	-0.45	0.10	**0.44**	**0.48**	-0.34	**0.54**
5 - Upper Lid Raiser	-0.12	**0.89**	0.05	-0.15	0.15	-0.15	-0.48	0.14	**0.79**	-0.66	-0.17			
6 - Cheek Raiser	-0.09	-0.21	-0.19	**0.62**	-0.36	-0.30	**0.62**	0.27	-0.54	**0.51**	-0.16	**0.71**	0.06	0.12
7 – Lid Tightener	**0.68**	-0.10	-0.16	0.11	-0.32	**0.82**	0.24	0.13	-0.53	0.31	-0.04	**0.64**	0.12	**0.62**
10 - Upper Lip Raiser	**0.94**	-0.03	-0.01	-0.02	-0.11	0.05	0.23	**0.85**	0.02		-0.62	**0.62**	-0.05	**0.57**
12 - Lip Corner Puller	0.24	-0.23	-0.47	**0.57**	-0.81	-0.22	**0.79**	0.23	-0.39	**0.79**	-0.03	**0.65**	**0.52**	-0.26
14 - Dimpler	-0.16	-0.28	**0.67**	0.01	**0.97**	-0.05	-0.78	0.08	0.23	-0.33	0.22	-0.65	-0.28	0.42
15 - Lip Corner Depressor	-0.10	-0.01	**0.84**	-0.06	**0.97**				-0.14	-0.69		-0.39	-0.27	0.08
17 - Chin Raiser	0.36	-0.02	**0.46**	**0.67**	0.12	**0.90**	-0.08	0.02	-0.24	-0.30	0.12	-0.03	**0.58**	0.09
18 - Lip Puckerer	**0.84**	-0.03	0.03	0.03	-0.02	-0.15	-0.20	-0.12	**0.70**	-0.48	**0.44**	-0.41	-0.18	**0.48**
20 - Lip Stretcher	-0.20	-0.06	-0.01	-0.29	**0.97**	**0.90**	-0.13	-0.18	0.04	-0.05		-0.23	-0.08	-0.12
23 - Lip Tightener					**0.97**	**0.78**	0.02	-0.26	-0.42	0.08		-0.14	**0.66**	-0.11
24 - Lip Pressor	0.01	0.13	-0.11	**0.79**	-0.06	-0.31	0.13	-0.14	-0.38	0.03	**0.70**	-0.14	**0.90**	-0.03
25 - Lips Part	-0.08	0.15	-0.51	-0.60	-0.12	0.02	-0.02	**0.80**	0.34	**0.69**	-0.70	0.31	-0.44	-0.51
26 - Jaw Drop	0.03	-0.07	-0.18	-0.36							-0.08	-0.07	-0.14	0.13
27 - Mouth Stretch	-0.06	**0.94**		-0.12	-0.06	-0.07	**0.54**	-0.18		0.26	**0.44**	0.13	-0.18	-0.48
43 - Eyes Closed	**0.68**	-0.10	-0.18	0.19	-0.29	0.13	**0.42**	-0.77	-0.23	**0.53**	0.35	-0.46	**0.47**	**0.47**

Blank cells denote cases where the action unit was not active and not eligible for inclusion in analysis.
Where more than one factor better describes the variance in the data orthogonal rotated (Varimax) loadings are given.
* indicates prompt types where the strongest factor was less than parallel analysis
Items in bold indicate loadings >0.4

3.3.4 What are the relationships between AU activation and screening measures?

The average AU presence in both posed and spontaneous images is presented along with the Autism Spectrum Quotient score and Toronto Alexithymia scale score per participant in table 3.5 below. The relationship between AU activity in posed and spontaneous images is investigated separately because the ability to assume emotional states in posing expressions is expected to be directly related to Alexithymia scores.

Table 3.5: *Mean expression activity, AQ and TAS-20 scores*

Participant no.	Posed AU activity	Spontaneous AU activity	AQ	TAS-20
1	0.79	0.78	27	38
2	0.48	0.76	18	57
3	0.47	0.64	19	30
4	0.58	0.44	13	51
5	0.55	0.61	31	60
6	0.43	0.56	12	39
7	0.57	0.48	8	33
8	0.51	0.58	20	39
9	0.41	0.64	25	46
10	0.67	0.51	9	28
11	0.51	0.51	17	39
12	0.66	0.61	15	40
13	0.44	0.56	30	58
14	0.58	0.43	22	37
15	0.42	0.44	7	52
16	0.38	0.54	15	58
17	0.44	0.56	19	32
18	0.54	0.49	20	41
19	0.45	0.52	17	38

Pearson's correlations showed non-significant relationships between posed AU activation and both AQ scores (r=0.06, p=0.82) and TAS scores (r=-0.35, p=0.14). There was a significant medium positive correlation between spontaneous AU activation and AQ scores (r=0.49, p=0.03) but no relationship between spontaneous AU activation and TAS scores (r=0.12, p=0.62).

3.4 Discussion

The aim of the current research was to create a stimuli set of expressions broader in range than those that have been previously used (See Cassidy et al., 2014; Pillai et al., 2012). Through PCA the research hoped to identify patterns of AU activity investigating if specific patterns emerged for each prompt type and if this differed between the conditions. Results showed for posed expressions, the factors identified for four of the prompts were a poor fit (maths, monopoly, no repeat and not recording). The negative feedback prompt was best explained by a single factor structure and the positive feedback and repeat experiment prompts were best explained by 3 and 4 factor structures respectively.

For spontaneous expressions only a single prompt was a poor fit (positive feedback); the monopoly money, no repeat and not recording prompts were best explained by a single factor structure whilst negative feedback and repeat experiment were best explained by a 3 factor structure and the maths question prompt best explained by a 4 factor structure. Comparisons between the prompts suggest repeat experiment was the only prompt with multiple identifiable response patterns in both posed (4 factors) and spontaneous (3 factors) conditions. Differences between the posed and spontaneous conditions showed four separate prompts in the posed condition, where the strongest factor explained less of the variance than a random dataset, compared to only a single prompt in the spontaneous condition.

Overall the number of identifiable AU patterns that emerged in spontaneous prompts was higher than in posed, as many of the posed factor structures did not present stronger loadings than a parallel analysis of random data. These results suggest spontaneous expressions are more likely to present facial patterns that are consistent across individuals than posed expressions. Further, spontaneous reactions present in multiple statistically identifiable patterns from the same prompts more frequently than posed expressions.

Analyses of the AU patterns through PCA were exploratory in purpose to highlight clusters of AUs that most frequently occur per prompt, and if these combine to display a typically expected reaction. The differences in component structures, particularly where a single component structure explained less variance than random data, would suggest there is no pattern across participants in how they posed these expressions. Given that patterns could be determined for all of these expressions (except positive feedback) in the spontaneous condition it would suggest the attempts at posing these expressions were inaccurate and individuals could not accurately portray the complex nature of these expressions on request. This may be due to the complexity of these expressions, they involve blends of emotions and this may be difficult to replicate with enough clarity for software such as FaceReader to detect.

The findings are supportive of those from Hoque and Picard (2011) that showed spontaneous smiles can manifest in multiple ways (frustration for example) and may explain the poor fit of spontaneous positive feedback. Participants gave such unique and distinct reactions to a prompt that should illicit happiness; this likely resulted in the inability to identify a single factor. Another potential explanation for the three factor structure of posed positive feedback is the refined skill of displaying happiness in accordance of social display rules (Hoque & Picard 2011; Hoque et al., 2011). Happiness is far more likely to be one of the expressions frequently posed for social purposes, and so it is to be expected a larger arsenal of happiness ‘types’ would be present than other posed expressions.

The inclusion of the AQ and TAS-20 as measures to simultaneously screen for effects on expressivity is the first, to the author’s knowledge, implemented in the creation of stimulus sets. Investigating the relationship between AU activation in posed and spontaneous expressions and AQ and TAS-20 scores showed the only significant relationship present was a medium positive one between spontaneous AU activation and AQ scores. This relationship would seem counterintuitive given that expressions created by ASC individuals are typically poorly recognised (Brewer et al., 2016), although the difficulties in recognising ASC expressions in Brewer and colleagues’ work (2016) were not fully explained, just highlighted, there is potential that this difficulty is due to an overactive expressive arsenal which is confusing to others.

Research has highlighted the atypical movement in ASC (Cook, Blakemoor & Press, 2013) and awkward, often exaggerated intensity of expressions (Faso, Sasson & Pinkham, 2015; Grossman, Edelson & Tager-Flusberg, 2013). Such positions should be met with caution in this research and are merely speculative at this point as none of the individuals from which expressions were captured in this research had a clinical diagnosis of autism. In light of previous research where expressions from ASC individuals are poorly recognised, combined with the findings that ASC expressions are rated awkward and overly expressive, there is clearly a need for work of a more empirical nature quantifying expression morphology differences comparing individuals with a clinical diagnosis of autism to neurotypical.

The lack of a relationship between Alexithymia and AU activation is an important finding given the comorbid relationship of ASC and Alexithymia. It may suggest the comorbidity of Alexithymia and ASC is not a linear relationship but Alexithymia becomes more pronounced past a point of severity on the ASC spectrum. There is a need for future research to investigate the comorbidity of ASC and Alexithymia across respective severity.

There are some potential limitations with using software such as FaceReader to detect AUs in expressions, FaceReader has a facial mapping function that fits a polygon mesh overlay to the face and uses this to track relative AU positions. This meshing can become distorted if it is fit to individuals with glasses, or if the individuals face is angled too far from the camera; the rotation method available can attempt to rotate the facial mesh in these instances but is sometimes unreliable (although this is more relevant to dynamic stimuli) and can skew readings. Another potential limitation is the inability of the Facereader software to infer AU positions based on the rest of face if the overall fit cannot be applied. When comparing this to a human rater, the ability to infer facial states, even with slight obstructions, can be overcome because the prior knowledge of facial states before and after the obstruction allows for contextual inference.

On a similar note to FaceReader lacking human insight, the very nature of applying an algorithm to detect AU activity seems counter intuitive given that this work believes displays of emotions have evolved to be communicative to other humans. However this process, as has been discussed, takes on a holistic form, very rarely in non-scientific settings do humans consciously analyse the individual features of the face with the local processing taking precedence over global. The FACS serves to understand and explain the unconscious features of expressions that make this recognition so seamless. Without specific training human raters would not identify the individual aspects of expressions, or likely think them important at all. In this context FaceReader is a tool to apply the FACS system with minimal human error; it is not employed to identify the emotion, although this function exists. The self-report emotional states serve this purpose and the observations of emotions present by viewers can similarly achieve this. In places there are discussions of sequences of AU’s that are prototypical of specific emotions but primarily the FACS analysis serves to identify the physical display characteristics of the expression types when posed and spontaneous.

For the potential drawbacks that using FaceReader brings there are also positives, the automated analysis removes human error, it also provides a quality estimation of the image of how well it could be analysed allowing researchers to set their own threshold of quality and remove any images falling below this. For other analyses FaceReader gives estimations of the six basic emotions (plus neutral and contempt) present in the stimuli as well as facial states; such as left and right eyebrow (raised or lowered) and eye and mouth states (open or closed) along with estimates of valence and arousal.

Along with the potential benefits of the method used to illicit the emotions such as the control in standardised prompts, the ability to capture all expressions from all participants, and ability to capture expressions without the expressed aim of doing so being divulged to displayers, there are also negatives. One such negative is the limited range of expressions; for a stimulus set, the full library of 266 expressions is a reasonable size but it is important to note that exactly half of this set is a posed replication of the spontaneous expressions. With seven unique expressions per displayer, considering the aim was to create a stimulus set that better reflects social interaction, the end product is quite limited in the range of emotions created. However, this is partly constrained by the design because all expressions were captured from all displayers, introducing more expressions risked expanding the collection process beyond acceptable limits given that novel eliciting situations need to be acted out and these then need to be posed afterward. It was believed introducing more target expressions would result in an overall fatigue to displayers where they would be exposed (unknowingly) to an array of emotional experiences.

The use of the video recorder in view of participants also has implications for the expressions created. Although participants were told the camera was switched off, it is still likely their behaviour would be less natural than if the camera had been out of view. This was unfortunately limited by the requirements to capture good quality shots of the face at conversation distance. Attempting to hide the video recorder is one potential option and might be a direction for future research to pursue. The decision taken in this research was to inform participants that there would be recording at a later stage so participants expected cameras to be present, this was because it was ethically more acceptable to have participants agree to some video recording at some stage, to allow an element of informed consent.

Similarly, the procedural process of having the spontaneous expressions always captured before the posed expressions had the potential to influence the posed expressions. For example, posed expressions created after spontaneous are themselves potentially different from posed expressions created before spontaneous or altogether independently. This is because the affective change from the spontaneous expression could aid in posed expression creation, in effect the posed expressions in this research may more closely resemble the previously discussed attempt of using relived memories to create spontaneous expressions. Consequentially, the results that posed and spontaneous expression activity differed, support some of the previous claims made in chapter 2 that reliving events is unlikely to produce the same emotion expression as a lived event. The alternative to combat this would be to counterbalance expression order with some participants posing expressions first and some naturally evoking them; however this would undermine the deception involved in the research that the true aim was to capture naturalistic expressions. Just as spontaneous expressions may influence subsequent posed expressions, it is almost certain that asking participants to display how they would feel in situation X will have subsequent effects when they are then placed in situation X. It is likely the response would be one of confusion for most prompts or cues, as the participants become aware of the true aim of the research.

A further issue with the current design, and research focusing on quantifying expression development in general, is the reliance on static images to define the emotion episode as a whole. Using static images is problematic because expressions are formed in a gradual process, and the emotional state conveyed at the beginning of this process can be different from that at its peak or end (Calvo, Marrero & Beltran 2013; Valstar et al., 2006). By opting for a single frame approach as a measure of recognition, the elicited emotion presented is a reduced version of a social episode. A single frame during a shift in emotional state throughout the episode means the social data of context is lost, this is particularly important because expressions can be subject to display rules (Wagner 1990; Wagner et al., 1992). An example of this can be the reaction to an unwanted gift; the initial disappointment is (typically) quickly masked by a socially appropriate gesture of happiness and gratitude. Opting for a single frame approach in this instance would result in either; A) a picture of disappointment or B) happiness, neither is fully explanatory of the situation that occurred.

This issue is problematic in emotion expression research, the nature of means based statistical testing would reduce the trends in expressions to a singular point losing context; similarly a single frame does not sufficiently capture the expression episode on show. The quantity of analyses that would be required to address this would result in either: MANOVA where the measurement at one time point is highly likely to be correlated to the subsequent time point resulting in collinearity issues. Alternatively, separate ANOVAs can be used for each time point, which the data does not typically lend itself to with action unit measurements where the IVs can run into double digits resulting in power issues.

In classifying the expressive episode, there appear to be two routes: to average the entire episode and consider this a good approximation, or to identify the most expressive point and use this as an example under the assumption that being the most expressive point it must encapsulate the most relevant social data. The issue with averages is that the average may not be exactly representative of any singular time point and so can result in a measurement that never occurred. Secondly, over the time course of expression development for an average to be a reliable measure, a normal distribution of expression activation would be expected. Expressions do not form and dissipate at the same rate (Cohn and Schmidt, 2004; Hoque et al., 2011), an expression slow to form would result in an average far lower than the actual formation would portray.

By comparison identifying the most expressive frame is limited too in that it does not account for other points in the expressive episode which convey the overall social context. However, when human raters are used to identify this point, they do see the entire episode including any emotion sequences and can identify the point which best conveys the most social data. Given the two options identifying the most expressive frame is recommended as a better route of assessing the emotion in an episode as one can be fairly confident that at least the most expressive frame of that episode is accurately measured whereas an average will always be some approximation of the entire episode open to bias in skew over time. This was particularly true when considering the current analysis which would require a single data stream to represent each expression. Previous research has similarly opted to identify the most expressive frame from a range (Matsumoto & Willingham 2006), or captures a photograph of an intentionally posed expression which could reasonably be presumed to depict the apex of an expression period (Tracy et al., 2009).

In an effort to overcome this issue, future research could investigate developmental trajectories of emotion activity over time. Such a method is outlined in Thomas and colleagues (2009) work on language and cognitive difficulties throughout development, which may translate well to the current topic. It allows a comparison of trajectories over time; in the case of the current research this could include the aforementioned basic expression activation FaceReader provides across posed and spontaneous expression development over time. Issues still exist if one wanted to include AUs in a trajectory where the options are to create separate trajectories of the most intense action units or an overall mean (which again dilutes the very specificity of interest). Nevertheless statistical methods are becoming available that better suit the needs of such a topic.

In summary this chapter has created a stimuli set that consists of 266 dynamic colour videos from 19 individuals, reacting to 7 social prompts to address the issues raised. These stimuli were captured in both a spontaneous and posed format to allow analysis of expression patterns. An additional 266 static images are also available of the most expressive frame per video identified by the researcher (133 of which were validated by two independent raters). The results of expression patterns showed more statistically identifiable patterns in spontaneous expressions than posed; making a strong case for future research to include more spontaneous expressions as these conform to universal display patterns more readily than posed expressions do. The stimuli set was created ascribing to the RM paradigm, which allows the stimuli to be used as a more in depth task of emotion recognition ability; the stimuli set is broader in expression range than those previously used, and has the option of either posed or spontaneous stimuli types to suit the researchers' needs. The dual set of both posed and spontaneous expressions reflective of true social interchange, provide exciting new opportunities for research where there have been inconsistent results such as in the field of ASC (See Harms et al., 2010). The availability of a broader stimulus set of naturalistic spontaneous reactions can be used to better assess individuals on the autism spectrum and help to better understand the methods used when processing expressions closer to natural social interaction created under controlled conditions. This stimulus set is freely available for use in research, information about how to access the stimuli set can be found in appendix E.

Chapter 4 Adults are More Successful at Interpreting Spontaneous than Posed Emotional Responses

With the newly created stimuli introduced in chapter 3, and evidence that spontaneous expressions conform to universal display patterns more than posed expressions it is important to consider if this display pattern translates to differential recognition rates. It is also important that the expressions created are recognisable and convey the affective component intended before they can be used to accurately assess an individual's emotion recognition abilities. As such this chapter will investigate the communicative aspect of emotion expressions considering if posed expressions convey the same meaning as spontaneous and why this would be important. The results could have implications for previous methods which may have been limited in their approach to assess emotion recognition, overlooking complex variables such as emotion intensity. New methods need to address this issue by using stimuli that more accurately reflect expressions encountered in typical social interaction. Therefore the aim of the current research is to validate the newly created stimuli set of spontaneous emotional reactions captured in a realistic social interchange.

4.1 Introduction

As was discussed in chapter 2, the expressions captured in response to viewing images and videos are questionable as truly spontaneous. This is because reactions captured in response to stimuli without another person present are fundamentally different to expressions captured with others present (Schmidt et al., 2003). This is evidenced by stronger amplitudes of onset in social conditions than isolation, and the peak duration being significantly longer in isolation than in social conditions (Schmidt et al., 2003). Expressions captured in isolation do not have clear beginnings like social expressions, and tend to develop at a gradual rate rather than the more intense beginning and clear peak of social expressions (Cohn & Schmidt 2004). This could result in expressions from non-social situations having worse recognition due to more ambiguous developmental trends.

With posed expressions being open to many fundamental differences in their display patterns (Dibeklioğlu et al., 2010; Calvo et al., 2013; Valstar et al., 2006; Ekman, Davidson, & Friesen, 1990; Williams et al., 2001), intensity (Valstar et al., 2006) and complexity (Naab & Russell, 2007) there is room to also consider the affective component. Currently there is a gap in the literature questioning if the valence, the affective component of the expression, is different in posed and spontaneous expressions. Namely, do people experience a change of internal emotional state when posing expressions? The potential is that posed expressions may lack the affective component, not accurately portraying the felt emotion, merely replicating the physical changes. Posed expressions could then be showing emotion responses but not appearing genuine with affective changes that are perceivable and resonate with others. Research has highlighted differences in expression physiology (Namba, Makihara, Kabir, Miyatani & Nakao, 2016) and measured expression valence (Partala, Surakka & Vanhala, 2005), but not investigated valence differences in posed and spontaneous expressions. This is important because affective changes in emotional valence, if perceivable by others, may influence the likelihood of empathic responses and emotional mimicry (Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2008) which can influence the physiological system (Kraft & pressman, 2012) and subsequently feedback into emotion processing.

Currently no distinction has been found between recognition of specific types of expressions in posed and spontaneous format, only a global improvement for posed expressions (Hess & Blairy, 2001; Wagner 1990; Wagner et al., 1992; Naab & Russell, 2007). This appears to be due to variations in complexity such as emotion blends (Naab & Russell, 2007), or signal clarity (Cassidy et al., 2016), and the inability of posed emotions to accurately replicate social display rules (Wagner 1990; Wagner et al., 1992). The reported prominence for posed expression recognition over spontaneous, may be a result of the stimuli used and methods employed. The posed expressions used over-simplify the communicative intent of expressions, lacking the social element required to effectively recreate expressions with meaningful social information beyond basic physical changes of the facial muscles. The spontaneous expressions previously created overlook the true nature of spontaneity in expressions in typical social interaction by using methods of evocation not truly spontaneous or social.

Through the use of the RM paradigm this research aims to validate the newly developed stimuli set by investigating the specific recognition patterns of posed and spontaneous expressions and what emotions people associate to specific reactions. The presence of intentionally posed expressions in typical social interaction would suggest there will be differences in recognition within the posed expressions of those more frequently encountered and those not typically engaged in a socially manipulative manner. It is hypothesized in line with previous research there will be a significant difference in the recognition of posed and spontaneous expressions with posed expressions being better recognised. Specifically, it is predicted this improvement in recognition will be concentrated on the more frequently socially posed emotions of positive and negative feedback when displayed in a posed format. A secondary aim will investigate the relationship of autistic and Alexithymia traits influencing the recognisability of expressions and the relationship of those traits to expression recognition in those that view expressions.

4.2 Method

4.2.1 Design

A between participants design was employed with the 266 expressions divided into five groups, each consisting of 50 - 66 expressions. The distribution of expressions between the groups was matched: posed and spontaneous expressions from the same displayer; and an even spread of each prompt and displayer type. The research was granted ethical clearance by Coventry University ethics board (See Appendix F)

4.2.2 Participants

141 participants (36 male, 104 female, 1 non-disclosed, mean age = 24.80, SD = 12.44, age range = 18-74) were recruited from Coventry University via the online research participation scheme and the Cambridge Autism Research Database (CARD) volunteer mailing list, the research was only mailed out to control volunteers.

4.2.3 Materials and apparatus

There were 266 expressions (19 targets: 9 males, 10 females each displaying 7 posed, and 7 spontaneous responses) developed for use in the current study, displayed at a rate of 29 frames per second via Qualtrics online survey tool. Videos were embedded in the survey webpage displaying only one video per page with subsequent questions; videos would begin playing once the participant pressed the play button. 7 example prompt videos showed the researcher demonstrating the prompts that were used in the stimuli development. Participants also completed The Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001) and The Toronto Alexithymia Scale (TAS-20; Bagby, Parker & Taylor, 1994; Bagby, Taylor & Parker, 1994). The expressions created and edited in chapter 3, as outlined in sections 3.2.3, 3.2.4 and 3.2.5 were used in this experiment.

4.2.4 Procedure

Participants accessed the survey via a webpage. On accessing the link, participants were informed the aim of the experiment was to validate a newly developed stimulus set of naturalistic expressions to be used in future research. Upon providing consent to take part, participants provided demographic details (age, sex, employment status, highest level of qualification, IQ if known, and any diagnoses). Participants then completed the TAS-20 followed by the AQ. Participants were then informed that they would see videos of peoples' reactions to different social prompts, and would have to decide whether; a) they thought the response was genuine or posed; b) which prompt caused the reaction (forced choice of 7 options); c) the emotional state of the person (free response, but with emotion glossary provided the same as that provided in appendix C); d) how intense the emotion was (scale 0-100); and e) how positive or negative (valence) the emotion was (scale -100 to +100). Seven example videos displayed each prompt. Participants were then randomly assigned to view either 50 or 66 videos in random order. Participants were instructed to watch the videos only once.

4.2.5 Analysis

4.2.5.1 Emotion description coding

To allow a better understanding of the emotional states a bottom up approach was used rather than arbitrarily labelling an expected mental state to each given scenario. This entailed participants providing free emotion responses. To allow analysis, a coding scheme was developed to capture the range of emotion labels provided. Hence, participants' emotion attributions were coded into one of eight categories:

Positive – Labels with a positive connotation: happy, pleased, enjoying, positive, glad.

Negative – Labels with a negative connotation that doesn't more readily fit the code of frustrated: unhappy, disappointed, shy, anxious, overwhelmed, unfriendly.

Confused – Labels that infer a lack of understanding of the situation: unsure, uncertain, confused, puzzled.

Shocked – Labels that convey something unexpected: surprised and shocked.

Engaged – Labels with a connotation of being mentally engaged or focussed on the task at hand: thinking, informed, sure, listening.

Pretend – Labels which infer an attempt to conceal or mask emotions: sneaky, staged, false, framed.

Sceptical – Labels which infer an element of scepticism towards the researcher or situation: disbelieving, doubtful, cynical.

Frustrated – Labels which infer annoyance: bothered, annoyed, fed up, angry.

6958 emotion labels were coded, 34 were uncategorised (0.48% of the total sample) as they were neutral: neutral, steady, unsurprised and fair. These 34 labels were initially included as 'other' in an analysis of model fit with likelihood-ratio, results showed that the 'other' code category did not occur above a chance expectation model would predict for any of the emotional prompts. As such this category and the 34 codes were removed from the data set resulting in a total of 6924.

4.2.5.2 Inter-rater agreement

To ensure accurate coding of emotion labels, a 20% (1385 cases) randomly selected sample (using RAND function in excel) of emotion labels were coded by an independent rater. Krippendorff's Alpha was used to determine inter-rater agreement of codes ascribed when using the above scheme. Inter-rater agreement was $\alpha = 0.88$, $p<0.001$ with a 91% agreement rate between raters (1251 of 1385). The most notable disagreements were between positive and engaged, in 104 instances the raters disagreed with one coding the emotional state as positive and the other as engaged or vice versa, there were only 26 instances of disagreement outside of positive-engaged. Emotion labels used in analyses were coded by the experimenter.

4.3 Results

Total recognition scores were calculated and differences compared between the individual groups which saw differing expressions. There were no Significant differences in recognition rates between groups (F (4,136) = 2.22, p=0.070, η_p^2 = 0.06). In order to allow analyses of the entire stimuli set the data were pooled and proportion correct recognition of each prompt type were calculated for each participant, this allowed repeated measures analyses across the entire stimuli set by comparing recognition rates of stimuli and prompt type. A similar method in validation of pooling data from different samples when using large stimuli sets has been used in previous work (Tottenham et al., 2009).

4.3.1 The pattern of emotion recognition

In order to investigate the recognition rates the proportion of correct recognition of each prompt type was calculated in each condition (posed and spontaneous). Recognition rates varied between the expressions and the conditions, for example, posed positive feedback was more accurately recognised than spontaneous positive feedback. The same recognition pattern was present in posed and spontaneous negative feedback and no repeat, although the recognition rates were much closer to chance (figure 4.1).

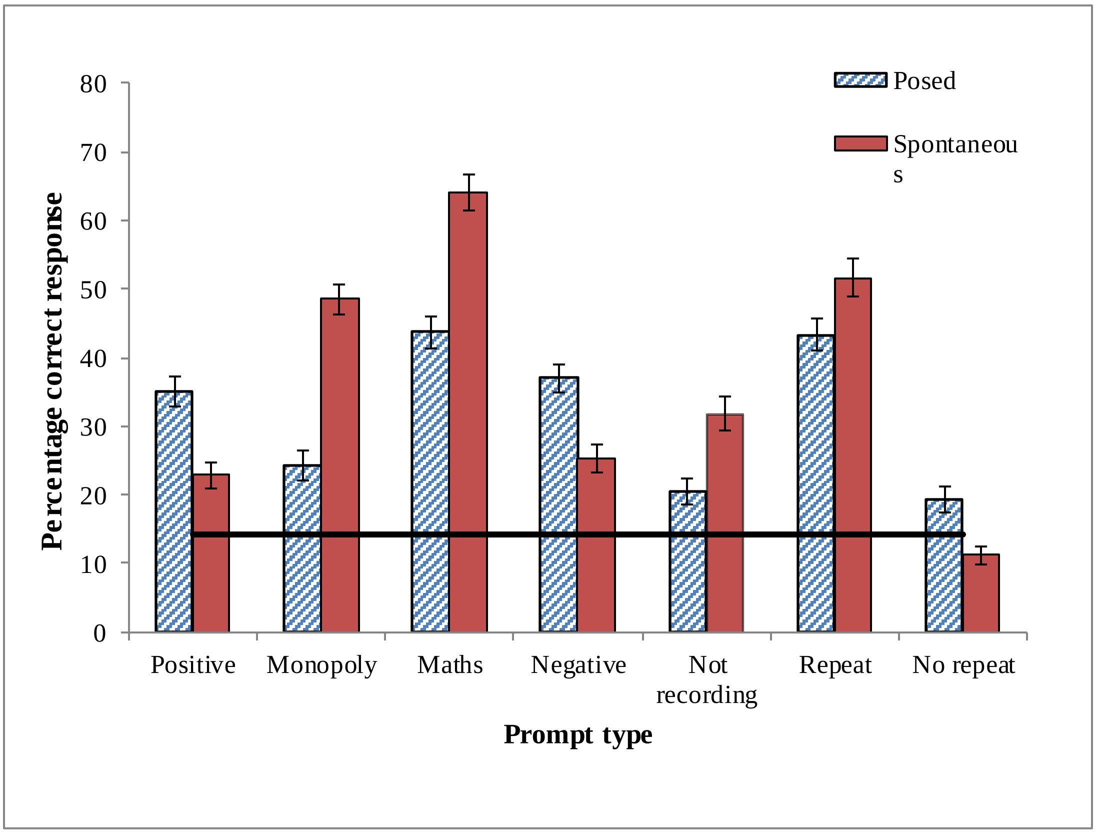


Figure 4.1: *Percentage of correct prompt inferences between posed and spontaneous stimuli. Line indicates chance recognition (14.29%) Error bars ± 1 SE.*

Overall, participants correctly identified prompts more from spontaneous (1425) than posed (1261) reactions. The results of participants' inferences for posed (a) and spontaneous (b) reactions are displayed in Table 4.1 below.

The errors in recognition show that some expressions appear more ambiguous in their presentation, and these can be confused with other prompt types which share a similar valence. For example posed not recording is often confused with negative feedback/repeat experiment (prompts that would typically result in a negative reaction), whilst monopoly money and no repeat can be confused with positive feedback (similarly these prompts would be expected to produce a positive reaction). When viewing spontaneous expressions, error patterns showed positive feedback was sometimes confused with negative feedback. This would seem counter intuitive if not for the reactions to positive feedback being so varied; individuals were often embarrassed or sceptical of the information given to them. Interestingly negative feedback did not present the same confusion with positive, suggesting negative responses are less ambiguous. These error patterns suggest there is a step of inferring the emotional state of the individual, if this is positively or negatively valenced, and then appropriate social cues are deduced from this.

Table 4.1: *Confusion matrices showing frequency of correct and incorrect prompt inferences for posed and spontaneous stimuli*.

		Correct answer (% in brackets)						
a) Posed stimuli participants responses		Positive	Monopoly	Maths	Negative	Not rec	Repeat	No repeat
	Positive	199 (36.7)	112 (21)	33 (6.14)	61 (11.5)	41 (7.72)	31 (5.73)	86 (16.2)
	Monopoly	58 (10.7)	133 (25)	18 (3.35)	14 (2.64)	23 (4.33)	17 (3.14)	39 (7.35)
	Maths	21 (3.88)	46 (9)	235 (43.7)	62 (11.6)	66 (12.4)	35 (6.46)	48 (9.05)
	Negative	66 (12.1)	93 (17)	94 (17.5)	205 (38.6)	117 (22.0)	100 (18.4)	54 (10.1)
	Not rec	32 (5.91)	40 (7)	66 (12.2)	50 (.43)	128 (24.1)	59 (10.9)	65 (12.2)
	Repeat	62 (11.4)	55 (10)	51 (9.49)	72 (13.5)	100 (18.8)	243 (44.9)	90 (16.9)
	No repeat	69 (12.7)	28 (5)	17 (3.16)	36 (6.79)	31 (5.83)	30 (5.54)	118 (22.2)
	Blank	34 (6.28)	32 (6)	23 (4.28)	30 (5.66)	25 (4.70)	26 (4.80)	30 (5.66)
	Total	541	539	537	530	531	541	530
b) Spontaneous stimuli participants response		Positive	Monopoly	Maths	Negative	Not rec	Repeat	No repeat
	Positive	131 (24.2)	81 (15.0)	15 (2.79)	79 (14.9)	24 (4.51)	21 (3.88)	78 (14.7)
	Monopoly	56 (10.3)	275 (51.0)	12 (2.23)	21 (3.96)	43 (8.09)	11 (2.03)	46 (8.67)
	Maths	37 (6.83)	48 (8.90)	340 (63.3)	78 (14.7)	60 (11.2)	38 (7.02)	29 (5.47)
	Negative	88 (16.2)	48 (8.90)	61 (11.3)	123 (23.2)	87 (16.3)	52 (9.61)	71 (13.3)
	Not rec	50 (9.24)	25 (4.63)	36 (6.70)	41 (7.73)	196 (36.9)	74 (13.6)	97 (18.3)
	Repeat	72 (13.3)	21 (3.89)	35 (6.51)	100 (18.8)	69 (12.9)	290 (53.6)	114 (21.5)
	No repeat	78 (14.4)	19 (3.52)	10 (1.86)	59 (11.1)	23 (4.33)	25 (4.62)	70 (13.2)
	Blank	29 (5.36)	22 (4.08)	28 (5.21)	29 (5.47)	29 (5.46)	30 (5.54)	25 (4.71)
	Total	541	539	537	530	531	541	530

Note: shaded cells denote correct prompt inferences.

4.3.2 The effects of stimuli type on recognition rates

To explore recognition levels between conditions and prompt types, a two way repeated measures ANOVA was conducted with stimuli (posed, spontaneous) and prompt type (maths question, monopoly money, positive feedback, negative feedback, repeat experiment, no repeat, not recording) as independent variables. The dependent variable was proportion of correct prompt inferences, Mauchly's test of sphericity was violated (Greenhouse-Geisser prompt type = .87, stimuli x prompt = .92) as such Greenhouse-Geisser adjustments are reported. Results showed a significant main effect of stimuli (F (1, 140) = 16.70, p<0.001, η_p^2 = 0.11) with spontaneous expressions (37%) recognised significantly more than posed (33%). There was also a significant main effect of prompt type (F (5.22, 731.26) = 67.04, p<0.001, η_p^2 = 0.32), and a significant interaction between stimuli and prompt type (F (5.49, 769.02) = 29.90, p<0.001, η_p^2 = 0.18). Simple main effects analysis followed up by Bonferroni corrected *t*-tests were used to explore this interaction, in each condition separately.

Bonferroni corrected *t*-tests showed significant differences in recognition between the stimuli types for each prompt type. The maths question (62.5%, p<0.001), monopoly money (50%, p<0.001), not recording (34%, p<0.001), and repeat experiment (52%, p<0.05) prompts were recognised significantly more in a spontaneous format. The negative feedback (38%, p<0.001), no repeat (21%, p<0.01) and positive feedback (36%, p<0.001) prompts were recognised significantly more in a posed format means and confidence intervals can be viewed in table 4.2. To further investigate the recognition levels within posed and spontaneous stimuli subsequent analyses were carried out.

4.3.2.1 Recognition rates within posed stimuli

To better understand the main effects, differences in recognition rates between the prompts were investigated. Bonferroni corrected *t*-tests showed that for *posed stimuli* the maths question prompt was recognised significantly more accurately than the monopoly money, no repeat and not recording prompts (all p<0.001). The monopoly money prompt was recognised significantly less than negative feedback (p<0.05) positive feedback (p<0.05) and repeat experiment (p<0.001). The negative feedback prompt was recognised significantly more than no repeat and not recording (p<0.001). The no repeat prompt was recognised significantly less accurately than positive feedback and repeat experiment (p<0.001). The not recording prompt was recognised significantly less than positive feedback and repeat experiment (p<0.001). See Table 4.2 for mean proportion correct recognition and confidence intervals.

4.3.2.2 Recognition rates within spontaneous stimuli

Bonferroni corrected *t*-tests showed for *spontaneous stimuli* the maths question prompt was recognised significantly more accurately than all other prompts (all $p<0.001$ except repeat experiment $p<0.05$). The monopoly prompt was recognised significantly more than negative, no repeat, not recording and positive feedback (all $p<0.001$). The negative feedback prompt was recognised significantly more than no repeat ($p<0.01$), but significantly less than not recording ($p<0.05$) and repeat experiment ($p<0.001$). The no repeat prompt was recognised significantly less than not recording, positive feedback and repeat experiment (all $p<0.05$). The not recording prompt was recognised significantly less than repeat experiment ($p<0.001$). The positive feedback prompt was recognised significantly less than repeat experiment ($p<0.001$). See Table 4.2 for mean proportion correct recognition with confidence intervals.

Table 4.2: *Mean proportion correct recognition and confidence intervals*

	Mean proportion correct			
Prompt type	Posed	95% CI	Spontaneous	95% CI
Positive	0.37	0.32, 0.41	0.26	0.22, 0.30
Monopoly	0.27	0.22, 0.31	0.50	0.46, 0.54
Maths	0.43	0.39, 0.48	0.63	0.57, 0.68
Negative	0.38	0.34, 0.42	0.23	0.19, 0.27
Not recording	0.23	0.19, 0.26	0.34	0.29, 0.39
Repeat	0.44	0.40, 0.48	0.52	0.47, 0.58
No repeat	0.21	0.17, 0.24	0.12	0.10, 0.15

4.3.3 What is the pattern of errors?

To investigate if participants could systematically infer the correct antecedent prompt from observed behaviour, each participant’s responses were tabulated and a three way repeated measures ANOVA was conducted. Frequency of answer given was the dependent variable, there were three independent variables; stimuli type (posed, spontaneous), correct answer (maths question, monopoly money, negative feedback, no repeat, not recording, positive feedback and repeat experiment), and participants’ response (maths question, monopoly money, negative feedback, no repeat, not recording, positive feedback and repeat experiment).

Results showed a significant three-way interaction between stimuli type, correct answer and participants’ response F (22.58, 3161.71) = 11.89, $p<0.001$ although this effect size was small (η_p^2 = 0.08). As expected a significant interaction was present between correct answer and answer given F (12.51, 1751.57) = 99.48, $p<0.001$, this appeared to account for more of the variance (η_p^2 = 0.42). To explore this interaction, analyses of simple main effects compared the frequency of correct to incorrect prompt inferences, in each condition separately.

The following analyses will report the frequency of participants responses within the correct categories, the mean frequency of correct answers given will be compared to the frequencies of incorrect answers. This will highlight if participants could clearly differentiate the correct answer for each expression type. This will be carried out first for posed stimuli and then for spontaneous.

4.3.3.1 Within posed stimuli

Bonferroni corrected t-tests showed for the maths question, negative feedback, positive feedback and repeat experiment prompts the correct answer was chosen significantly more than all other incorrect options (p<0.001). Participants were significantly more likely to choose the correct monopoly money prompt above all other options (p<0.001) except positive feedback (p=1). Participants were significantly more likely to choose the correct no repeat than incorrect Monopoly money and Maths question (p<0.001) but not significantly more than incorrect positive (p=1), negative (p=0.165), not recording (p=0.072) and repeat (p=0.832). Participants were significantly more likely to correctly distinguish not recording from incorrect positive feedback (p<0.001), monopoly money (p<0.001) and no repeat (p<0.001); But could not distinguish correct not recording from incorrect maths question (p=0.57), negative feedback (p=1) or repeat (p=1). The mean frequencies of answers given to each prompt type and Confidence intervals are reported are presented in table 4.3 below.

4.3.3.2 Within spontaneous stimuli

Bonferroni corrected *t*-tests showed for the maths question, monopoly money, not recording and repeat experiment prompts participants could correctly identify the appropriate answer significantly more than all other incorrect options (p<0.001). Participants could significantly correctly identify negative feedback over all other incorrect prompt types (p<0.05) except repeat experiment (p=0.808). Participants could not correctly distinguish the no repeat prompt from all other incorrect options (p>0.05) instead incorrectly guessing repeat experiment significantly more than the correct no repeat prompt (p<0.01). Participants could correctly distinguish the positive feedback prompt from all other incorrect options (p<0.05) except negative feedback (p=1). The mean frequencies of answers given to each prompt type and Confidence intervals are presented in table 4.4 below.

Table 4.3: *Mean frequency of correct and incorrect answers given to posed stimuli with confidence intervals*

		Correct answer													
		Positive	95% CI	Monopoly	95% CI	Maths	95% CI	Negative	95% CI	Not recording	95% CI	Repeat	95% CI	No repeat	95% CI
Answer given	Positive	1.34	1.18, 1.50	0.81	.67, .95	0.23	.16, .31	0.43	.33, .54	0.29	.20, .38	0.2	.12, .27	0.71	.57, .85
	Monopoly	0.41	.31, .52	0.92	.78, 1.07	0.13	.07, .19	0.21	.13, .29	0.2	.12, .28	0.12	.06, .18	0.26	.18, .35
	Maths	0.16	.10, .23	0.47	.35, .58	1.67	1.49, 1.85	0.43	.31, .55	0.57	.46, .69	0.23	.15, .32	0.35	.26, .43
	Negative	0.46	.35, .58	0.57	.45, .70	0.67	.55, .79	1.41	1.26, 1.57	0.76	.63, .89	0.71	.58, .84	0.48	.36, .60
	Not recording	0.26	.18, .35	0.23	.15, .32	0.47	.35, .59	0.29	.20, .38	0.78	.65, .92	0.53	.42, .64	0.47	.36, .58
	Repeat	0.48	.38, .57	0.38	.28, .49	0.36	.27, .46	0.48	.38, .58	0.76	.63, .89	1.65	1.47, 1.84	0.54	.42, .65
	No repeat	0.5	.39, .62	0.21	.14, .29	0.12	.06, .18	0.29	.20, .38	0.22	.14, .30	0.21	.14, .28	0.74	.61, .86

Table 4.4: *Mean frequency of correct and incorrect answers given to spontaneous stimuli with confidence intervals*

		Correct answer													
		Positive	95% CI	Monopoly	95% CI	Maths	95% CI	Negative	95% CI	Not recording	95% CI	Repeat	95% CI	No repeat	95% CI
Answer given	Positive	0.87	.74, 1.00	0.64	.50, .77	0.08	.03, .12	0.45	.35, .55	0.3	.20, .41	0.16	.10, .23	0.48	.37, .59
	Monopoly	0.37	.27, .47	1.85	1.69, 2.02	0.12	.06, .18	0.13	.07, .18	0.33	.24, .42	0.13	.07, .19	0.36	.26, .46
	Maths	0.23	.16, .31	0.25	.17, .33	2.45	2.24, 2.65	0.61	.48, .74	0.43	.34, .53	0.24	.16, .33	0.24	.16, .32
	Negative	0.71	.57, .85	0.42	.31, .53	0.43	.32, .55	0.96	.81, 1.12	0.6	.48, .72	0.41	.30, .52	0.48	.36, .60
	Not recording	0.43	.31, .54	0.21	.13, .28	0.19	.12, .27	0.26	.17, .35	1.21	1.00, 1.42	0.54	.42, .66	0.67	.54, .81
	Repeat	0.52	.41, .63	0.15	.08, .22	0.26	.17, .36	0.7	.56, .84	0.55	.41, .68	1.97	1.72, 2.22	0.94	.78, 1.09
	No repeat	0.54	.42, .66	0.16	.10, .23	0.06	.02, .11	0.45	.35, .56	0.15	.08, .22	0.18	.11, .26	0.43	.32, .53

4.3.4 Does the stimuli type influence the intensity and valence ratings of emotion responses?

To analyse the influence of each stimuli and prompt type on the perceived intensity and valence of emotion responses, a two way repeated measures ANOVA was conducted on participant's intensity (Scored 0 to 100) and valence (Scored -100 to +100) ratings, in each condition (posed, spontaneous) and prompt type, results of which are presented below in table 4.5.

Table 4.5: *Mean intensity and valence of prompt types when posed and spontaneous*

Prompt types	Posed (SD)	95% CI	Spontaneous (SD)	95% CI
		Intensity		
Positive	35.50 (18.75)	32.38, 38.62	35.08 (19.60)	31.82, 38.34
Monopoly	36.98 (19.85)	33.68, 40.29	39.41 (21.16)	35.89, 42.94
Maths	35.89 (20.76)	32.43, 39.34	37.79 (20.86)	34.32, 41.27
Negative	33.63 (19.43)	30.39, 36.86	31.85 (18.47)	28.78, 34.93
Not recording	35.50 (19.90)	32.19, 38.81	33.66 (18.96)	30.51, 36.82
Repeat	32.14 (18.31)	29.09, 35.19	34.08 (19.42)	30.85, 37.32
No repeat	34.90 (19.02)	31.74, 38.07	34.81 (18.07)	31.81, 37.82
		Valence		
Positive	21.01 (18.37)	17.96, 24.07	11.60 (19.52)	8.35, 14.85
Monopoly	12.04 (21.84)	8.40, 15.68	24.59 (21.85)	20.95, 28.23
Maths	-3.75 (19.28)	-6.96, -.54	-2.76 (17.95)	-5.75, .23
Negative	-3.60 (17.98)	-6.60, -.61	0.41 (18.19)	-2.62, 3.44
Not recording	-3.28 (19.95)	-6.60, .05	-7.92 (19.64)	-11.19, -4.65
Repeat	-2.18 (18.90)	-5.33, .97	1.97 (20.20)	-1.40, 5.33
No repeat	8.84 (17.63)	5.90, 11.77	10.31 (20.91)	6.83, 13.79

The results in table 4.5 show the mean intensity differences between posed and spontaneous stimuli is marginal, however the differences are more prominent within each type. The largest differences for both types of stimuli was between monopoly money rated the most intense and negative feedback (within spontaneous expressions) and repeat experiment (within posed expressions) rated the least intense with spontaneous negative feedback marginally lower in intensity suggesting an element of social display rules are in effect with targets downplaying their negative response in spontaneous reactions but not (as much) in posed. This effect is mirrored in ratings of valence where the spontaneous negative feedback was rated as less negatively valenced than posed negative feedback again suggesting the target was able to mask their negative state more effectively in spontaneous expressions than posed.

4.3.4.1 The effect of stimuli type on intensity ratings

According to Mauchly's test the assumption of sphericity was violated for prompt type and the stimuli and prompt type interaction (Greenhouse-Geisser =.88 and .95 respectively) as such Greenhouse-Geisser adjustments are reported. There was a non-significant effect of *stimuli type* on intensity ratings (F (1, 140) = .71, p=0.401, η_p^2=0.005). There were however significant differences in the intensity ratings ascribed to the prompts (F (5.29, 740.82) = 9.25, p<0.001, η_p^2=0.06). There was also a significant interaction effect between the stimuli and prompt type on intensity ratings (F (6,840) = 2.74, p=0.012, η_p^2=0.02). Analyses of the prompt ratings showed the main effect was largely driven by the monopoly money prompt which was rated as significantly more intense than all other prompts (Negative p<0.001, Repeat p<0.001, No repeat p<0.05, Not recording p<0.01, Positive p<0.05) except maths question (p=1). The maths question prompt was also rated as significantly more intense than negative feedback (p<0.001) and repeat experiment (p<0.05). The significant interaction was due to more fluctuation between expression ratings within stimuli types specifically with monopoly money and negative feedback rated more and less intense respectively in spontaneous delivery than posed.

4.3.4.2 The effect of stimuli type on valence ratings

According to Mauchly's test the assumption of sphericity was violated for prompt type and the stimuli and prompt type interaction (Greenhouse-Geisser =.81 and .92 respectively) as such Greenhouse-Geisser adjustments are reported. There was a non-significant main effect of stimuli type on *valence ratings* (F (1,140) = 3.47, p=0.065, η_p^2=0.02). There was a significant main effect of prompt type on the valence ratings (F (4.87, 681.72) = 83.05, p<0.001, η_p^2=0.37) and a significant interaction between stimuli type and prompt type (F (5.54, 776.16) = 15.42, p<0.001, η_p^2=0.10). Simple main effects analyses showed there were significant differences in the valence ratings ascribed to prompt types depending on the stimuli type; monopoly money (p<0.001) negative feedback (p<0.05) and repeat experiment (p<0.05) were rated significantly more positively valenced when displayed in a spontaneous format, whereas positive feedback (p<0.001) and not recording (p<0.01) were rated significantly more negatively valenced when displayed in a spontaneous format. The monopoly money prompt was rated as the most positively valenced reaction with significant differences from all other prompts (maths p<0.001, negative p<0.001, no repeat p<0.001, not recording p<0.001, repeat experiment p<0.001) except positive feedback (p=1) by contrast the not recording prompt was rated as the most negatively valenced reaction with significant differences from all other prompts (monopoly p<0.001, no repeat p<0.001, positive p<0.001, repeat experiment p<0.01) except maths question (p=1) and negative feedback (p=.109)

4.3.4.3 *Does the valence of the expressions influence recognition?*

To investigate if the differences in recognition rates between the prompt types were influenced by how positive or negative the expressions were rated, a one way ANCOVA was conducted with the prompt types as the independent variable with seven levels (as previous) and recognition rates as the dependent variable. The valence ratings participants gave to reactions were averaged to provide an overall valence score per prompt type that would reflect their proportion recognition in the dependent variable. Results showed a significant main effect of expression type on recognition rates (F (6,979) = 55.85, p<.001 η_p^2 =.26) after controlling for expression valence (F (1,979) = .79, p=.375).

4.3.5 Are emotion and prompt inferences systematic?

In order to check if participants were providing systematic emotion attributions to the different prompts, the responses were coded into the eight emotion categories described previously in section 4.2.5.1 (positive, negative, confused, shocked, engaged, pretend, sceptical and frustrated). To investigate if participants tended to attribute different emotion categories to different prompts, likelihood-ratios were calculated as described in Cassidy and colleagues' work (2014; 2015). Here the observed frequencies of emotion and prompt inferences are compared to chance, for both correct (table 4.6) and incorrect (table 4.7) responses.

In the tables below it can be seen that for *correct* spontaneous responses the positive feedback prompt was overwhelmingly attributed with a positive emotional state, the monopoly money prompt showed the greatest proportion of observed inferences to expected was for a shocked emotion attribution. However, there was also a strong attribution above expected levels for a positive attribution to monopoly money, both those are to be expected as it accurately reflects that responses to monopoly money were both positive and shocked. The maths question prompt was mostly attributed an emotional state of engaged whilst the greatest attribution for negative feedback was a negative emotional response. Both of the not recording and no repeat prompts were most frequently attributed the frustration emotional state above expected levels. The no repeat prompt was most frequently attributed a positive emotional state. The greatest ratio of observed emotion state inferred to expected emotional state inferred by raters when they *correctly* retrodicted the category prompt are considered consistent emotions for their respective categories. This is to allow comparisons of what participants believed to be the most appropriate emotion for specific prompts when they correctly retrodicted the prompt to when they incorrectly retrodicted the prompt. By defining consistent emotions based on participant perceptions it ensures comparisons of emotions inferences to correct and incorrect retrodictions are grounded in the most frequent inference above what would be expected associated with correct recognition rather than arbitrary guesswork.

There is the potential to define the correct emotion by the self-reported emotions taken at stimuli creation, however it was believed the volume of emotion states provided by participants in this experiment (>6000) would provide a clearer image of the overall emotions being portrayed than the self-report emotions which totalled less than 150.

Comparing those attributions of spontaneous emotions to posed displayed a similar pattern as previous recognition rates. Where attributions of positive feedback, negative feedback and no repeat (expressions recognised better when posed) had higher consistent attributions when posed and the remaining expressions (monopoly money, maths question, not recording) showed a decrease in consistent emotion attributions in comparison to spontaneous expressions (the repeat experiment prompt showed a marginal increase in consistent attributions for posed expressions which is contrary to the pattern outlined above). This would suggest the type of stimuli (posed or spontaneous) influences the likelihood of providing correct emotional inferences which in turn is used in retrodicting events.

For incorrect prompt responses the same pattern is not present, it would appear spontaneous stimuli resulted in an overall lower consistent emotional state attribution than posed stimuli. However the proportion of correct prompt inferences observed to those that would be expected was minimised throughout incorrect prompt recognitions (except posed positive feedback) which would suggest when participants could not correctly identify the appropriate cause of the expression they also struggled to identify a consistent emotional state.

Table 4.6: *Frequency of emotion inferences for correct retrodictions in spontaneous and posed stimuli.*

		Correct prompt response (expected frequencies in brackets)						
		Positive	Monopoly	Maths	Negative	Not recording	Repeat	No repeat
A) Spontaneous Emotion Inference	Positive	**108_A (36.8)**	129 (78)	13 (95.2)	9 (32.5)	12 (55.2)	85 (81.7)	**43_A (19.6)**
	Negative	2 (16.8)	13 (35.6)	28 (43.4)	**49_A (14.8)**	40 (25.5)	44 (37.3)	6 (8.9)
	Confused	2 (19.9)	45 (42.2)	72 (51.5)	17 (17.6)	39 (29.9)	35 (44.2)	6 (10.6)
	Shocked	7 (11.2)	**63_A (23.6)**	2 (28.9)	4 (9.9)	29 (16.7)	9 (24.8)	7 (5.9)
	Engaged	3 (28)	3 (59.2)	**213_A (72.3)**	11 (24.7)	12 (41.9)	56 (62)	5 (14.9)
	Pretend	1 (1.2)	4 (2.5)	3 (3.1)	1 (1.1)	2 (1.8)	2 (2.7)	0 (.6)
	Sceptical	4 (4.4)	11 (9.4)	0 (11.5)	6 (3.9)	16 (6.6)	11 (9.8	0 (2.4)
	Frustrated	1 (9.7)	3 (20.5)	0 (25.1)	16 (8.6)	**42_A (14.5)**	**42_A (21.5)**	1 (5.1)
B) Posed Emotion Inference		Positive	Monopoly	Maths	Negative	Not recording	Repeat	No repeat
	Positive	**165_A (61)**	48 (39.4)	7 (71.7)	11 (61.7)	9 (38.8)	64 (75.4)	**80_A (36)**
	Negative	4 (31.6)	8 (20.4)	16 (37.1)	**91_A (32)**	17 (20.1)	53 (39.1)	10 (18.7)
	Confused	5 (31.3)	36 (20.2)	74 (36.8)	18 (31.6)	22 (19.9)	33 (38.1)	9 (18.5)
	Shocked	14 (15.3)	**19_A (9.9)**	6 (17.9)	17 (15.4)	24 (9.7)	10 (18.9)	6 (9)
	Engaged	5 (26.1)	4 (16.8)	**118_A (30.6)**	12 (26.3)	4 (16.6)	17 (32.3)	4 (15.4)
	Pretend	1 (2.5)	2 (1.6)	3 (3)	2 (2.6)	1 (1.6)	5 (3.1)	2 (1.5)
	Sceptical	1 (9.4)	8 (6.1)	5 (11)	13 (9.5)	20 (6)	9 (11.6)	3 (5.5)
	Frustrated	0 (17.8)	1 (11.5)	0 (20.9)	33 (18)	**27_A (11.3)**	**50_A (22)**	1 (10.5)

Note: frequencies bolded and with subscript A denote correct prompt and consistent emotion inference

Table 4.7: *Frequency of emotion inferences for incorrect retrodictions in spontaneous and posed stimuli .*

		Incorrect prompt response (expected frequencies in brackets)						
A) Spontaneous		Positive	Monopoly	Maths	Negative	Not recording	Repeat	No repeat
Emotion Inference	Positive	**112_a (115.4)**	111 (73.2)	16 (50.9)	128 (113.5)	51 (92.8)	71 (66.4)	**156_a (132.8)**
	Negative	86 (74.8)	45 (47.4)	41 (33)	**56_a (73.6)**	77 (60.1)	45 (43)	68 (86.1)
	Confused	48 (52.2)	30 (33.1)	30 (23)	38 (51.4)	53 (42)	26 (30.1)	67 (60.1)
	Shocked	23 (30.8)	**18_a (19.5)**	21 (13.6)	17 (30.3)	24 (24.7)	18 (17.7)	51 (35.4)
	Engaged	36 (46)	20 (29.2)	**14_a (20.3)**	69 (45.2)	51 (37)	27 (26.5)	40 (52.9)
	Pretend	4 (3.8)	1 (2.4)	3 (1.7)	3 (3.7)	2 (3)	3 (2.2)	5 (4.3)
	Sceptical	19 (15.6)	5 (9.9)	10 (6.9)	10 (15.3)	15 (12.5)	10 (9)	18 (17.9)
	Frustrated	44 (33.5)	6 (21.2)	29 (14.8)	45 (32.9)	**26_a (26.9)**	**14_a (19.2)**	23 (38.5)
B) Posed		Positive	Monopoly	Maths	Negative	Not recording	Repeat	No repeat
Emotion Inference	Positive	**122_a (89.1)**	148 (105.4)	46 (78.9)	80 (82.7)	60 (107.1)	61 (79.8)	**134_a (108)**
	Negative	69 (62)	53 (73.3)	64 (54.9)	**46_a (57.6)**	80 (74.5)	79 (55.5)	62 (75.1)
	Confused	36 (54.2)	58 (64.1)	49 (48)	41 (50.3)	101 (65.1)	48 (48.6)	63 (65.7)
	Shocked	12 (19.3)	**22_a (22.8)**	44 (17.1)	24 (17.9)	18 (23.2)	3 (17.3)	18 (23.4)
	Engaged	45 (37.6)	38 (44.5)	**21_a (33.3)**	52 (34.9)	39 (45.2)	40 (33.7)	40 (45.6)
	Pretend	3 (4)	4 (4.7)	8 (3.5)	2 (3.7)	7 (4.8)	4 (3.6)	1 (4.8)
	Sceptical	6 (12.5)	15 (14.7)	12 (11)	13 (11.6)	20 (15)	12 (11.2)	13 (15.1)
	Frustrated	14 (28.3)	25 (33.5)	28 (25.1)	27 (26.3)	**44_a (34.1)**	**28_a (25.4)**	41 (34.3)

Note: frequencies bolded and with subscript a denote incorrect prompt and consistent emotion inference

For simplicity the percentage of emotion inferences to each prompt when correct and incorrect are displayed below in tables 4.8 and 4.9 respectively.

Table 4.8: *Percentage of emotion inferences for correct retrodictions in spontaneous and posed stimuli.*

		Correct prompt response						
		Positive	Monopoly	Maths	Negative	Not recording	Repeat	No repeat
a) Spontaneous Emotion Inference	Positive	**84.38**	47.60	3.93	7.96	6.25	29.93	**63.24**
	Negative	1.56	4.80	8.46	**43.36**	20.83	15.49	8.82
	Confused	1.56	16.61	21.75	15.04	20.31	12.32	8.82
	Shocked	5.47	**23.25**	0.60	3.54	15.10	3.17	10.29
	Engaged	2.34	1.11	**64.35**	9.73	6.25	19.72	7.35
	Pretend	0.78	1.48	0.91	0.88	1.04	0.70	0.00
	Sceptical	3.13	4.06	0.00	5.31	8.33	3.87	0.00
	Frustrated	0.78	1.11	0.00	14.16	**21.88**	**14.79**	1.47
b) Posed Emotion Inference		Positive	Monopoly	Maths	Negative	Not recording	Repeat	No repeat
	Positive	**84.62**	38.10	3.06	5.58	7.26	26.56	**69.57**
	Negative	2.05	6.35	6.99	**46.19**	13.71	21.99	8.70
	Confused	2.56	28.57	32.31	9.14	17.74	13.69	7.83
	Shocked	7.18	**15.08**	2.62	8.63	19.35	4.15	5.22
	Engaged	2.56	3.17	**51.53**	6.09	3.23	7.05	3.48
	Pretend	0.51	1.59	1.31	1.02	0.81	2.07	1.74
	Sceptical	0.51	6.35	2.18	6.60	16.13	3.73	2.61
	Frustrated	0.00	0.79	0.00	16.75	**21.77**	**20.75**	0.87

Note: percentages bolded denote correct prompt and consistent emotion inference

Table 4.9: *Percentage of emotion inferences for incorrect retrodictions in spontaneous and posed stimuli.*

		Incorrect prompt response						
		Positive	Monopoly	Maths	Negative	Not recording	Repeat	No repeat
a) Spontaneous Emotion Inference	Positive	**30.11**	47.03	9.76	34.97	17.06	33.18	**36.45**
	Negative	23.12	19.07	25.00	**15.30**	25.75	21.03	15.89
	Confused	12.90	12.71	18.29	10.38	17.73	12.15	15.65
	Shocked	6.18	**7.63**	12.80	4.64	8.03	8.41	11.92
	Engaged	9.68	8.47	**8.54**	18.85	17.06	12.62	9.35
	Pretend	1.08	0.42	1.83	0.82	0.67	1.40	1.17
	Sceptical	5.11	2.12	6.10	2.73	5.02	4.67	4.21
	Frustrated	11.83	2.54	17.68	12.30	**8.70**	**6.54**	5.37
b) Posed Emotion Inference		Positive	Monopoly	Maths	Negative	Not recording	Repeat	No repeat
	Positive	**39.74**	40.77	16.91	28.07	16.26	22.18	**36.02**
	Negative	22.48	14.60	23.53	**16.14**	21.68	28.73	16.67
	Confused	11.73	15.98	18.01	14.39	27.37	17.45	16.94
	Shocked	3.91	**6.06**	16.18	8.42	4.88	1.09	4.84
	Engaged	14.66	10.47	**7.72**	18.25	10.57	14.55	10.75
	Pretend	0.98	1.10	2.94	0.70	1.90	1.45	0.27
	Sceptical	1.95	4.13	4.41	4.56	5.42	4.36	3.49
	Frustrated	4.56	6.89	10.29	9.47	**11.92**	**10.18**	11.02

Note: percentages bolded denote incorrect prompt and consistent emotion inference

For *correct prompt responses*, results showed that significantly more consistent and less inconsistent emotion and prompt responses were made than the model predicted (*Spontaneous stimuli*: observed consistent=560, expected consistent=203.1, observed inconsistent=827, expected inconsistent=1180.5, $L\chi^2$ (42) = 1131.54, p<0.001; *Posed stimuli*: observed consistent=550, expected consistent=202.8, observed inconsistent=677, expected inconsistent=1023.8, $L\chi^2$ (42) = 1059.73, p<0.001).

For *incorrect prompt responses*, results showed significant differences between consistent emotion and prompt responses to those predicted by the model although the differences are much less pronounced and largely driven by inferences made from posed stimuli (*Spontaneous stimuli*: observed consistent=396, expected consistent=407.7, observed inconsistent=1683, expected inconsistent=1671.5, $L\chi^2$ (42) = 202.97, p<0.001; *Posed stimuli*: observed consistent=416, expected consistent=370.3, observed inconsistent=1815, expected inconsistent=1872.6, $L\chi^2$ (42) = 229.86, p<0.001).

4.3.6 What role does Autism and Alexithymia play?

As autism and Alexithymia traits were measured in both the participants who created the expressions and those who viewed them, there is ample opportunity to investigate how both conditions influence expression recognisability from senders and recognition ability in the receivers.

4.3.6.1 Do Autistic and Alexithymia traits influence recognisability of one's emotional responses?

Investigating the relationship of Autistic and Alexithymia traits in the displayer (n=19) on recognisability of their emotion responses via two-tailed Pearson's correlations showed non-significant relationships between expressers' self-reported autistic traits and judges accuracy in interpreting their responses, irrespective of stimuli type (is this expression posed or spontaneous?) (Total recognition r=-0.227 p=0.349, posed recognition r=-0.243 p=0.316, spontaneous recognition r=0.030 p=0.903) and or prompt type recognition (recognition of emotional states) (total recognition r=-0.146 p=0.552, posed recognition r=-0.193 p=0.429, spontaneous recognition r=-0.031 p=0.899). Similar relationships were shown between Alexithymia traits in the displayer and recognition of stimuli type (total recognition r=-0.449 p=0.054, posed recognition r=-0.178 p=0.467, spontaneous recognition r=-0.405 p=0.085) and recognition of prompt types (total recognition r=-0.340 p=0.154, posed total r=-0.288 p=0.231, spontaneous total r= -0.272 p=0.259).

The distribution of AQ scores can be seen in Figure 4.2 below with a peak around the expected score of 17 for a typically developing sample. The distribution follows a normal curve from minimal traits to 30 just below the cut off of 32 identified as a marker for clinical levels of autism traits.

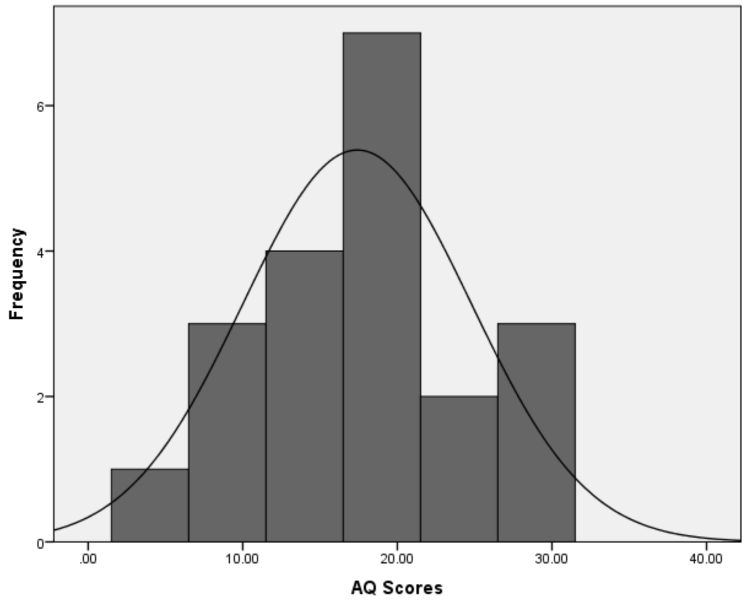


Figure 4.2*: A histogram of autism quotient scores of expression displayers*

4.3.6.2 Do Autistic and Alexithymia traits in the judges influence recognition rates?

Investigation of autistic and Alexithymia traits in the expression viewers via two-tailed Pearson's correlations showed a significant moderate positive correlation between AQ scores and Alexithymia scores (*r*= 0.495, *p*=<0.001). There was a significant negative correlation between AQ scores and overall recognition (*r*= -0.175, *p*=0.019), this was driven by difficulties in spontaneous emotion recognition (*r*= -0.232, *p*=0.003), not posed (*r*= -0.060, *p*=0.239). Alexithymia displayed the same trend although not statistically significant (*r*= -0.137, *p*=0.053) the trend was once again driven by association with recognition of spontaneous stimuli (*r*= -0.159, *p*=0.030) but not posed (*r*= -0.086, *p*=0.156).

4.4 Discussion

This research aimed to validate a new naturalistic set of emotion responses for studies exploring RM in typical and atypical development. A secondary aim was to compare methods of eliciting emotion responses, either spontaneously felt during a social interaction, or deliberately posed on direct request from the experimenter. Results showed that overall participants were significantly better at recognising spontaneous expressions than posed. However, this varied according to specific emotions; the positive, negative and no repeat prompts were significantly more accurately recognised from posed than spontaneous expressions. The opposite effect was found with maths question, monopoly money, repeat and not recording which were significantly better recognised when spontaneous than posed.

The overall improved recognition of spontaneous expressions compared to posed was contrary to expectations from previous research, which present a unanimous improvement for posed expressions (Hess & Blairy, 2001; Wagner 1990; Wagner et al., 1992; Naab & Russell, 2007). Potential reasons for this contradictory finding could be the method of emotion evocation used in this experiment. By capturing naturalistic reactions to social cues under covert recording, the responses collected are higher in ecological validity than those captured in isolation (Schmidt, Ambadar, Cohn & Reed, 2006; Schmidt et al., 2003) or in contexts that don't require a socially reactive response (Valstar & Pantic 2010; Lang et al., 2008; Gur et al., 2002; Gosselin et al., 1995). This in turn would suggest the reactions used in this experiment are closer to truly naturalistic socially typical responses than those used previously. Therefore the improvement in spontaneous recognition may be a result of expressions more accurately reflecting true social interaction which participants could more readily identify. Coupling this with the work of Schmidt and colleagues (2003), which demonstrated stronger onset amplitudes of expressions captured in social situations, and those of chapter 3 evidencing less consistent display patterns in posed expressions, the improved recognition of spontaneous expressions in this research further highlights the importance of truly social cues that may be more intense and subsequently invoke expressions that better resemble typical reactions.

Analysis of participants' error patterns showed there were systematic choices evident for most expressions where the correct answer was chosen significantly more than the incorrect alternatives. Only the no repeat and not recording prompts showed participants had difficulty in distinguishing the correct answer from incorrect options. This systematic pattern was mirrored in emotion attributions to each social prompt, where more emotion and prompt observations we would expect to be consistent with one another (e.g. positive to positive feedback, engaged to maths question) were present than a model expected and less inconsistent observations (e.g. negative to positive feedback, monopoly money to frustration) than a model expected. The pattern of emotionally consistent attributions across prompt and stimuli types was similar to recognition rates, with positive and negative feedback having higher consistent emotion attributions when presented in a posed format compared to spontaneous. This may be due to incorrect prompt inferences in spontaneous stimuli being caused by low signal clarity in the stimuli. The higher consistent emotion attribution in the posed stimuli is potentially due to participants forming a singular basic expression less complex than those in naturally occurring spontaneous expressions. The systematic nature of the prompt recognition and emotion attributions present similar findings to (Cassidy et al., 2014; 2015), suggesting the emotional inference ascribed to a reaction influences what people perceive to have caused said reaction. Furthermore, participants can successfully gauge a person's emotional response in order to correctly infer what actually happened to them. The findings in this study add to this evidence base, showing the importance of stimuli type (posed or spontaneous) in influencing this decision making process.

Analysis of participants' intensity and valence ratings of videos showed no significant effect of stimuli type on intensity but a significant effect on valence with spontaneous expressions rated more positive than posed. Differences in intensity were present between the prompts but this was to be expected given the varied nature of the reactions, the most intense expression was maths question and the least intense was negative feedback, which suggests elements of social display rules were present. Such findings should be considered for future research looking to measure emotion recognition; this evidence would suggest the subtle changes in both intensity and valence are tempered by the social context. In this instance participants' spontaneous reaction to negative feedback was perceived as both less intense and less negatively valenced than their attempt at posing the same reaction. This could be due to social display rules minimising the negative reaction or a flawed attempt to recreate the expression, in either case the difference is noticeable to raters and as such research should consider the aims being explored and if posed expressions can answer the questions set.

There were no significant relationships between traits of autism or Alexithymia in the emotion displayer influencing recognition. This is contrary to previous research (Brewer et al., 2016; Volker et al., 2009; Macdonald et al., 1989) but not unexpected as no individuals used to create the stimuli scored highly enough to indicate risk of clinical autism (scores >32) (two participants were borderline scoring 31 and 30). However considering the small sample size used, it is likely that given the associations shown and in the expected directions (Self-report autistic traits negatively associated with posed emotion recognition and self-report Alexithymia traits negatively associated with spontaneous emotion recognition), a significant effect would be found with a larger sample on the autistic spectrum. Investigating the presence of self-report autism and Alexithymia traits in participants used to validate the expressions showed significant negative correlations between both AQ and TAS scores and spontaneous expression recognition. Such a finding is consistent with previous research highlighting difficulties in these populations (Harms et al., 2010); the specificity of this relationship to spontaneous expressions is not surprising given previous research has identified group differences can emerge with more subtle stimuli (Hoffmann et al., 2010) and evidence that spontaneous expressions are shorter in length than posed (Schmidt et al., 2003).

The findings then suggest the stimuli set consists of valid spontaneous and posed expressions that viewer's process in a systematic way with recognition rates significantly above chance for six of the seven categories (no repeat prompt falling below chance). The secondary aim of the research to investigate recognition patterns across emotions did not support the hypothesis that posed expressions would be better recognised than spontaneous. However typically socially posed emotions (positive feedback/happiness and negative feedback/sadness/anger) were better recognised when displayed in a posed format which may be due to the similar nature in the manifestation of those expressions. This finding has important implications for future research assessing emotion recognition and the methods employed. These results question previous reports of improved recognition of posed stimuli, particularly with the stimuli used which are captured in a controlled naturalistic social interchange. Future research should consider the stimuli used, if posed expressions can be considered easier recognised than spontaneous expressions and the validity of those spontaneous expressions. Including naturalistic spontaneous expressions in future research may shed new light on reported differences in emotion recognition between the sexes (Hall 1984; 1978; Hall & Matsumoto, 2004; McBain et al., 2009) and those with atypical development (Harms et al., 2010).

These findings have implications for methods in future research investigating emotion recognition. They question the validity of previous stimulus sets as adequate measures of emotion processing competency and expand a new paradigm with which to explore emotion processing in realistic social situations. This stimulus set has practical applications in research investigating recognition competencies and eye tracking research interested in visual perusal patterns. The higher quality stimuli set evidencing an improvement for spontaneous recognition poses questions on the visual patterns employed, and if these are likely to vary between posed and spontaneous expressions. Similarly, there is room for research to investigate the physiological differences in a stimuli set of matching posed and spontaneous expressions where the spontaneous expressions are of a high quality.

This research has its limitations due to its use of judges' emotion inferences as a method to establish a 'consistent' emotion to a given situation. This method, although it has its strengths, relies on inferences external to the displayer to define the displayers felt emotions and subsequently use this as an objectively correct answer. This of course may be entirely contradictory to what the individual in the stimuli reports to feel. However, the stance in this work is that emotions are communicative in nature, to apply uneven weight to one side of this communication process by assuming whatever people report to feel is unquestionably what they have communicated or displayed may be too simple an approach. By the same line of argument, to assume what someone see's is how someone else feels is also simplistic, but the latter approach does have the benefit of consensus in large sample sizes. Future research may find it fruitful to investigate the degree to which self-report emotions are corroborated by judges ratings, this particular question would be better addressed with spontaneous expressions where genuine changes in emotional state are more likely to occur.

The stimuli validated in this research contain 133 spontaneous expressions captured in a naturalistic social interchange via covert recording from participants unaware of the true aim of the research. 133 matching posed expressions were created to allow comparisons in recognition, emotional inferences, intensity and valence in a depth not covered previously. Participants used for expression development were screened with the AQ and TAS to control for difficulties in emotion production ability, similarly the participants used to validate the expressions were screened to control for difficulties in recognition that could confound the validity of the stimulus set. The finished stimulus set is larger than many spontaneous sets currently available; with expressions more representative of typical social interchange due to the strict methods employed.

In summary this chapter presents evidence that the expressions created are recognised above chance for six of the seven prompts (No repeat not above chance). Contrary to previous work the spontaneous expressions were recognised significantly better than posed. Only for 'positive feedback', 'negative feedback' and 'no repeat' prompts was recognition significantly better in a posed format. Participants' attributions of emotion to the prompts appeared to be systematic and this influenced the likelihood of inferring the correct prompt to the video. These results underpin the importance of correct emotional attributions in inferring socially appropriate responses and highlight the usefulness of the RM paradigm as a method to assess emotion recognition and understanding of socially appropriate responses.

Chapter 5 The Relationship between Viewing Patterns, Retrodictive Mindreading Ability and Autistic Traits

The previous chapters have highlighted the need for a new stimulus set and shown stimuli that address some of the concerns of complexity, spontaneity, and task demands can result in different display patterns and recognition rates. The current chapter will expand this further by investigating if this is emulated in viewing styles and if those viewing styles are predictive of ASC traits.

5.1 Introduction

Chapter 2 highlighted the importance of emotion recognition and processing as a vital part of social cohesion as well as relationship development and maintenance. This ability is used in virtually every aspect of daily living from social chit-chat to forming sustained relationships with loved ones. The development of emotion processing was also discussed previously, with infants displaying the ability to orient to faces at birth (Johnson & Morton 1991; Morton & Johnson 1991), developing to holistic processing (focussing on the eyes, nose and mouth to produce a whole) (Tanaka et al., 1998) and later advanced featural processing (Bruce et al., 2000). Research involving emotion processing with children has tended to focus on expressions that do not accurately reflect the emotion responses that would be expected in daily situations. Much research utilizes the JACFEE (Matsumoto and Ekman, 1988; Biehl et al., 1997) which only contain examples of the basic six expressions and are typically presented as monotone colour, static images (Kessler et al., 2008; Shioiri et al., 1999; Hall & Matsumoto 2004; Matsumoto et al., 2002; Elfenbein & Ambady 2002). As the research in chapter 3 showed differential display patterns in posed and spontaneous expressions and chapter 4 showed differential recognition, it is required to investigate further if these results are translating to viewing styles.

As methods in the literature have advanced, paradigms such as the part-whole paradigm can be replaced with eye tracking measures which allow detailed analysis of where visual attention is directed. When using eye-tracking equipment to monitor how visual attention is allocated multiple measures are considered important. These measures can include; the number of fixations to a specific region of interest, the duration of those fixations, the sequence of fixations and distance and velocity of saccades and scan paths (Jacob & Karn 2003). Numbers of fixations provide a metric for how many times individuals focus on a specific point, it is a useful measure to quantify which locations attract more attention (when defined as a region of interest). The duration of fixations allows an understanding of where most of the time is spent viewing the stimuli, Duchowski (2007) suggests fixation duration is correlative of cognitive function, with greater durations associated with more cognitive activity. Scan path analysis or sequence/time course analysis is more prevalent in newer research with better eye-tracking equipment, it is particularly useful for highlighting different viewing styles between individuals (Rutherford & Towns 2008; Yi et al., 2013)

Eye-tracking research has highlighted that visual scanning of faces develops from an analytical style (scanning across the facial features) to holistic with age (schwarzer, Huber & Dümmler, 2005; Durand, Gallay, Seigneuric, Robichon & Baudouin, 2007). After early infancy it appears most attention is focussed on the eyes (Haith, Bergman & Moore, 1977) sometimes up to three times as much time is spent viewing the eyes as the mouth (Speer et al., 2007; Wagner, Hirsch, Vogel-Farley, Redcay & Nelson, 2013). Crucially the first fixation to a stimulus is typically made to the eyes (Hernandez et al., 2009; Fletcher-Watson, Leekam, Benson, Frank, & Findlay, 2009). These findings would suggest the eyes are a key region in gleaning social information; this is true for when attention is directed to the eyes as much of the cumulative duration of time is spent fixated there.

The eyes also hold important information because they provide a window into another perspective on the world. By paying attention to other people's eyes we are able to gain more information about what is important and worth attention in the current environment. Put simply, where people focus their attention will tend to draw the attention of others (Langton & Bruce 1999; Ristic et al., 2005; Senju, Csibra & Johnson 2008). Research has shown that typically developing individuals attend to people and faces as a priority when shown complex photographic scenes (Birmingham, Bischof & Kingstone 2009). The results in autism show a different pattern of visual attention with ASC individuals less attentive to people, specifically faces, along with other social cues (Dawson et al., 2004; Dawson, Meltzoff, Osterling, Rinaldi & Brown 1998; Pelphrey et al., 2002).

In some research there appears to be no differences in viewing styles between ASC participants and matched controls (Van Der Geest, Kemner, Cafferman, Verbaten & van Engeland 2002). However, the particular method in this research involved the viewing styles to cartoon faces, the previously discussed research of Rosset and colleagues demonstrated no differences between ASC and control participants in recognition of cartoon faces, and highlighted the over exaggerated features of cartoons as likely causes for this result. It is possible the same effect is present in van der Geest and colleagues work with cartoon faces posing different demands in viewing styles and salience than would be expected of real faces. The authors do make note of this limitation suggesting other factors such as social interaction or scenes more social in nature play a bigger role.

More recent research has investigated viewing styles to more realistic social scenes with inherently social information embedded in the form of gaze cues. Comparing the viewing styles of high-functioning ASC individuals to typically developing matched controls showed similarly large portions of time spent viewing the face in both groups (Freeth, Chapman, Ropar & Mitchell 2010). However differences did emerge in attention to the eyes, and perhaps most importantly although the ASC individuals did show responsiveness to gaze direction cues, this was not reflected by fixation duration increase to the gaze location. This lack of looking to informative cue but not translating to meaningful information suggests ASC individual can identify someone is looking at something in this direction that they find interesting, but this saliency of a worthwhile object or event does not translate to the ASC individual as they show notably less time fixated at the gaze cue location. Gaze cues also provide more information than the immediate environment; they allow a window into the mental states of others as demonstrated by Baron-Cohen's (1995) work which showed children as young as four can infer the mental state of thinking to an image of someone looking up. Similarly, looking down can be associated with shame or embarrassment, the idea was further developed in the 'reading the mind in the eyes task' (Baron-Cohen et al., 1997; 2001),

The previously discussed results of display rules and their lack of presence in posed expressions have implications for social emotions, such as pride, shame and embarrassment. These are often associated with gaze cues (looking down in shame or avoiding eye contact in embarrassment); this rich information is almost entirely governed by the eyes (and some head gesture). Preferential looking to or away from these regions could have key implications for social understanding, and different viewing in posed or spontaneous expressions could hold similarly important results.

Thinking spontaneous expressions are an improvement towards more ecologically valid approximations of true social interaction is logical; but such a claim should be supported by evidence of differences in display patterns and recognition rates. Some such evidence suggests the physical presentation of expressions differ when spontaneous, with smiles of lower amplitude that last longer than posed smiles (Cohn & Schmidt, 2004). There also appears to be altered action unit (the distinct elements that make up expressions such as upturned lips for smiling) occurrences, durations, and intensity of eyebrow movements in spontaneous expressions. The evidence of altered expression formation, ranging from distinct physiological patterns to duration and intensity means there is legitimate reason to continue investigating the differences between posed and spontaneous expressions in more avenues. It is important to consider if the previously reported effects of spontaneous expressions translate to the manner in which these expressions are viewed. This has implications for the established viewing styles that are considered normative, and that which is (haphazardly) reported as atypical in ASC. As is sound scientific practice a control baseline is required to compare everything else to, currently the baseline in emotion perception is formed from expressions that for various reasons outlined in chapter 2 are highly unlikely to invoke viewing styles that would be representative of real world processing.

Incorporating the RM paradigm with a newly developed stimulus set of matched spontaneous and posed evoked emotion expressions, the current research aims to investigate the recognition rates of typically developing children on a task that should better asses emotion processing and contextual understanding with stimuli that is more naturalistic to allow valid assessments. Through the use of eye tracking software the research also aims to investigate the viewing patterns children exhibit, if these are governed by the stimuli type, and crucially if viewing style and the ability to retrodict events can predict autistic traits. An age range of 6-12 is identified to investigate the ability of a developing sample to complete a retrodictive mindreading task; research typically focusses on labelling of emotions at this age range but there is scope to investigate if children have developed a socially appropriate understanding of emotions at this age. It is also important to consider with the distinct factor structures present between posed and spontaneous expressions how children view these expressions to establish data for a viewing style of posed and spontaneous expressions before processing maturity is reached. The results could have implications for the type of stimuli that is deemed appropriate for future investigation of emotion recognition/processing in children.

Fixations and durations were chosen as dependent variables because they provide a reliable indicator of areas of high salience they are commonly used in eye-tracking research (Dalton et al., 2005; Klin et al., 2005; Pelphrey et al., 2005; Speer et al., 2005; Freeth et al., 2010; Cassidy et al., 2014; 2015). Scan-path/sequence analysis is not included because this typically holds more value in comparing between individuals with inherent differences (such as autism and control) but this was not the sample intended for this research. Similarly, the analysis of scan paths can become over complex, this is particularly true in the case of multiple types of expressions in different display formats (posed and spontaneous). To this end it was decided fixations and duration of fixations provided a more manageable whilst informative measure of which areas are deemed salient,

It is predicted based on performance in typically developing adults and evidence of expression expressivity, that recognition of spontaneous expressions will be significantly better than posed. As previous findings with the stimuli have shown less consistent emotion patterns in posed expressions, it is predicted there will be significantly more fixations to posed expressions where participants should be less likely to have their attention drawn to specific regions. It is also predicted significantly longer will be spent viewing the highlighted regions of interest (the eyes, mouth, face and body) in spontaneous expressions where participants should find clear expression patterns to direct their attention towards for longer periods of time. Finally it is predicted that RM ability and viewing patterns will significantly predict autistic traits, it is expected worse performance on the RM task and more time viewing the mouth and body will predict higher autistic traits according to the autism quotient.

5.2 Method

5.2.1 Design

The research employed a repeated measures design, participants viewed both posed and matching spontaneous expressions. Analysis of recognition rates between the expression types was investigated via one-way ANOVA with RM performance as DV and expression type as IV with four levels (maths, monopoly, negative, positive). Analysis of viewing behaviour was analysed via three-way ANOVA comparing stimuli with two levels (posed, spontaneous), expression with four levels (maths, monopoly, negative, positive) and region of interest (eye-to-mouth ratio, face-to-body ratio) this analysis was completed twice; once with number of fixations as the dependent variable and again for duration of fixations as the dependent variable. The eye region spanned both eyes including the nose in the middle, the mouth region expanded to the bottom of the chin, this is because key AU activity for certain expressions such as disgust and surprise rely on nose and chin movement respectively. Finally a multiple regression was conducted investigating RM performance, eye-to-mouth and face-to-body viewing behaviour as predictors of autism quotient scores. Ethics was granted through part of the Coventry

Young Researchers event as a whole, evidence of submission to Coventry young researchers and confirmation of event clearance can be seen in appendix G.

5.2.2 Participants

The research recruited 38 participants. Parents were invited to bring children to Coventry Young Researchers, a science engagement event organised by the Psychology department at Coventry University. Children were invited to take part in various educational activities as well as research. Of the 38 participants that took part usable eye-tracking data was collected from 32 children (16 males, 16 females, Mean age = 9.12, SD= 1.57, range 6 – 12.75), this was the remaining sample that achieved accurate calibration and tracking. Analysis of the validity ratings showed 82.66% of the fixations identified achieved the recommended validity ratings of 0 or 1 for analysis. Of the 6 children where accurate tracking of the eyes could not be achieved this was usually attributed to children wearing glasses which interrupted the infrared tracking system, whilst other children were unable to maintain a static seated position long enough to complete the task.

5.2.3 Materials and apparatus

Thirty-two videos (ranging in duration from 2 to 8.3 seconds) from four emotion expression categories were selected for this experiment, sixteen of which were posed and sixteen were spontaneous. These were presented on a Tobii (TX300) eye tracker in high definition (1920x1080). Eye movements were recorded at a rate of 300Hz per second. The WASI-II short form of vocabulary and matrix reasoning was used as a measure of IQ and a parent report version of the autism quotient was used to measure autistic traits in the children.

The autism spectrum quotient: child version (Auyeung et al., 2008) was used as a screening measure for autism traits. The scale has shown high sensitivity (95%) and specificity (95%) with high test-retest reliability (r = 0.88) and good internal consistency with all sub-scales presenting $\alpha > 0.8$ and on overall $\alpha = 0.97$.

5.2.3.1 Stimuli

The stimuli used in the present study were created in chapter 3. The detailed process of the stimuli creation can be seen in sections 3.2.4 and 3.2.5. A smaller range of expressions were used in this research; this included the maths question, monopoly money, positive feedback and negative feedback. This was done for two reasons, it allowed shortening of the experimental procedure in line with more manageable expectations of children who would be required to sit still to allow accurate use of the eye tracker. Secondly, the four previously mentioned expressions showed good recognition rates across various different emotional categories; they also showed reasonable factor structures or the most marked differences in factor structures between posed and spontaneous expressions. There was a strong case for the inclusion of the repeat experiment prompt as this too showed good recognition rates, however the frequency of emotion inferences to this prompt were more varied across other emotion options suggesting this reaction could be interpreted multiple ways which may be beyond the competencies of the sample proposed.

The process by which expressions were selected for this research was constrained by the interest in measuring viewing styles and recognition rates between posed and spontaneous expressions. To ensure any differences were due to stimuli expression type and not individual differences any spontaneous expressions selected also required the paired posed expression from that displayer to be chosen. This presented issues where some ideal spontaneous expressions with good recognition rates had a paired posed expression with poor recognition or vice versa.

Thirty-two expressions were used in the current study from the four expressions types listed above. Four matching posed and spontaneous videos were chosen from each expression type with good recognition rates resulting in a total of 16 posed and 16 matching spontaneous expressions. The recognition rates of individual expressions across the entire stimuli set along with highlighted chosen categories and specific expressions can be seen below in Table 5.1

Table 5.1: *Recognition rates of individual expressions and chosen expressions*

Participant No.	Maths		Monopoly		Negative		No repeat		Not recording		Positive		Repeat	
	Posed	Spont.	Posed	Spont.	Posed	Spont.	Posed	Spont.	Posed	Spont.	Posed	Spont.	Posed	Spont.
1	0.21	0.74	0.13	0.85	0.12	0.52	0.00	0.12	0.08	0.26	0.39	0.09	0.36	0.58
2	0.20	0.72	0.21	0.00	0.19	0.24	0.15	0.12	0.09	0.39	0.05	0.03	0.22	0.48
3	0.33	0.70	0.08	0.81	0.36	0.17	0.04	0.20	0.12	0.84	0.42	0.04	0.29	0.39
4	0.33	0.67	0.04	0.63	**0.71**	**0.40**	0.23	0.13	0.24	0.12	0.38	0.16	0.44	0.91
5	0.04	0.67	0.05	0.11	0.33	0.52	0.43	0.05	0.22	0.14	0.21	0.17	0.32	0.88
6	**0.89**	**0.73**	0.17	0.63	0.29	0.48	0.04	0.61	0.38	0.41	**0.59**	**0.39**	0.42	0.68
7	0.38	0.17	0.28	0.74	**0.67**	**0.28**	0.00	0.04	0.42	0.17	**0.51**	**0.63**	0.63	0.39
8	0.91	0.26	0.23	0.52	**0.64**	**0.28**	0.61	0.13	0.19	0.59	0.25	0.00	0.16	0.26
9	0.78	0.57	0.3	0.42	0.56	0.12	0.12	0.04	0.29	0.25	0.28	0.29	0.12	0.61
10	**0.80**	**0.68**	0.23	0.76	0.18	0.25	0.21	0.00	0.23	0.77	**0.78**	**0.60**	0.81	0.65
11	0.00	0.81	**0.46**	**0.42**	0.26	0.19	0.42	0.13	0.12	0.40	0.26	0.07	0.00	0.83
12	0.63	0.96	0.30	0.38	0.17	0.08	0.06	0.11	0.09	0.57	0.63	0.40	0.70	0.59
13	**0.96**	**1.00**	0.12	0.41	**0.88**	**0.42**	0.42	0.05	0.22	0.19	0.25	0.54	0.58	0.5
14	0.32	0.71	0.00	0.35	0.28	0.00	0.15	0.15	0.44	0.40	**0.42**	**0.58**	0.45	0.38
15	0.13	0.39	0.08	0.44	0.25	0.08	0.56	0.31	0.19	0.32	0.17	0.08	0.78	0.39
16	0.11	0.73	**0.83**	**0.83**	0.65	0.09	0.21	0.24	0.52	0.24	0.11	0.19	0.75	0.92
17	0.83	0.57	**0.81**	**0.49**	0.74	0.21	0.75	0.00	0.44	0.42	0.75	0.04	0.88	0.50
18	**0.77**	**0.92**	**0.54**	**0.63**	0.25	0.11	0.09	0.09	0.40	0.84	0.61	0.33	0.60	0.25
19	0.28	0.65	0.13	0.68	0.29	0.25	0.14	0.24	0.18	0.22	0.51	0.08	0.52	0.89
Average	0.47	0.67	0.26	0.53	0.41	0.25	0.24	0.15	0.26	0.40	0.40	0.25	0.48	0.58

Note: Shaded columns denote reaction types used in experiments bolded and outlined cells denote selected expressions

5.2.4 Procedure

Participants' parents had given consent to the Coventry Young Researchers event before arriving but renewed verbal consent was gained after the research had been explained. Participants sat at a standard 2 seater desk approximately 70 centimetres in distance from the Tobii eye-tracker directly in front of them. The researcher sat on the opposite side of the 2 seater desk administering the experiment via laptop computer. The task was explained to the participants that they would see a short video and be asked which of the four options that would appear on the screen in front of them do they think caused the reaction (see appendix H for example options). They would then be asked how they thought the person in the video felt from a four choice forced option with a guidance sheet to aid them (see appendix I for guidance sheet) finally it was made clear it is important to stay as still as possible to allow the eye-tracker to work. The expressions were administered in two counterbalanced parts to allow a short break for participants in between and allow recalibration of the eye-tracker halfway through the experiment. Matching expressions were ensured within each part (e.g. if person A showing a posed reaction to monopoly money was shown in part 1, the matching spontaneous reaction to monopoly money was also in part 1) the expressions were presented in a randomised order within each part. After completing the eye-tracking portion of the experiment participants completed the WASI-II. Parents completed the parent report form of the autism quotient while the child was participating in research.

5.3 Results

5.3.1 Screening

The AQ scores of participants were calculated to ensure the sample was majority typically developing. Only two participants (scores of 80 and 120) presented AQ scores greater than the 76 threshold outlined in the manual for accuracy of sensitivity and specificity (Auyeung et al., 2008). These participants were retained as their exclusion did not overly affect the mean and only the participant scoring 120 was shown to be an outlier during regression which did not subsequently show high leverage. The mean AQ score of the sample was 53.94 (SD=17.44), the mean of the sample with the two participants removed was 50.86 (SD=12.33).

5.3.2 What are the patterns of expression recognition?

Participants' responses were collated and a confusion matrix compiled, it shows the responses given relative to the correct answer. In table 5.2 below it can be seen the maths question response and monopoly money response had more correct recognition than the three alternative responses. The negative feedback and positive feedback responses show poor recognition, often confused with maths question and monopoly money responses respectively. The confusion matrix shows the expressions are likely to be confused with an alternative that fits the same valence category. Although the maths question and monopoly money prompts were clearly recognised, the next most frequent response was negative feedback for maths question and positive feedback for monopoly money suggesting there is a clear distinction between responses that convey a positive valence (monopoly money and positive feedback) and those that convey a negative valence (maths question and negative feedback). The same pattern of confusion is found in negative and positive, where the respective valence congruent responses (maths-negative/ monopoly-positive) are actually more consistent than the correct answer but still more frequent than valence incongruent responses.

Table 5.2: *Confusion matrix of participants emotion responses when stimuli is posed and spontaneous*

		Correct answer				
		Maths	Monopoly	Negative	Positive	Total
a) Posed stimuli participants responses	Maths	77	21	55	23	176
	Monopoly	17	74	22	47	160
	Negative	25	4	42	29	100
	Positive	21	38	24	39	122
	Don't know	4	7	1	6	18
	Total	144	144	144	144	
		Maths	Monopoly	Negative	Positive	Total
b) Spontaneous stimuli participants responses	Maths	75	17	36	30	158
	Monopoly	15	86	23	46	170
	Negative	33	3	44	32	112
	Positive	16	32	33	32	113
	Don't know	5	6	8	4	23
	Total	144	144	144	144	

Note: Shaded cells denote correct answer

5.3.3 Are there differences in the recognisability of the expressions?

In order to investigate the differential recognition rates of the four expressions, percentage of correct recognition was calculated and two-way ANOVA conducted. Percentage correct recognition was the dependent variable and expression type as the first independent variable with four levels (maths question, monopoly money, positive feedback and negative feedback) and stimuli type as the second independent variable with two levels (posed, spontaneous).

Results showed the main effect of Stimuli type was non-significant (F (1, 32) = .06, p=.82. There was a significant main effect of expression type on percentage correct recognition (F (3, 96) = 3.45, p=0.02) η_p^2 (.09). There was no interaction between stimuli type and expression type on recognition rates (F (1, 32) = 1.14, p=.29. Bonferroni corrected post-hoc analyses showed the main effect of expression was specific to posed expressions where the monopoly money expression was recognised significantly more than positive feedback (p=.02) There were no other significant differences in recognition rates between posed and spontaneous stimuli or individual expression types. A graph depicting the mean percentage correct recognition per prompt can be seen in figure 5.1.

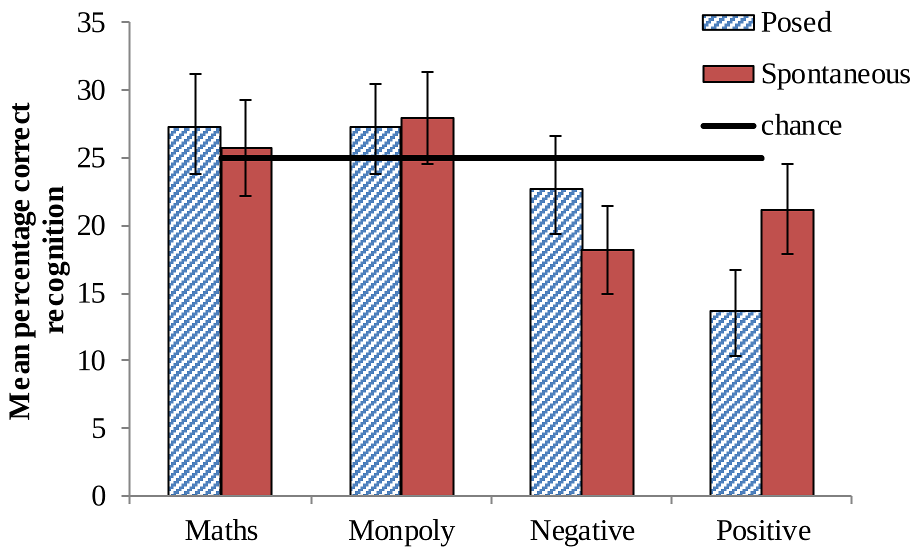


Figure 5.1: *Mean recognition rates of expressions with 25% chance error bars show ±1SE*

5.3.4 Are the emotion inferences given to expressions systematic?

To check if participants gave situationally appropriate emotion inferences to the expressions the occurrences of each inference made when the expression recognition was correct and incorrect was tabulated as was conducted in Chapter 4 and in previous research (Cassidy et al., 2014). The consistent emotion to reaction inferences were maths question to thinking, monopoly money to surprised, negative feedback to sad and positive feedback to happy. The consistent emotion to reaction follow the same coding scheme developed when the stimuli was validated with typically developing adults (Chapter 4) Using maximum likelihood theory, the observed number of consistent emotion to reaction attributions is compared to chance via likelihood ratio for both correctly retrodicted expressions and incorrect.

The frequencies of emotion attributions for correct and incorrect prompt retrodiction can be seen in table 5.3 and 5.4 respectively. Table 5.3 shows the frequency of emotional states that were reported when participants *correctly* retrodicted the prompt (e.g. the participant is shown a video of someone reacting to being given monopoly money and correctly retrodicts that the person in the video has been given monopoly money). Table 5.4 shows the frequency of emotional states that were reported after *incorrect* retrodiction of a prompt (e.g. the participant is shown a video of someone reacting to some negative feedback but incorrectly retrodicts that they were asked a maths question). The columns in table 5.4 refer to the incorrect answer the participant gave. Between table 5.3 and 5.4 it is possible to compare the frequency of emotions inferred to the same video after correct and incorrect retrodiction of the preceding event, this allows an insight into the importance of correct retrodiction on subsequent emotions inferred. In correct recognition for both the posed and spontaneous prompts the consistent emotion is observed more frequently than would be expected. Only the monopoly money expressions shows an inconsistent emotion attribution occurring more frequently than would be expected, in this instance children attributed happiness more than would be expected this was more pronounced in spontaneous expressions

Table 5.3: *Frequency of emotion inferences for correct retrodictions to posed and spontaneous expressions.*

	Posed correct response						Spontaneous Correct response						
Emotion inference		Maths	Monopoly	Negative	Positive	Total	Emotion inference		Maths	Monopoly	Negative	Positive	Total
Thinking	Count	**52**[A]	10	2	0	64	Thinking	Count	**46**[A]	4	1	0	51
	Expected Count	21.24	20.41	11.59	10.76	64		Expected Count	16.14	18.51	9.47	6.89	51
	% within column	67.5 %	13.5 %	4.8 %	0.0 %	27.6 %		% within column	61.3 %	4.7 %	2.3 %	0.0 %	21.5 %
Surprised	Count	13	**30**[A]	7	4	54	Surprised	Count	12	**26**[A]	5	1	44
	Expected Count	17.92	17.22	9.78	9.08	54		Expected Count	13.92	15.97	8.17	5.94	44
	% within column	16.9 %	40.5 %	16.7 %	10.3 %	23.3 %		% within column	16.0 %	30.2 %	11.4 %	3.1 %	18.6 %
Sad	Count	8	2	**32**[A]	0	42	Sad	Count	7	3	**37**[A]	0	47
	Expected Count	13.94	13.40	7.60	7.06	42		Expected Count	14.87	17.05	8.73	6.35	47
	% within column	10.4 %	2.7 %	76.2 %	0.0 %	18.1 %		% within column	9.3 %	3.5 %	84.1 %	0.0 %	19.8 %
Happy	Count	3	32	1	**35**[A]	71	Happy	Count	10	53	0	**31**[A]	94
	Expected Count	23.56	22.65	12.85	11.94	71		Expected Count	29.75	34.11	17.45	12.69	94
	% within column	3.9 %	43.2 %	2.4 %	89.7 %	30.6 %		% within column	13.3 %	61.6 %	0.0 %	96.9 %	39.7 %
Don't know	Count	1	0	0	0	1	Don't know	Count	0	0	1	0	1
	Expected Count	0.33	0.32	0.18	0.17	1		Expected Count	0.32	0.36	0.19	0.14	1
	% within column	1.3 %	0.0 %	0.0 %	0.0 %	0.4 %		% within column	0.0 %	0.0 %	2.3 %	0.0 %	0.4 %

Note: [A] denotes consistent reaction and emotion inference

Table 5.4: *Frequency of emotion inferences for incorrect retrodictions to posed and spontaneous expressions.*

		Posed incorrect response							Spontaneous incorrect response				
Emotion inference		Maths	Monopoly	Negative	Positive	Total	Emotion inference		Maths	Monopoly	Negative	Positive	Total
	Count	**50**[A]	12	4	2	68		Count	**37**[A]	11	3	1	52
Thinking	Expected Count	20.65	17.94	12.1	17.31	68	Thinking	Expected Count	13.66	13.82	11.19	13.33	52
	% within column	50.5 %	14.0 %	6.9 %	2.4 %	20.9 %		% within column	44.6 %	13.1 %	4.4 %	1.2 %	16.5 %
	Count	23	**23**[A]	7	4	57		Count	19	**16**[A]	9	5	49
Surprised	Expected Count	17.31	15.04	10.14	14.51	57	Surprised	Expected Count	12.87	13.03	10.54	12.56	49
	% within column	23.2 %	26.7 %	12.1 %	4.8 %	17.5 %		% within column	22.9 %	19.0 %	13.2 %	6.2 %	15.5 %
	Count	10	14	**43**[A]	0	67		Count	12	11	**53**[A]	0	76
Sad	Expected Count	20.35	17.67	11.92	17.06	67	Sad	Expected Count	19.96	20.20	16.35	19.48	76
	% within column	10.1 %	16.3 %	74.1 %	0.0 %	20.6 %		% within column	14.5 %	13.1 %	77.9 %	0.0 %	24.1 %
	Count	14	36	3	**74**[A]	127		Count	15	45	3	**75**[A]	138
Happy	Expected Count	35.57	33.50	22.60	32.33	127	Happy	Expected Count	36.25	36.68	29.7	35.37	138
	% within column	14.1 %	41.9 %	5.2 %	89.2 %	39.0 %		% within column	18.1 %	53.6 %	4.4 %	92.6 %	39.7 %
	Count	2	1	1	3	7		Count	0	1	0	0	1
Don't know	Expected Count	2.13	1.85	1.25	1.78	7	Don't know	Expected Count	0.26	0.27	0.22	0.26	1
	% within column	2.0 %	1.2 %	1.7 %	3.6 %	2.1 %		% within column	0.0 %	1.2 %	0.0 %	0.0 %	0.3 %

Note: [A] denotes consistent reaction and emotion inference

For correct responses, results showed significantly more consistent (e.g. Positive to happy) attributions were made than inconsistent (e.g. Positive to sad) (Spontaneous stimuli: observed consistent = 140, expected consistent = 53.53, observed inconsistent = 96, expected inconsistent 182.48, $L\chi^2$ (12) = 262.5, $p<0.001$; Posed stimuli: observed consistent 149, expected consistent 58, observed inconsistent = 82, expected inconsistent = 173, $L\chi^2$ (12) = 243.2, $p<0.001$)

The pattern of inferences made to incorrectly recognised expressions mirrored those to correctly recognised. There were more consistent emotion inferences observed than would be expected and less inconsistent inferences. Only in the case of monopoly money which has happiness attributed more than would be expected, this was again more pronounced in spontaneous expressions. There was also a minor decrease in the number of observed consistent monopoly money inferences (surprised) within incorrect expression recognition compared to correct.

For incorrect responses results showed again significantly more consistent attributions were made than a model would expect and significantly less inconsistent attributions. (Spontaneous stimuli: observed consistent = 181, expected consistent = 78.41, observed inconsistent = 134, expected inconsistent = 236.58, $L\chi^2$ (12) = 257.6, $p<0.001$; Posed stimuli: observed consistent = 190, expected consistent = 79.94, observed inconsistent = 129, expected inconsistent = 239.06, $L\chi^2$ (12) = 256.5, $p<0.001$)

5.3.4.1 Summary of expression inferences

Consistent emotion inferences were made significantly more frequently than chance would expect. This occurred whether the expression was correctly recognised or not. The Monopoly money expression had happiness attributed to it more frequently than would be expected and more frequently than the consistent emotion (surprised) for that reaction. This was more pronounced in spontaneous monopoly money suggesting it may be delivered with a blended expression. Overall the margin of difference in observed consistent to expected consistent was larger when expressions were correctly retrodicted; there was also less inconsistent emotion inferences relative to expected when the expression was correctly retrodicted.

5.3.5 How were the expressions viewed?

As participants viewed responses the number and duration of fixations made to regions of interest was monitored. Four regions of interest were tracked; the eyes, mouth, face and body. This allowed detailed analysis of where the participant was looking and for how long; enabling summaries of how long was spent looking at the face and then a breakdown of time within the face. The time spent viewing the eyes and mouth summed does not necessarily equate to the time spent viewing the face as the eye and mouth regions do not physically cover the entire face. Where the duration of time spent viewing does not amount to 100%, this is due to instances where the target would clap or make hand gestures these were identified as regions of interest but did not occur frequently enough to influence overall viewing pattern and so are not included in analyses. Similarly, in rare cases the sum of eyes and mouth can be greater than time spent viewing the face this may be in certain instances where the region of interest outlined as the eyes may fall outside the region outlined as the face. In such instances, this is due to either rapid head movement from frame to frame where the movement of identified regions of interest can be slightly erratic and jarred, or an expanded eye region to accommodate glasses frames. An example (figure 5.2) image is provided below of the expressions viewed by participants with the defined regions of interest displayed.

Figure 5.2: *Example image of expressions viewed (with defined regions of interest displayed for clarity)*

Figure 5.2 demonstrates the defined regions of interest; in this case the regions eyes and mouth include the nose and chin respectively. This is because scan path analysis for the eye region typically involves a back and forth between the eyes which encapsulates the nose (Rutherford & Towns 2008; Yi et al., 2013; Cassidy et al., 2014; 2015), the nose also holds valuable information in emotions highlighted by its presence in the FACS (AU 9 nose wrinkler) for indicating disgust. Similarly the chin is included in the 'mouth' region because deviations from the mouth and lips at rest are the informative actions; again this is demonstrated in AU activity associated with this region (AU 17 chin raiser, AU 26 jaw drop)

In viewing table 5.5 below it can be seen there were consistently more fixations to the mouth than the eyes, this translated to longer durations spent fixated on the mouth than the eyes; this difference was consistent between both posed and spontaneous expressions. As would be expected there was more time spent viewing the face than the body, again this was consistent between posed and spontaneous stimuli. A notable trend between the expressions was a much larger duration of time spent fixated on the body in negative expressions than the other three, this increase in viewing time to the body of negative expressions was more than double any other posed expression and more than triple any other spontaneous expression.

Table 5.5: *Mean number of fixations and mean percentage of duration spent fixated per region of interest SD in brackets*

	Maths		Monopoly		Negative		Positive	
Region	Fixations	% Duration	Fixations	% Duration	Fixations	% Duration	Fixations	% Durati
A) Posed stimuli								
Eyes	8.31 (6.48)	26.88 (14.68)	5.22 (5.37)	15.16 (15.66)	7.94 (6.04)	21.60 (17.25)	5.75 (4.58)	21.59 (15.
Mouth	12.69 (5.91)	48.88 (14.62)	11.66 (4.43)	53.78 (19.44)	12.97 (6.20)	54.33 (21.25)	10.00 (4.36)	54.64 (21.
Eye to mouth ratio	0.35 (0.22)	0.35 (0.18)	0.27 (0.22)	0.22 (0.22)	0.37 (0.24)	0.29 (0.25)	0.34 (0.23)	0.30 (0.2
Face	25.31 (10.47)	88.28 (5.99)	21.28 (7.29)	82.13 (10.58)	25.91 (8.41)	76.85 (7.50)	18.75 (6.43)	87.14 (6.8
Body	1.91 (2.37)	3.66 (3.08)	4.47 (3.04)	7.99 (4.63)	1.84 (2.19)	15.42 (6.66)	2.88 (3.00)	5.66 (3.7
Face to body ratio	0.92 (0.10)	0.96 (0.03)	0.80 (0.13)	0.91 (0.06)	0.93 (0.08)	0.84 (0.07)	0.86 (0.12)	0.94 (0.0
B) Spontaneous stimuli								
Eyes	8.41 (5.03)	31.35 (13.55)	5.16 (6.14)	14.19 (15.81)	6.94 (11.15)	18.88 (18.15)	3.31 (3.03)	14.68 (15.
Mouth	10.34 (4.37)	45.70 (14.98)	13.47 (5.11)	54.17 (19.88)	12.72 (7.21)	54.92 (21.08)	8.31 (2.93)	61.47 (20.
Eye to mouth ratio	0.43 (0.14)	0.41 (0.17)	0.23 (0.22)	0.21 (0.22)	0.29 (0.27)	0.26 (0.10)	0.27 (0.22)	0.20 (0.2
Face	21.50 (7.31)	87.26 (7.42)	22.16 (9.10)	79.55 (15.04)	18.19 (15.07)	62.24 (11.87)	13.56 (3.57)	85.29 (9.0
Body	2.28 (1.95)	5.43 (4.36)	5.59 (3.35)	9.21 (6.63)	8.28 (7.24)	29.74 (11.33)	2.19 (1.94)	7.36 (6.6
Face to body ratio	0.89 (0.09)	0.94 (0.05)	0.77 (0.14)	0.89 (0.09)	0.71 (0.10)	0.68 (0.12)	0.85 (0.12)	0.92 (0.0

Note: higher ratios represent more fixations or duration to eyes or face

5.3.5.1 Does the stimuli type affect the number and duration of fixations?

To investigate if displaying expressions in a posed or spontaneous format affected the number and duration of fixations, 2x4 ANOVAS were conducted between the stimuli types (posed and spontaneous) and regions of interest (eyes, mouth, face and body). This analysis was conducted twice with total number of fixations and total duration of fixations as dependent variables.

Does the number of fixations differ between stimuli types?

Results showed significant main effects of stimuli (F (1, 31) = 5.88, p<0.05, η_p^2 .16), region (F (1.65, 51.22) = 151.27, p<0.001η_p^2 .83) and a significant stimuli x region interaction (F (1.57, 48.72) = 17.58, p<0.001 η_p^2.36). The assumption of sphericity was violated for the region and interaction main effects, as such Greenhouse-Geisser (.55, .52 respectively) adjusted values are reported.

The main effect of stimuli type was in the direction of more fixations to posed (44, 95% CI [39.65, 48.79]) expressions than spontaneous (40.60, 95% CI [36.37, 44.83]). In regards to region the main effect identified the differences in fixations to the face (83.33, 95% CI [75.28, 91.38], from the mouth (46.08, 95% CI [41, 51.12], eyes (25.52, 95% CI [18.76, 32.27]) and body (14.72, 95% CI [12, 17.44]). The significant stimuli by region interaction showed changes in opposite directions for two regions according to the stimuli type shown. There were significantly more fixations to the faces of posed expressions (91.25, 95% CI [81.72, 100.97]) than spontaneous (75.41, 95% CI [67.10, 83.71], p<0.001), however there were significantly less fixations to the bodies of posed expressions (11.09, 95% CI [8.68, 13.51]) than spontaneous (18.34, 95% C [14.70, 21.99], p<0.001).

Does the duration of fixations differ between stimuli types?

As was the case with fixations there were significant main effects of stimuli (F (1, 31) = 33.37, p<0.001, η_p^2 .52), region (F (1.65, 51.20) = 141.36, p<0.001 η_p^2 .82) and a significant stimuli x region interaction (F (1.87, 57.87) = 46.75, p<0.001 η_p^2 .60) albeit with larger effect sizes. The assumption of sphericity was violated for the region and interaction main effects, as such Greenhouse-Geisser (.55, .62 respectively) adjusted values are reported.

As with fixations the durations followed a similar pattern with more time (in seconds) fixated to posed expressions (24.62, 95% CI [21.93, 27.31]) than spontaneous (20.68, 95% CI [18.65, 22.71]). The amount of time fixated to specific regions also mirrored the frequency of fixations (face=45.69, 95% CI [41.21, 50.16], mouth= 29.16, 95% CI [24.58, 33.74], eyes=11.32, 95% CI [8.23, 14.42], body=4.43, 95% CI [3.68, 5.19]). The interaction again followed the same direction as number of fixations but was more pronounced in durations with significant differences for all regions between stimuli types. The eyes (12.74, 95% CI [9.08, 16.42]), mouth (31.32, 95% CI [26.07, 36.56]) and face (51.98, 95% CI [46.36, 57.60]) attracted significantly longer fixations in posed expressions than spontaneous (eyes=9.90, 95% CI [7.28, 12.52], mouth=27.01, 95% CI [22.84, 31.17], face=39.39, 95% CI [35.65, 43.14], $p \leq 0.001$). There were significantly longer fixations to the body in spontaneous (6.43, 95% CI [5.32, 7.55]) expressions than posed (2.43, 95% CI [1.85, 3.01], $p<0.001$).

5.3.5.2 Do the patterns of fixations differ between stimuli and expression types?

In order to simplify the interactions the regions of the face were collapsed into ratio of time spent viewing the eyes relative to the mouth (eye-to-mouth ratio = eyes/ (eyes + mouth)) and face relative to the body (face-to-body ratio = face/ (face + body)), the same calculations were carried out on the number of fixations that occurred to regions. This resulted in measures per participant of how often they viewed the eyes relative to the mouth and face relative to the body with higher values denoting more time spent viewing the eyes or face respectively. To investigate if there are any effects of the stimuli type on viewing patterns and if viewing patterns differed across reactions a 3-way ANOVA was conducted comparing stimuli with two levels (posed/spontaneous), expression with four levels (maths/ monopoly/ negative/ positive) and region of interest (eye-to-mouth ratio/ face-to-body ratio) for the number of fixations and percentage duration.

Mauchly's test of sphericity was met for all eligible variables and interactions. For number of fixations there was a significant main effect of stimuli with more fixations to the combined eyes and face of posed (60.3%) stimuli than spontaneous (55.5%) stimuli (F (1, 31) = 36.63, $p<0.001$, η_p^2 0.54) However this was largely driven by the tendency for children to spend the majority of time viewing the face. There was a significant main effect of expression (F (3, 93) = 20.53, $p<0.001$, ηp^2 0.40) with significantly more fixations to the maths (64.9%) expression than monopoly (51.7%), negative (57.4%) and positive (57.8%) (all $p<0.001$), the positive feedback expression also attracted significantly more fixations than monopoly ($p<0.05$). There was a significant main effect of region of interest (F (1, 31) = 278.35, $p<0.001$ η_p^2 0.90) with more fixations made to the face relative to the body (84%) than there were to the eyes relative to the mouth (31.8%). There was also a significant three way interaction between stimuli, expression and region of interest (F (3, 93) = 7.63, $p<0.001$, η_p^2 0.20).

What is the effect of stimuli type on fixations patterns?

Analysis of simple main effects with Bonferroni adjusted t-tests showed that stimuli type influenced the number of fixations to the eyes in the maths question, negative feedback and positive feedback expressions. More specifically, the increased number of fixations to the eyes was more pronounced in the spontaneous condition (43.4%, 95% CI [38.2, 48.5]) of maths question than the posed condition (35.3%, 95% CI [27.4, 43.2], $p<0.05$). While in the posed condition increased numbers of fixations to the eyes were evident in positive (33.7%, 95% CI [25.4, 42.0], $p<0.01$) and negative (36.7%, 95% CI [28.2, 45.2], $p<0.05$) feedback expressions compared to spontaneous (26.7%, 95% CI [18.7, 34.6], 28.8%, 95% CI [19.2, 38.5] respectively). The only expression that presented differences in face to body fixations between stimuli conditions was negative feedback where there were significantly more fixations to the face when the stimuli was presented in a posed format (92.6%, 95% CI [89.7, 95.6]) than a spontaneous format (71.3%, 95% CI [67.8, 74.8], $p<0.001$).

What is the effect of expression type on the number of fixations?

Simple main effects of expression type with Bonferroni adjusted t-tests showed the only significant difference in number of fixations to the *eyes* within *posed* stimuli, was between monopoly money (27%, 95% CI [19,35]) and negative feedback (36.7%, 95% CI [28.2, 45.2]), consisting of more fixations made to the eyes when viewing negative feedback ($p<0.05$). The number of fixations to the *face* region within posed stimuli showed significantly more fixations to maths expressions (91.5%, 95% CI [87.9, 95.1]) than monopoly (79.9%, 95% CI [75.1, 84.7], $p<0.001$) and significantly more in negative feedback (92.6%, 95% CI [89.7, 95.6], compared to monopoly money (79.9%, 95% CI [75.1, 84.7], $p<0.001$), and positive feedback (86%, 95% CI [81.8, 90.1], $p<0.05$).

Differences in fixations between the expressions were more pronounced when delivered in a *spontaneous* format. The maths expression (43.3%, 95% CI [38.2, 48.5] attracted significantly more fixations to the *eyes* than all other expressions (monopoly=22.9%, 95% CI [14.9, 30.9], negative=28.8%, 95% CI [19.2, 38.5], positive=26.7%, 95% CI [18.7, 34.6], $p<0.01$) whilst the previous difference between monopoly and negative feedback reduced to non-significance ($p=.549$). Concerning fixations to the *face*, there were significantly more fixations to the maths expressions (89.3%, 95% CI [86.2, 92.5]) than monopoly (76.8%, 95% CI [71.8, 81.7]) and negative feedback (71.3%, 95% CI [67.8, 74.8], both $p<0.001$). The monopoly expression attracted significantly fewer fixations to the face than negative feedback ($p<0.001$) and positive feedback (84.8%, 95% CI [80.6, 89.1] ($p=0.038$).

What effect does region of interest have on the number of fixations?

Simple main effects analyses with Bonferroni corrected t-tests of differences in region of interest show a unanimous significant difference in the number of fixations to the face relative to the body, compared to the eyes relative to the mouth; with consistently more fixations to the face. This difference was found at every level of stimuli and expression type (p<0.001). Plots of the ratio of fixations to the eyes relative to the mouth (figure 5.3) and face relative to the body (figure 5.4) can be seen below when posed or spontaneous for each expression type.

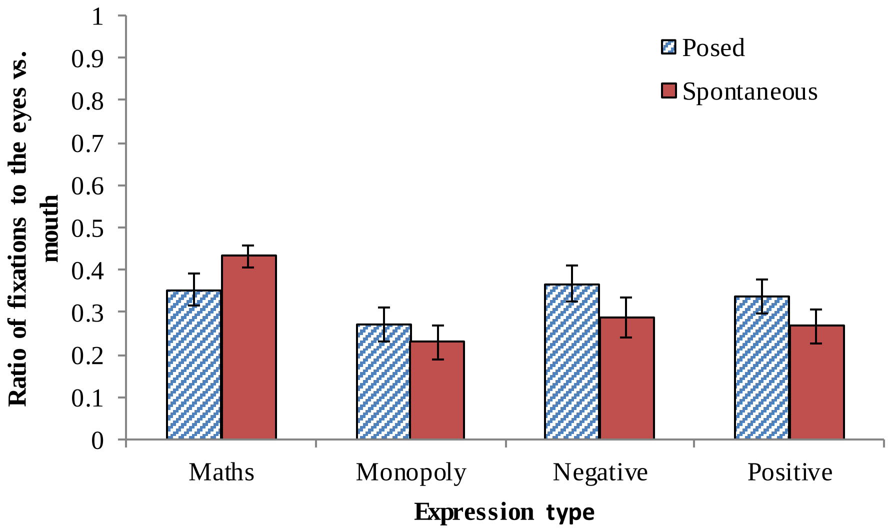


Figure 5.3: *Ratio of fixations made to the eyes relative to the mouth, higher count represents more fixations to the eye region error bars denote ± 1SE*

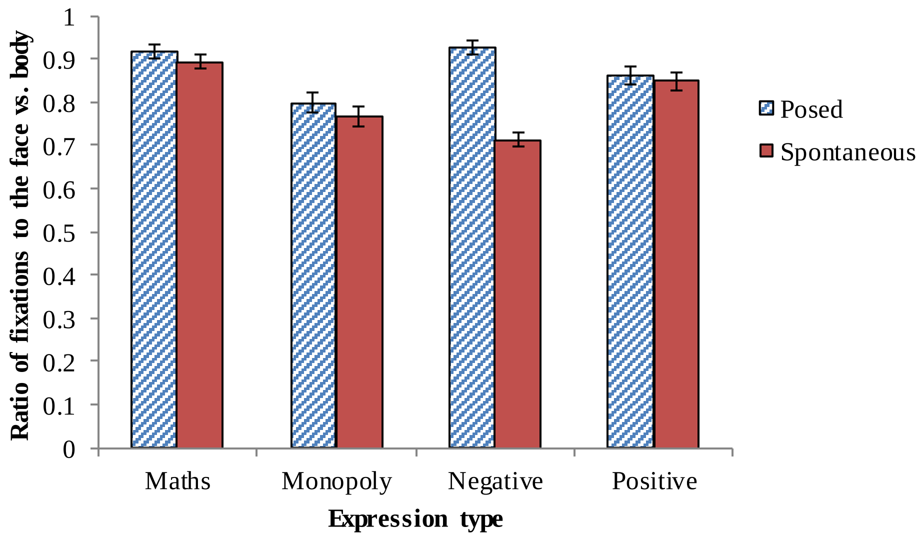


Figure 5.4: *Ratio of fixations made to the face relative to the body, higher count represents more fixations to the eye region error bars denote ± 1SE*

Summary

The type of stimuli the expressions are delivered in did not appear to present a clear pattern. Number of fixations to the eyes was significantly increased for different expressions in both the posed (maths) and spontaneous (positive and negative) conditions, whilst number of fixations to the face was only significantly affected in the negative expression when posed. Overall between the expressions the most prevalent effect was an increase in the number of fixations to the eyes when the maths expression was posed, there was also a reversal in the significance of fixations to the face between monopoly and negative feedback when spontaneous.

5.3.5.3 Does the duration of fixations differ between stimuli and expression types?

A second ANOVA was conducted on duration of fixations, with the same IV's and levels as outlined above. Mauchly's test of sphericity was violated (stimuli x expression x region = .59) so greenhouse-geisser adjusted epsilon β values are reported. There was a significant main effect of stimuli type on the duration of fixations with significantly longer fixation durations to the eyes and face of posed stimuli (60.1%, 95% CI [56.6, 63.5]) than spontaneous stimuli (56.3%, 95% CI [52.6, 59.9]) (F (1, 31) = 14.95, p=0.001, η_p^2 .33). There was a significant main effect of the expression shown on the duration of fixations made (F (3, 93) = 33.33, p<0.001, η_p^2 .52). The negative feedback reaction (51.6% 95% CI [48.1, 55.1]) attracted significantly shorter fixations to the eyes and face than maths question and positive feedback (p<0.001), whilst the maths question expression (66.4%, 95% CI [63.2, 69.7]) attracted significantly longer fixations than all other expressions (p<0.001). There was a significant main effect of the duration of fixations made to the regions of interest with significantly more time spent looking at the face relative to the body (88.4%, 95% CI [86.8, 90.0]) than the eyes relative to the mouth (28%, 95% CI [21.6, 34.3]) (F (1, 31) = 379.20, p<0.001, η_p^2 .92). There was also a significant three way interaction between the stimuli type, expression type and region of interest (F (1.76, 54.71) = 35.53, p<0.001, η_p^2 .24).

What is the effect of stimuli type on fixation durations?

Analysis of simple main effects with post-hoc Bonferroni corrected t-tests showed posed stimuli was characterised by greater viewing time of the face but spontaneous stimuli with greater viewing time of the eyes. Posed expressions attracted significantly longer viewing times to the face for negative feedback (83.5%, 95% CI [81, 86.1], p<0.001) and positive feedback (93.8%, 95% CI [92.4, 95.3], *p*<0.05) compared to spontaneous (negative=67.8%, 95% CI [63.4, 72.1], positive=92%, 95% CI [89.5, 94.6]). When the stimuli presented was *spontaneous* this increased the duration of fixations to the eyes, there were significantly longer fixations in the maths (42.5%, 95% CI [35.4, 49.6]) compared to posed (maths=35%, 95% CI [28.6, 41.4]. (*p*<0.001)

What are the effects of different expression types on fixation durations?

Simple main effects with post-hoc Bonferroni corrected t-tests showed that when presented in a *posed* format, the only expression to influence duration of fixations to the *eyes* was maths question (35%, 95% CI [28.6, 41.4]), which attracted significantly longer fixations than monopoly (22%, 95% CI [14.1, 29.9], *p*<0.001). In regards to viewing time of the *face* there were significantly longer fixations to the maths expressions (96%, 95% CI [94.7, 97.2] than all other expressions (monopoly = 90.9%, 95% CI [88.8, 92.9] *p*<0.001, negative feedback = 83.5%, 95% CI [81, 86.1] *p*<0.001, positive feedback = 93.8% 95% CI [92.4, 95.3] *p*=.032. There was significantly less time spent fixated on the negative feedback expression (56.5%, 95% CI [51.5, 61.4]) than all other expressions (Maths= 96%, 95% CI [94.7, 97.2] *p*=0.002, monopoly money= 90.9%, 95% CI [88.8, 92.9], positive=93.8% 95% CI [92.4, 95.3], all *p*<0.001)

When viewing *spontaneous* expressions there was much more variation between the expressions in the amount of time fixating the *eyes*, most notably characterised by an increase in the maths expression (40.7%, 95% CI [34.7, 46.7]) which had significantly longer fixations than all other expressions (monopoly money= 20.5% 95% CI [12.6, 28.4], negative feedback = 25.8% 95% CI [16.7, 34.8], positive feedback= 20.3%, 95% CI [12.4, 28.1], *p*<0.001).

What effect does region of interest have on fixation durations?

As with the effects outlined in number of fixations, there was a unanimous significant increase in the duration of fixations to the face compared to the eyes, this effect was significant at all levels of stimuli and expression type (*p*<0.001). Plots of the ratio of time spent viewing the eyes relative to the mouth (figure 5.5) and face relative to the body (figure 5.6) per expression and stimuli type are presented below.

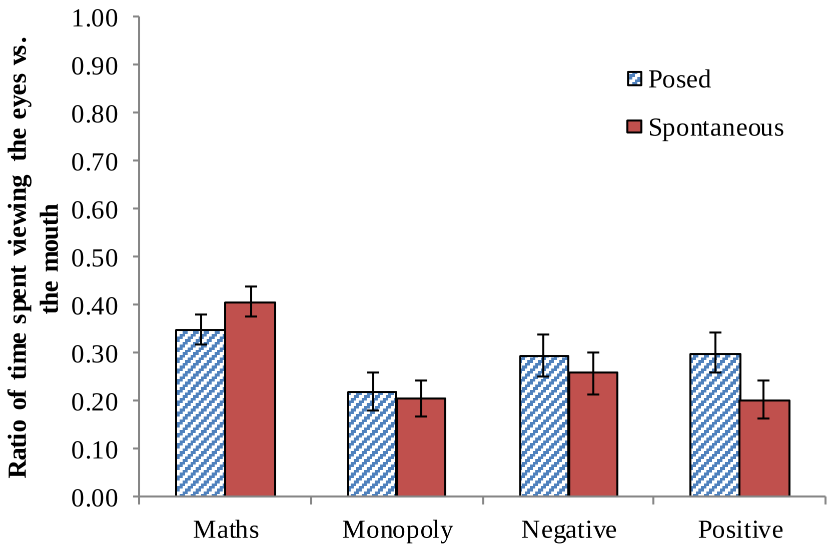


Figure 5.5: *Ratio of duration spent viewing the eyes relative to the mouth, higher count represents more time viewing the eye region error bars show ± 1SE*

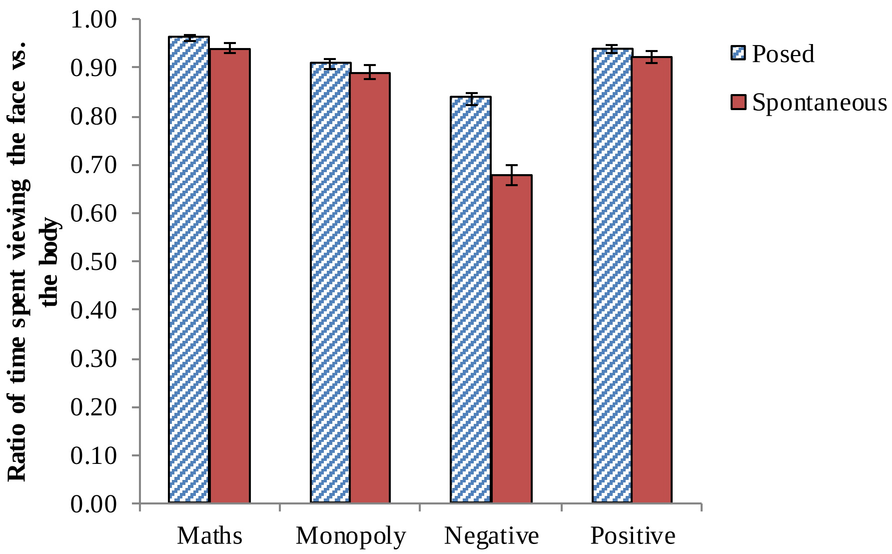


Figure 5.6: *Ratio of duration spent viewing the face relative to the body, higher count represents more time viewing the face region error bars show ± 1SE*

Summary

Each IV affects the duration of fixations differently, presenting expressions in a posed format increased viewing time to the face (relative to the body) for the negative feedback expression. Presenting expressions in a spontaneous format increased viewing time to the eyes (relative to the mouth) in the maths question expressions, but showed increased viewing time to the eyes for the other three expressions when presented in a posed format. Variation between the expressions in viewing time to the eyes was more pronounced when the expressions were spontaneous; specifically the maths expression presented significantly longer durations to the eyes than other expressions. Differences in viewing times to the region of interest did not differ according to expression or stimuli type, presenting only a unanimous significant increase in percentage of time viewing the face relative to the body compared to the eyes relative to the mouth.

5.3.6 Do retrodictive mindreading ability and viewing patterns predict autism traits?

Where previously the focus was on the relationship between ASC traits and the ability to recognise expressions or have those expressions recognised (section 4.3.6), this analysis will investigate the capabilities of the RM paradigm and newly developed stimuli as a measure that might identify ASC traits. This is particularly important given previous work has shown specific viewing styles in autism when viewing complex social scenes (Klin et al., 2002; Klin & Jones 2006; Sasson, Turner-Brown, Holtzclaw, Lam & Bodfish 2008).

A multiple regression was carried out to predict autism quotient scores from RM ability and the proportion of time spent viewing the eyes relative to the mouth and face relative to the body whilst controlling for age, sex and IQ. Correlations showed a significant relationship between AQ scores and RM score, there were no significant relationships between AQ and other individual predictors, Individual *r* shown below in table 5.6. The frequency of AQ scores within the sample population can be seen below in figure 5.7 which shows a similar distribution as would be expected in a typically developing sample (Auyeung et al., 2008)

Table 5.6 *Correlations between output AQ score and predictors significance in brackets*

	RM score	IQ Score	Eye to mouth ratio	Face to body ratio	Age
AQ score	-.297 (.049)	-2.16 (.236)	.233 (.148)	-.250 (.235)	.082 (.327)

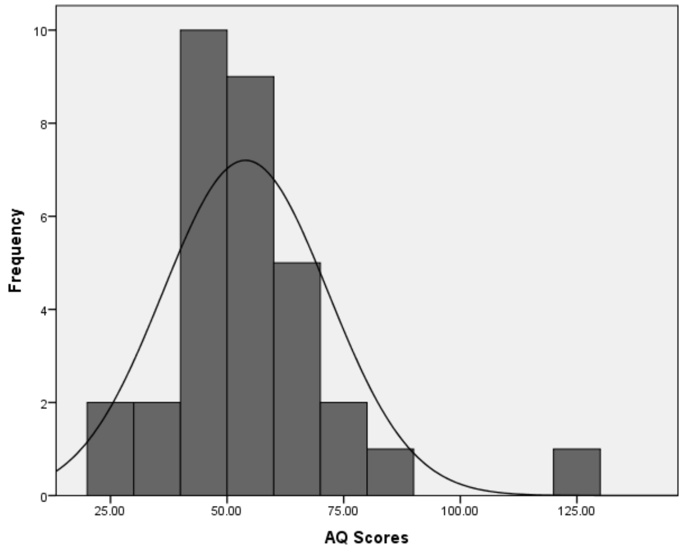


Figure 5.7 *Frequency of AQ scores in sample*

Linearity was established via inspection of partial regression plots and studentized residuals against predicted values. Slight negative autocorrelation was present as assessed by Durbin-Watson statistic of 2.69 suggesting there may be an underestimate of statistical significance. Homoscedasticity was satisfied via visual inspection of studentized residuals plotted against unstandardized predicted values, and tolerance values >0.8 suggested no evidence of multicollinearity. Studentized deleted residuals showed one value as an outlier (4.17) driven by a high score on the AQ (120) however leverage (0.15) and Cook's distance (0.63) values were satisfactory and the participant retained given that variation in AQ scores was an outcome variable. One participant presented a leverage value approaching risk (.29), however this participant did not present as an outlier or show high Cook's d (0.27) and so was retained. Assumptions of normality were satisfied via inspection of P-P plot and histogram.

The model was a significant predictor of AQ scores (F (6, 25) = 2.62, p=0.041, adj. R^2 = .24), with face to body ratio and RM scores predicting autism traits. Correct RM score (p=0.006, R^2 = .088) was a significant predictor, with a standard deviation increase in RM ability there was a predicted 9.22 decrease in AQ scores, Similarly the face-body ratio predicted decrease in autism scores (p=0.034, R^2 =.063). Every one standard deviation increase of time spent looking at the face relative to the body predicts a 6.38 decrease in AQ scores. A one standard deviation increase of ratio looking to the eyes of the face relative to the mouth was associated with an increase of 4.96 in AQ scores but this relationship did not reach significance (p= 0.109), a full regression table can be seen below (table 5.7)

Table 5.7 *Regression table for coefficients predicting AQ scores*

Model	Predictor	B	SE B	β	*P*
1	Constant	68.10	28.95		p=.632
	Sex	1.65	6.54	.05	
	Age	1.17	2.09	.10	
	IQ	-.26	.21	-.23	
2 (ΔR^2=.33, p<0.05)	Constant	267.97	83.38		p=.041
	Sex	2.18	5.63	.06	
	Age	2.89	1.95	.26	
	IQ	-.29	.18	-.26	
	Eye to mouth ratio	24.69	14.85	.28	
	Face to body ratio	-190.55	85.11	-.36*	
	RM score	-3.44	1.15	-.52*	

Note: *= p<0.05

5.4 Discussion

Through the use of eye tracking software this research aimed to investigate the viewing patterns children exhibit, if these are governed by the stimuli type, and crucially if viewing style and the ability to retrodict events can predict autistic traits. It was predicted that recognition of spontaneous expressions would be significantly better than posed. It was also predicted there would be significantly more fixations to posed expressions where participants would be less likely to have their attention drawn to specific regions due to less coherent display patterns in posed expressions. On the contrary to the directions predicted for fixations, it was predicted significantly longer would be spent viewing the highlighted regions of interest (the eyes, mouth, face and body) in spontaneous expressions; This was due to consistent display patterns in spontaneous expressions which should attract attention for longer periods of time.

Results did not support the hypothesis that spontaneous expressions would be recognised significantly more than posed. This was a prediction based upon the result in chapter 4, however the lack of differences in this research may be due to two reasons; first the expressions chosen represent the two best recognised expressions when posed and when spontaneous. By default the prior result would cancel itself out in this instance where two expressions were expected to be better recognised when posed and two expected to be better recognised when spontaneous. Second, the process of stimuli selection which required matching expressions from the same individual when posed and spontaneous meant the ability to select a stimuli shortlist that reflected the overall expression averages was compromised and resulted in a stimuli shortlist which had previously demonstrated better overall recognition in posed display than spontaneous. It is possible that given a larger stimuli set that better reflects the previous task presented to typically developing adults, significant differences in recognition would emerge in the directions as seen in chapter 4. Of note in this research was the particularly poor recognition rates overall which converged around chance recognition rates. It is possible the RM task proved too difficult for the young sample who were unable to perform at the rates previously shown in adults despite being shown a shortlist of expressions which typically developing adults recognised on average four times better than chance would expect.

Results supported the hypothesis regarding number of fixations to posed and spontaneous stimuli, where there were significantly more fixations to posed expressions; however there was also significantly longer duration of fixations to spontaneous expressions. This is in line with previous research using the stimuli set where posed expressions did not form in statistically distinct patterns across individuals to the same degree spontaneous expressions did. That participants looked to posed expressions more frequently supports the prediction, however looking for longer durations to posed expressions suggests the amount of time viewing the expressions does not necessarily translate to better recognition and may actually be an indicator of higher cognitive load in deciphering ambiguous expressions. The nature of analysing the ratio of eye-to-mouth viewing and face-to-body viewing did not allow direct comparison of eyes to mouth for example, but this was investigated in outright fixations and durations and could be seen in the means and percentage duration reported. These showed consistently more fixations, and duration, was spent viewing the mouth region than the eyes. The preferential viewing to the mouth was consistent in both posed and spontaneous expressions of every type. Such a pattern is not consistent with previous research which has shown consistently more time spent viewing the eyes in typically developing populations (Haith et al., 1997; Speer et al., 2007; Wagner et al., 2013), but is consistent with previous research using the RM paradigm (Pillai et al., 2012; 2014; Cassidy et al., 2014) which suggests looking to the eyes is not related to task performance.

It was predicted that RM ability and viewing patterns would significantly predict autistic traits, it was expected worse performance on the RM task and more time viewing the mouth and body would predict higher autistic traits according to the autism quotient. This hypothesis was partially supported, the model was a significant predictor of AQ scores, but more time viewing the eyes did not significantly predict a decrease in AQ scores. Regarding viewing the eyes, the direction observed was opposite to the predicted direction with more time viewing the eyes associated with more severe autistic traits but this was non-significant. Given that viewing patterns showed more fixations and duration to the mouth region which has been associated with ASC in previous research (Klin et al., 2002; Pelphrey 2002; Baron-Cohen et al., 1997; 2001), it again suggests the viewing styles used appear to be reliant upon the stimuli shown. For spontaneous dynamic stimuli, a more flexible approach to attention allocation may be required, which includes more fixations to the mouth which is possibly more informative than the eyes. The current *typical* viewing patterns that are reported have been based on observation of atypical stimuli that potentially do not apply to more valid tasks and so provide inaccurate assessments of abilities and subsequently draw inaccurate conclusions.

Worth note in regards to the increased viewing time to the eyes and the direction of association to autism scores may be attributable to the defined regions or interest. The regions of interest in this research termed eyes and mouth, also included the nose and chin respectively, previous research has demonstrated that viewing time to the eyes in ASC samples is more accurately located below the eyes (potentially due to avoiding the eyes directly) (Yi et al., 2013). The broader defined regions of eyes in this research may capture looking to the eye region, but not the pupils. However, it is important to make clear the present results are taken from a typically developing sample and have limited inferential validity to ASC samples.

One potential explanation for the results could be that the combination of dynamic stimuli with improved ecological validity, being used in a sample with a mean age of 9.12, is that although holistic processing should be complete by this age (Tanaka et al., 1998) the configural processing is still immature (Bruce et al., 2000). Previous research is unlikely to have presented expressions of such validity and complexity, for such short of periods of time to children at this developmental stage. The resulting findings, instead of being contradictory to previous work, may be distinct in the task presented and results obtained. This then might suggest that viewing patterns thought to be implicative of ASC traits are in fact only valid in unnatural conditions. When those viewing patterns manifest under more realistic conditions the individual curating them, in this case, did not show autistic traits worthy of diagnosis.

The patterns of emotion inference to situation retrodicted showed significantly more consistent emotion inferences than inconsistent, when the event was both correctly and incorrectly retrodicted. One would expect a decrease in consistent inferences when the event was incorrectly retrodicted, this would aid in explaining the incorrect retrodiction if an inconsistent emotion was attributed to the individual. In reality it may be that this does play a small role, as the overall margin of observed consistent to expected emotion inferences was larger after correct retrodictions than incorrect. However the processing and decision making appears to be mostly based on other factors around the retrodiction which then governs the decision making process for emotion to be inferred. For example if an individual decides that the person in the video was given some good news regardless of if they have got that retrodiction correct, the cognitive bias they have just made towards that decision will influence their following emotion inference. An individual is far more likely to say a person will feel happy after they have already outwardly stated the person looks as though they received some good news. In this way the design employed primed participants to select consistent emotion inferences based on their prior retrodictions, it is almost impossible to ask those two questions in direct succession and not have one influence the other. This is easily overcome in future research design, the entire videos to be used should be shown once asking for a retrodiction, then repeated asking for an emotional inference; Whilst this is a valid design solution it doubles the experiment length introducing new issues around participant fatigue, particularly with children. The order the inferences and retrodictions are asked should be counterbalanced to further control for any order effects.

A further issue that arose during data collection was a self-selecting sample of children who were willing to sit still and face the eye-tracker. The children who were unable to sit still, disabling calibration of the eye tracker means any children that showed more active personas or shorter attention spans were unable to complete the research and likely removed a much broader set of visual search strategies. Overcoming this issue is not realistically possible, the nature of the equipment requires the user to be seated in front of the apparatus with minimal movement, it is instead important that any interpretations made from the research are done with this self-selected sample in mind. There is the opportunity to use alternative eye tracking equipment, such as head mounted glasses which do not rely on such rigid posture and attention, but this equipment does not have the detail and accuracy of static eye-trackers.

The results of the present study question previous research which appears to show a specific visual search strategy that would be considered consistent with ASC or control populations. Instead the stimuli used draws into question the results obtained under previous conditions with various samples, suggesting those viewing patterns may be specific to less natural stimuli which are invalid when extrapolated to the real world. The methods used combined with the novel results, have shown the RM paradigm can produce naturalistic expressions with recognition rates above chance for many of the expression types. The patterns of recognition suggest that any previously reported differences in recognition rates between posed and spontaneous expressions have been overstated and may have the direction wrong entirely. Such a finding combined with the viewing patterns in this research, and those in previous chapters, make a strong case for future research to consider the inclusion of high quality naturalistic expressions. The results also have implications for future research, particularly in replication with a developing sample and in atypically developing samples such as those with ASC where the claims of atypical viewing patterns may only be atypical in the context they were gathered.

Chapter 6 The Effects of ASC and Alexithymia on Retrodictive Mindreading Ability

The literature discussed and experiments conducted thus far in this thesis have been done in an attempt to highlight the methodological and theoretical flaws in presenting non-natural, contextually neutral and emotionally rigid expressions to individuals with ASC. Subsequently, considering a finding of any direction to be implicative of a difficulty associated with ASC should not be considered valid. Thus far, the evidence has shown that spontaneous expressions form more readily identifiable patterns, are more easily recognised by typically developing adults, and are viewed differently, characterised by less fixations and durations to the face but more to the body, however the viewing styles did not appear to be linked to recognition. This chapter will investigate group differences between those with an ASC diagnosis and typically developing controls; attempting to produce accurate findings of any differences between the groups which would be directly relatable to abilities as they would be used in typical social interaction.

6.1 Introduction

The literature covered in section 2.8 demonstrated that emotion recognition abilities in ASC have shown inconsistent results. For example a sample of participants with AS or HFA showed significantly reduced abilities to correctly recognise facial expressions as well as attribute emotion to body movement and vocal affect (Philip et al., 2010). As Harms and colleagues (2010) note in their review of autism research, HFA samples comprise the majority of ASC individuals in adult studies. Among HFA samples where difficulties are present in FER they are more regularly confined to negative emotions (Ashwin et al., 2006; Bal et al., 2010; Corden et al., 2008; Wallace et al., 2008; Boraston, Blakemoor, Chilvers & Skuse, 2007; Howard et al., 2000) and possibly less pronounced than previously thought. There is also a body of research showing no such difference between ASC individuals and control (Loveland et al., 2008; Neumann et al., 2006; Rutherford & Towns 2008; Ogai et al., 2003; Teunisse & de Gelder 2001).

In some cases where research has shown intact FER, experiments that have investigated the subsequent understanding of that information through judgements of trustworthiness have shown difficulties in linking the visual information to subsequent behaviour (Adolphs et al., 2001). In another experiment where participants were tasked with retrodicting (inferring a correct root cause) the event to a reaction, the ASC sample struggled only with reactions to being given chocolate or a home-made gift; This suggests the complex nature of genuine and feigned gratitude is misunderstood in ASC samples (Cassidy et al., 2014). In the cases where no difference is present between ASC and control groups the suggestion would be that any observable traits in social communication or interaction are not due to emotion recognition difficulties.

One such cause of an apparently intact FER system but continued social interaction and communication difficulties could be alexithymic traits (see section 1.3.5). Emerging research suggests the difficulties in emotion processing in ASC are actually due to Alexithymia, Bird and Cook (2013) present a compelling case for Alexithymia as a major contributor to FER difficulties, and possibly responsible for the inconsistent findings of FER in ASC with some research showing difficulties (Ashwin et al., 2006; Humphreys et al., 2007; Wallace et al.; 2008), whilst others found no differences between ASC and controls (Ozonoff et al., 1991; Castelli 2005; Adolphs et al., 2001). The proposition is that differential performance on FER tasks between ASC and control groups could actually be due to differential degrees of Alexithymia between the groups. This is in part supported by the evidence reporting reduced empathic responses in Alexithymia (Johnson et al., 2009; Moriguchi et al., 2007).

With empathic difficulties linked to Alexithymia which has high co-morbidity with ASC and is thought to contribute to FER difficulties (section 1.3.4.4), this can have a knock on effect on social communication skills. On one front individuals with ASC and alexithymic traits can struggle to recognise, mimic and subsequently understand expressions displayed to them. On another front these individuals may also struggle to fashion recognisable expressions of their own. This can lead to unclear signals being sent and a misunderstanding in social interactions, which in turn can lead back to contextually odd expressions being returned and misinterpreted as in the first point raised above. This could have implications for the types of tasks used and methods of assessment which can tend to focus on emotion labelling rather than affective content or root causes.

The inconsistent literature surrounding FER in ASC requires more robust methods that better reflect the demands of everyday social interaction. The emerging literature linking Alexithymia with ASC and Alexithymia's known influence on empathy and FER performance requires a re-think of how ASC and its symptoms are approached. The current research will address the inconsistent results of FER processing in ASC using the RM paradigm. With new spontaneous expressions more representative of typical social interaction, combined with more robust and valid tests of emotion recognition and understanding, it is hoped there will be a better understanding of FER abilities in ASC. By employing a measure of Alexithymia, the research will investigate the reported co-morbidity of ASC and Alexithymia and any relationships between Alexithymia itself and FER performance. The research has three hypotheses: based on the nature of the task with its more complex design it is predicted the control group will correctly retrodict significantly more events than the ASC group. In line with previous research it is predicted the ASC group will present significantly higher Alexithymia scores than the typically developing group. Having predicted higher Alexithymia scores in the ASC groups it is also predicted the ASC group will make significantly less correct emotional inferences than the typically developing group due to Alexithymia's influence on empathic abilities.

6.2 Method

6.2.1 Design

A mixed factorial design was employed investigating the differences between an ASC sample and control sample on a RM task, with RM performance as the dependent variable. There were two within groups factors; stimuli type with two levels (posed, spontaneous) and expression type with four levels (maths, monopoly, negative, positive). Ethical clearance was granted by Coventry University ethics board (see Appendix J)

6.2.2 Participants

This research recruited an adult sample, it was expected the ability to retrodict social events would be fully developed in adulthood. This was partially governed by the results in previous chapters which demonstrated good recognition with adults in chapter 4 and poor recognition with children in chapter 5. It was therefore decided the intact recognition in chapter 4 utilizing the subset emotions from chapter 5 that demonstrated good recognition previously with adults would be used in this experiment with an adult sample. One hundred and thirty-seven participants were recruited via opportunistic sampling from various sources. This consisted of 53 ASC individuals (Mean age=43.34, SD =16.01, 25 males 28 females), falling into the subtypes Autism = 3, HFA = 1, other = 2 and AS = 46. 84 control (Mean age=35.29, SD = 17.28, 23 males 61 females). Participants were recruited through SONA the research participation scheme at Coventry University. The research was advertised on social media as well as 'swap survey', a similar concept service where researchers can upload projects to receive participants in exchange for participating in others' research. Autistic participants were recruited through multiple means; the research was advertised and distributed through the Cambridge Autism Research Database of volunteers and the autism west midlands charity. The disability service at Coventry University also advertised the research to its service users.

6.2.3 Materials

6.2.3.1 Scales/questionnaires

The Autism Quotient (AQ) (Baron-Cohen et al., 2001) is a 50 item likert questionnaire designed to assess autistic traits. It was included to measure traits in the autistic sample and screen the typically developing sample. It shows high specificity and reliability as evidenced previously in chapter 3. The Toronto Alexithymia Scale (TAS-20) is a 20 item likert questionnaire that measures emotional openness and understanding as a self-report measure of Alexithymia. The TAS-20 is considered the gold standard measure of Alexithymia presenting good internal reliability as evidenced previously in chapter 3. The reading the mind in eyes task refined version (Baron-Cohen et al., 2001) was used as a comparative measure against the RM task. This task was included as a measure of concurrent validity to check the performance on the RM task against the eyes task which has a similar component in requiring participants to infer emotional states to faces with complexity beyond that in typical emotion processing tasks. Because the RM task not only assesses recognition of responses in a socially appropriate manner but also asks individuals how they think people feel the eyes task is a good comparison measure. The eyes task consists of 36 images of eyes conveying emotional states and four choice forced response options.

6.2.3.2 Stimuli

The same 32 video expressions (ranging in duration from 2 to 8.3 seconds) were taken from the stimuli set as were used in chapter 5; these expressions covered four reactions captured in response to a specific cue/prompt (Maths, Monopoly, Negative, Positive). These expressions were uploaded to an online experiment on qualtrics and administered in randomised order.

6.2.4 Procedure

The research was completed online on Qualtrics, a survey data collection provider. Upon accessing the research participants were informed of the aims and purpose of the research, after providing consent participants were asked some demographic questions these included age, sex, confirmation of autism diagnosis and subtype, employment status, IQ and general index of ability if known. For the purposes of better understanding of the groups participants were also asked their highest qualification achieved and any mental health diagnoses they were comfortable disclosing. Following the demographic questions participants completed the RM task; this consisted of viewing 32 video reactions randomised in order which spanned four categories (maths, monopoly, negative and positive). Four different examples of each expression type were shown two posed and two spontaneous. Following each video participants were asked which event they believe caused the reaction in the video (four choice forced response categories as above) and how did they think the person in the video felt, with a four choice forced response (thinking, surprised, sad, happy). Upon completing the RM task participants completed the AQ followed by the TAS-20 and finally the eyes task at which point participants were debriefed and thanked for their participation.

6.3 Results

6.3.1 Group characteristics

The self-report demographic information provided by participants in regards to employment status, level of education completed and any medical diagnoses was quantified. To ensure fair comparisons between the uneven sample sizes in each group the frequency of reported characteristics were converted to percentages of the sample.

Results of employment status showed the ASC sample were more likely to be unemployed (28.3%) compared to the control sample (5.95%), there was also a larger student population in the control sample (44%) compared to the ASC sample (15%). When considering educational attainment for the control sample the most frequent level of qualification attained was A-levels (32%), whilst the most frequent qualification of the ASC sample was an undergraduate degree (36%). Notable group differences in self-report mental health issues were a notable increase in anxiety and depression, in the ASC sample anxiety was reported as three times more prevalent (58%) than the control sample (19%). Similarly, depression was reported twice as frequently in the ASC sample (43%) than the control sample (21%). Further information on group demographics for employment, education level and health can be found below in figures 6.1, 6.2 and 6.3 respectively.

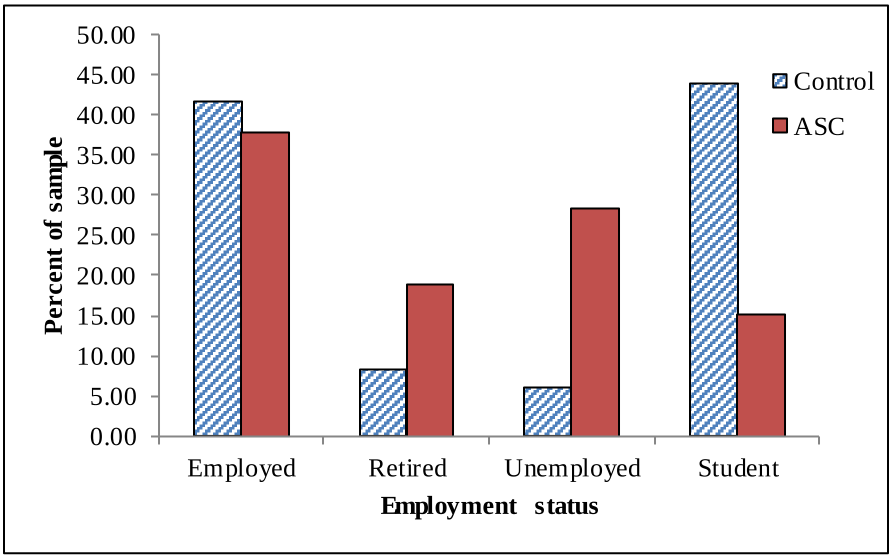


Figure 6.1: *Reported employment status of sample*

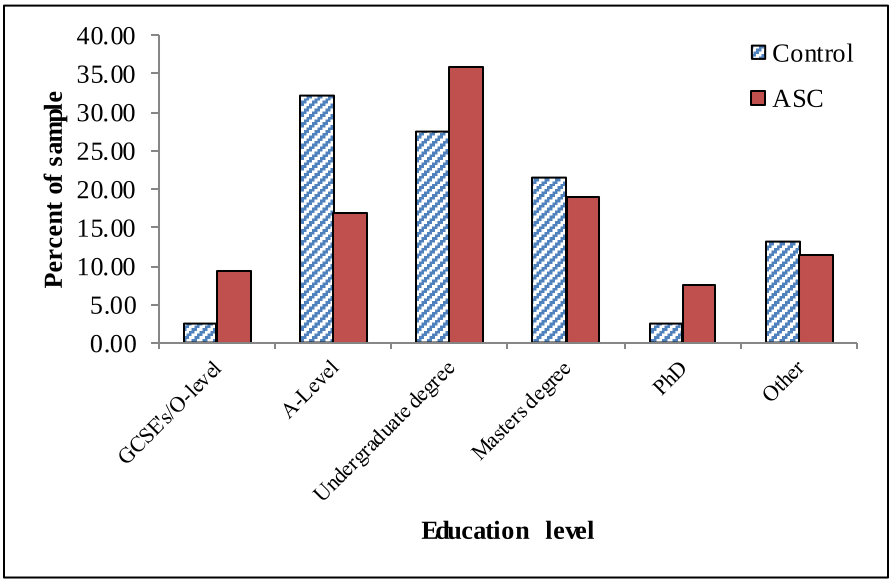


Figure 6.2: *Reported Education level of the sample*

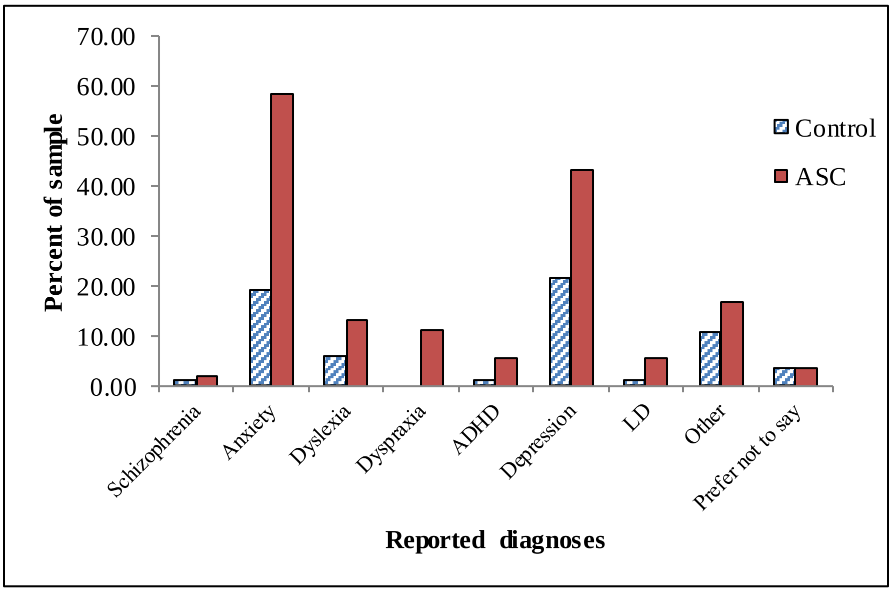


Figure 6.3: *Reported mental health diagnoses of the sample*

Upon screening of the data 5 participants were removed from the ASC group and 9 from the control group for abnormally low scores, these were found to be caused by participants not progressing with the task through to completion.

Analysis of the group characteristics according to demographics and the various measures administered showed there were significantly more females in the control sample (56) than the ASC sample (25) (*t* (89.901) = -2.546, *p*=0.013). To ensure any differences between the ASC sample and control sample were not confounded by sex differences independent samples *t*-tests were conducted on scores on the eyes task, RM task, AQ scores and Alexithymia scores. Results showed t significant differences in AQ scores in the expected direction with higher AQ scores in males 30.21 than females 24.43 (*t* (121) = 2.45, *p*=.016. However this result is to be expected as ASC traits are more readily identified in males than females. There were no significant differences between the sexes in any of the other measures (all *p*>0.05 two tailed). Further information on group characteristics and differences are displayed in Table 6.1 below.

Table 6.1: *Descriptive statistics of sample groups*

	Control			**ASC**			
	N	Mean	SD	N	Mean	SD	Significance result
Age	75	34.85	17.37	48	44.67	15.84	*U*(121)=2463.50, *p*< 0.001
Full scale IQ	9	141.78	12.17	16	136.94	15.05	*t*(23)=-0.82, *p*= 0.42
eyes task‡	74	25.78	4.82	48	24.52	5.80	*U*(120)= 1577, *p*= 0.148
RM score‡	75	18.59	3.99	48	18.46	3.04	*U*(121)=1723, *p*= 0.345
AQ scores†	75	18.05	7.32	48	39.46	6.85	*U*(121)=3498.5, *p*<0.001
TAS-20 score†	75	48.77	11.43	48	65.42	11.74	*U*(121)=3101, *p*<0.001

Note: RM= Retrodictive Mindreading AQ= Autism Quotient, TAS= Toronto Alexithymia Scale
‡= directional analysis control> ASC
†= directional analysis ASC>control

As the ASC sample was significantly older than the control sample Pearson's correlations were used to investigate any potential relationships between age and other variables. Correlations between age, eyes task, RM, AQ and TAS-20 scores showed age only correlated significantly with AQ scores (*r*(123)=.281,*p*=0.002). This was to be expected given the significant group differences in AQ scores, but also suggests the differences in age between the groups did not present any meaningful relationship with other variables recorded.

6.3.2 Did participants with ASC recognise expressions differently?

To investigate recognition a 2 (group) x 2 (stimuli type) x4 (expression) mixed factorial ANOVA was carried out with presence of autism diagnosis as the between groups variable and stimuli type and expression type as the within groups variables. Mauchly's test was violated and sphericity could not be assumed between levels of expression types (Greenhouse-Geisser =.92), as such Greenhouse-Geisser adjustments are reported. Levene's test showed equality of error variances between the groups ($p>.05$)

There was no main effect of group (ASC, Control) on recognition rates (F (1, 121) = 0.03, p=0.849). There was a significant main effect of stimuli type with spontaneous expressions (Mean = 60.57%, 95% CI [58.12, 63.03]) recognised more than posed expressions (Mean=55.19%, 95% CI [52.77, 57.61]) (F (1, 121) = 17.88, p<0.001, η^2 = .129). There was also a significant main effect of expression type (F (2.66, 322.32) = 82.09, p<0.001, η^2 = .404). There were significant interactions between expression type and group (F (2.66, 322.32) = 3.87, p=0.013, η^2 = .031) and a significant interaction between the type of stimuli shown and the expression type on recognition (F (2.86, 345.71) = 13.87, p<0.001, η^2 = .103). There were no significant interactions between the recognition rates of stimuli type viewed and group (F (1, 121) = .561, p=.455 or type of stimuli shown, expression type and group diagnosis (F (2.86. 345.71) = 1.24, p=.297.

6.3.2.1 How was each expression type recognised?

Bonferroni corrected post-hoc analyses showed the main effect of expression type followed a structured pattern with the expressions maths question (75.59%, 95% CI [72.32, 78.87]), monopoly money (61.98%, 95% CI [58.84, 65.12]), negative feedback (52.04%, 95% CI [48.90, 55.89]) and positive feedback (41.56%, 95% CI [37.57, 45.38]) recognised best to worst respectively. All p values were significant at the $p\leq0.001$ level.

6.3.2.2 How did groups differ in recognising different expression types?

Bonferroni corrected post-hoc analyses showed the significant interaction between expression type and group was in the case of the maths expression being significantly better recognised by the ASC group (79.69% 95% CI [74.57, 84.81]) than the control group (71.50% 95% CI [67.41, 75.59]) p=.015. There were also differences between the groups in inter expression recognition rates, this was specific to two expressions, within the ASC sample there was no significant difference between the negative expression (48.96%, 95% CI [43.50, 54.42] and positive expression recognition (40.63%, 95% CI [34.66, 46.59] p=.299), a difference that was significant in the control sample (negative 55.83%, 95% CI [51.47, 6.], positive (42.50%, 95% CI [37.73, 47.27] p=0.001).

6.3.2.3 What difference did stimuli delivery type have on expression recognition?

Investigating the interaction between expression and stimuli type, post-hoc analyses showed the maths question (79.50%, 95% CI [75.63, 83.37] p=.001), monopoly money (68.26%, 95% CI [63.75, 72.77] p<.001) and negative feedback (57.28%, 95% CI [52.93, 61.63] p<.001) expressions were recognised significantly better in a spontaneous delivery format than posed (71.69%, 95% CI [67.57, 75.80]; 55.69%, 95% CI [52.13, 59.27]; 47.51%, 95% CI [43.27, 51.75] respectively). The opposite effect was true for positive feedback (p=.002) which was significantly better recognised in a posed format (45.88%, 95% CI [40.88, 50.87]) than spontaneous (37.25%, 95% CI [32.87, 41.63]. Analysis of recognition rates between expressions within stimuli type suggest the pattern previously outlined in the main effect was driven by results from spontaneous expressions which follow the same recognition pattern (means provided above). However within posed stimuli the differences are less pronounced between expressions causing differences between negative to positive (p=1) to fall below the significance threshold (means provided above). A bar graph of recognition rates of expression types when posed or spontaneous can be found below in figure 6.4.

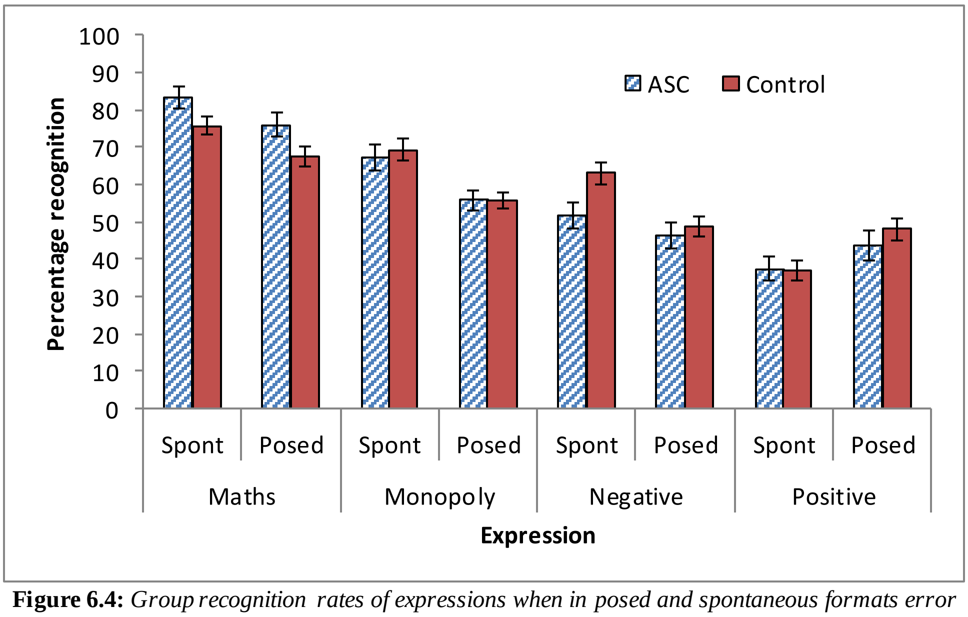


Figure 6.4: *Group recognition rates of expressions when in posed and spontaneous formats error bars show ±1SE*

Table 6.2: *Confusion matrix of control and ASC participants responses when expression were (A) posed and (B) spontaneous*

		Typically developing						ASC			
A) Posed		Correct answer						Correct answer			
		Maths	Monopoly	Negative	Positive			Maths	Monopoly	Negative	Positive
Participant response	Maths	213	29	78	29	Participant response	Maths	152	12	58	21
	Monopoly	12	172	16	61		Monopoly	3	110	10	43
	Negative	72	18	152	73		Negative	40	6	95	49
	Positive	17	90	63	150		Positive	9	75	39	89
B) Spontaneous		Correct answer						Correct answer			
		Maths	Monopoly	Negative	Positive			Maths	Monopoly	Negative	Positive
Participant response	Maths	237	24	23	44	Participant response	Maths	165	15	26	34
	Monopoly	21	214	30	76		Monopoly	8	132	19	41
	Negative	40	13	195	79		Negative	23	7	106	50
	Positive	19	62	62	114		Positive	6	44	49	75

Note: Shaded cells denote correctly retrodicted responses

6.3.3 What are the patterns of expression recognition?

Participants' responses to the videos were collated and a confusion matrix compiled (seen above in table 6.2) which shows the responses given relative to the correct answer.

6.3.3.1 Could participant's retrodict the correct event more than other options?

To investigate if participants could correctly retrodict the matching event that caused the reaction in the video a 2 x 2 x 4 x 4 mixed factorial ANOVA was conducted. Stimuli type (posed, spontaneous), Correct answer (video shown) and Actual answer (guess made) were within subjects factors and group (ASC, Control) was a between subjects factor the dependent variable was the event retrodicted. The assumption of sphericity was violated, as such Greenhouse-Geisser adjusted epsilon values are reported.

Main effects add little to the interpretation of any results in this analysis, for example the significant main effect present in correct (actual emotion shown) (F (2.62, 353.71) = 9.35, p<0.001) meaning more responses irrespective of if they were correct were made to one type of expression than another, does not add to interpretation other than participants felt more able to answer some expressions than others. As a result the significant interactions between Stimuli and correct (F (2.72, 367.40) = 12.90, p<0.001) and Correct and actual (F (4.66, 629.91) = 316.83, p<0.001) will be further investigated.

6.3.3.2 Did stimuli delivery type influence the number of guess attempts?

Post-Hoc Bonferroni corrected analyses showed that the significant interaction between the stimuli type shown and correct answer (what the expression type actually was) was driven by differences in the amount of selections made to monopoly money and positive feedback expressions when posed and spontaneous. The monopoly money expressions attracted significantly more guesses (more participants felt able to answer it) when shown in a spontaneous format (2.52, 95% CI [2.31, 2.72]) than a posed format (2.06, 95% CI [1.90, 2.22], p<0.001), whilst the opposite was true of positive feedback expressions where significantly more guesses were made when the expressions was delivered in a posed format (1.73, 95% CI [1.54, 1.93]) than a spontaneous format (1.39, 95% CI [1.21, 1.56], p<0.001).

6.3.3.3 Were participants more likely to retrodict the correct event?

Post-Hoc Bonferroni corrected analyses showed the significant interaction between correct response and actual response was due to participants' ability to retrodict the correct answer more frequently than other options. All four of the expression types had significantly more actual answers to the correct expression than alternative options (all $p<0.001$). A bar graph of the frequency of answers given to each expression type can be seen below in figure 6.5.

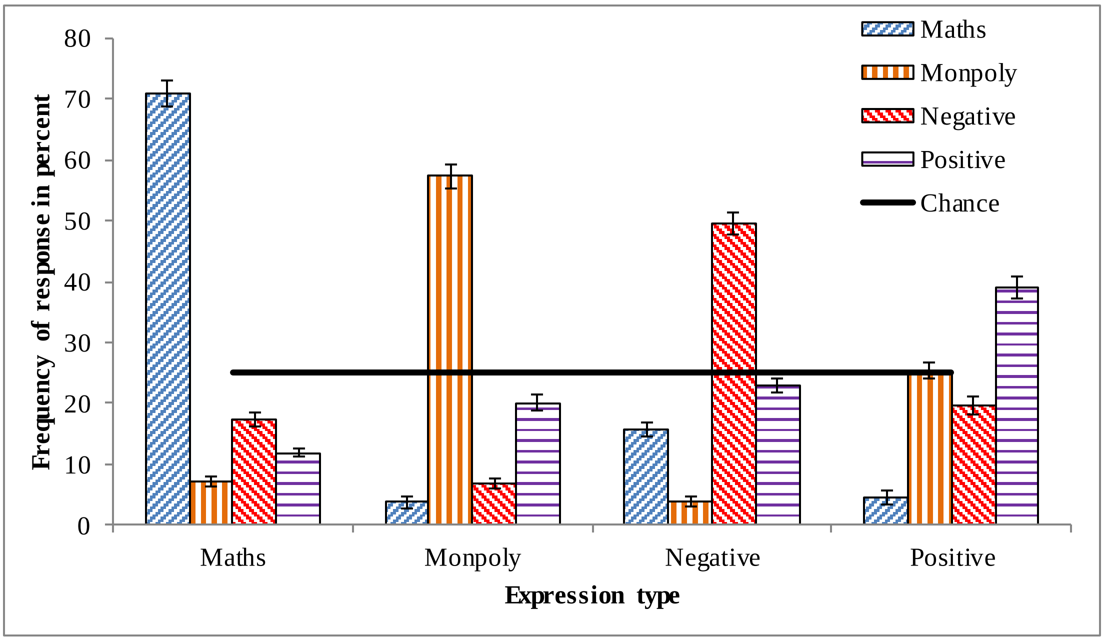


Figure 6.5: *The frequency of answers provided to each expression display error bars indicate ±1SE*

Figure 6.5 shows the recognition rates of each individual expression, which is the rate they selected the correct answer of the expression viewed over other options, is above chance for all expressions (maths = 70.86%, monopoly = 57.26%, negative = 49.52%, positive = 38.98). Of note is that alternate incorrect options in all cases fall below the expected chance rate (25%) for guessing, or on the chance rate in the case of monopoly money incorrectly guessed as the eliciting prompt when it was in fact positive feedback (25.34%). What Figure 6.5 demonstrates is that participants could correctly attribute the eliciting event of the expressions above the chance rate, and as correct recognition decreases incorrect guesses increase but in an expected pattern with even increase amongst appropriately valenced alternatives. For example, as positive feedback showed the poorest recognition there was an increase in incorrect guesses of monopoly money and negative feedback but not maths question. This is because an outwardly thankful response or even shy and reserved in some cases (explaining the rise in negative feedback guesses) is not considered an appropriate or typical response to being asked a maths question. Only the positive feedback expression showed a cumulative incorrect guess rate 49.45% greater than the correct rate (38.98) however as mentioned above and demonstrated in figure 6.5 none of the incorrect options occurred at above the chance rate.

6.3.4 Did participants make systematic emotional inferences to the expressions?

To investigate if participants gave systematic emotion inferences to the expressions viewed, the frequency of inferences made was tabulated. This was done for both the control and ASC samples, the frequencies of inferences were tabulated according to the stimuli type (posed or spontaneous) and if the events were retrodicted correctly (pairing the reaction in the video to the correct causal event). Likelihood Ratios were calculated from the total observed frequency of consistent emotions inferences (thinking to maths, for example) and inconsistent emotion inferences (Happy to negative feedback, for example) and comparing these observed frequencies to a null hypothesis of expected frequencies. The observed and expected frequencies of emotion inferences in any given condition can be seen in table 6.3 below. Below sub tables represent the inferences made to both spontaneous and posed expressions when the retrodictions were correct (A for controls, B ASC) and incorrect (C for controls, D ASC).

Table 6.3: *Frequency of emotion inferences made by each group to posed and spontaneous expressions when correctly and incorrectly retrodicted*

	Correct response (expected frequencies in brackets)										
A) Control group	Posed stimuli						Spontaneous stimuli				
	Maths	Monopoly	Negative	Positive	Total		Maths	Monopoly	Negative	Positive	Total
Thinking	**194 (83.1)**[A]	43 (67.1)	24 (59.3)	7 (58.5)	268	Thinking	**217 (83.9)**[A]	24 (75.7)	25 (69)	3 (40.4)	269
Surprised	14 (46.5)	**102 (37.6)**[A]	13 (33.2)	21 (32.8)	150	Surprised	7 (48)	**103 (43.4)**[A]	33 (39.5)	11 (23.1)	154
Sad	1 (36.6)	2 (29.5)	**115 (26.1)**[A]	0 (25.8)	118	Sad	0 (41.8)	0 (37.7)	**134 (34.4)**[A]	0 (20.1)	134
Happy	4 (46.8)	25 (37.8)	0 (33.4)	**122 (33)**[A]	151	Happy	13 (63.6)	87 (57.2)†	3 (52.1)	**100 (30.5)**[A]	203
B) ASC group											
	Maths	Monopoly	Negative	Positive	Total		Maths	Monopoly	Negative	Positive	Total
Thinking	**137 (63.4)**[A]	33 (45.9)	11 (39.6)	5 (37.1)	186	Thinking	**130 (58.3)**[A]	20 (46.7)	14 (37.5)	5 (26.5)	169
Surprised	11 (32.4)	**57 (23.4)**[A]	11 (20.2)	16 (19)	95	Surprised	10 (33.5)	**65 (26.8)**[A]	10 (21.5)	12 (15.2)	97
Sad	1 (26.9)	3 (19.5)	**73 (16.8)**[A]	2 (15.8)	79	Sad	2 (28.3)	0 (22.6)	**80 (18.2)**[A]	0 (12.9)	82
Happy	3 (29.3)	17 (21.2)	0 (18.3)	**66 (17.2)**[A]	86	Happy	23 (44.9)	47 (35.9)†	2 (28.8)	**58 (20.4)**[A]	130
	Incorrect response (expected frequencies in brackets)										
C) Control group	Posed stimuli						Spontaneous stimuli				
	Maths	Monopoly	Negative	Positive	Total		Maths	Monopoly	Negative	Positive	Total
Thinking	**105 (36.1)**[A]	13 (23.6)	27 (43.3)	3 (44.9)	148	Thinking	**57 (21)**[A]	12 (19)	16 (22.4)	5 (27.7)	90
Surprised	20 (42.5)	**38 (27.8)**[A]	49 (50.9)	67 (52.8)†	174	Surprised	10 (17.9)	**33 (16.3)**[A]	12 (19.1)	22 (23.7)	77
Sad	4 (22.5)	7 (14.7)	**79 (26.9)**[A]	2 (27.9)	92	Sad	2 (13.3)	3 (12)	**50 (14.2)**[A]	2 (17.5)	57
Happy	7 (34.9)	31 (22.8)†	8 (41.8)	**97 (43.4)**[A]	143	Happy	6 (22.8)	20 (20.7)	2 (24.3)	**70 (30.1)**[A]	98
D) ASC group											
	Maths	Monopoly	Negative	Positive	Total		Maths	Monopoly	Negative	Positive	Total
Thinking	**70 (25.2)**[A]	8 (15.5)	21 (26.3)	2 (34)	101	Thinking	**69 (20.7)**[A]	16 (28.9)	23 (30)	4 (32.5)	112
Surprised	11 (21.9)	**26 (13.5)**[A]	19 (22.9)	32 (29.7)†	88	Surprised	15 (24.7)	**69 (34.5)**[A]	27 (35.9)	23 (38.9)	134
Sad	5 (15)	1 (9.2)	**52 (15.6)**[A]	2 (20.2)	60	Sad	1 (15.3)	3 (21.4)	**76 (22.2)**[A]	3 (24.1)	83
Happy	5 (28.9)	21 (17.8)†	3 (30.2)	**87 (39.1)**[A]	116	Happy	6 (30.3)	39 (42.2)	6 (43.9)	**113 (47.6)**[A]	164

Note: **Bold**[A] Denotes consistent emotion inference to retrodiction response, † denotes values of interest

The bolded diagonal cells in Table 6.3 display consistent emotion to expression inferences, it is the combined total of the values not in parentheses of these cells that represents total observed consistent emotional inferences. The total value within parentheses of those same cells represents a null model expected frequency. A larger value outside parentheses than within suggests participants made more inferences than would be predicted. The opposite is true for inconsistent emotion inferences (values not bold or on the diagonal) where a larger value would be expected within parentheses indicating inconsistent emotion inferences were less frequent than a null model would predict.

The individual breakdown of observed to expected frequencies displayed above can be useful for isolating specific instances where an inconsistent emotion attribution was made more than would be expected. Some values have been highlighted above where this is the case, it is mostly confined to monopoly money but in two specific conditions: correct retrodictions to spontaneous stimuli, and incorrect retrodictions to posed stimuli. Both the control and ASC sample inferred happiness as an emotional state more than would be expected. This does not necessarily mean that participants are particularly poor at inferring emotional states to the monopoly money expression; instead it appears more appropriate to acknowledge that the monopoly money expression may have two appropriate emotional inferences which may even be blended in one expression. Viewing the observed to expected frequencies it can be seen that incorrectly retrodicted posed expressions were most likely to attract inconsistent emotion inferences.

Despite the instances highlighted above, significant likelihood ratios were present for all categories and groups (posed incorrect retrodiction, spontaneous incorrect retrodiction etc.). This suggests participants were significantly more likely to infer a consistent emotion to event and significantly less likely to infer an inconsistent emotion. No apparent difference was present between the control and ASC sample; although the smallest $L\chi2$ statistics were present in incorrectly retrodicted expressions from the ASC sample. Smaller $L\chi2$ statistics are less likely to produce significant results providing evidence against the current model in favour of the null. Because significance was still present in these instances it can be stated the current model (that consistent inferences will be more frequent than inconsistent) is still applicable to the ASC sample but slightly less robust. The totalled consistent and inconsistent observed and expected frequencies per condition with respective Likelihood Ratios are presented below in table 6.4 for brevity.

Table 6.4: *Total observed (with percentages) and expected frequencies of emotion inferences between groups and stimuli type to correct (A) and incorrect (B) retrodictions*

	Control				**ASC**			
	Posed		Spontaneous		Posed		Spontaneous	
A) Correct	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent
Observed frequency	533 (77.6%)	154 (22.4%)	554 (72.9%)	206 (27.1%)	333 (74.7%)	113 (25.3%)	333 (70.4%)	145 (30.6%)
Expected frequency	179.8	507.3	192.2	567.9	120.8	325.2	123.7	354.3
Likelihood Ratio	$L\chi2$ (9)=946.72 p<0.001		$L\chi2$ (9)=1031.19 p<0.001		$L\chi2$ (9)=544.73 p<0.001		$L\chi2$ (9)=531.81 p<0.001	
	Posed		Spontaneous		Posed		Spontaneous	
B) Incorrect	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent
Observed frequency	319 (57.3%)	238 (42.7%)	327 (66.3%)	166 (33.7%)	235 (64.4%)	130 (35.6%)	210 (65.2%)	112 (34.8%)
Expected frequency	134.2	422.6	125	368.1	93.4	271.6	81.6	240.4
Likelihood Ratio	$L\chi2$ (9)=449.84 p<0.001		$L\chi2$ (9)=462.73 p<0.001		$L\chi2$ (9)=343.65 p<0.001		$L\chi2$ (9)=287.96 p<0.001	

6.3.5 Does Alexithymia severity predict retrodictive mindreading ability within autism?

To directly test the Alexithymia hypothesis a linear regression was conducted using Alexithymia to predict the performance on a retrodictive mindreading task within the ASC sample recruited. Durbin Watson statistic (2.28) was satisfactory and Homoscedasticity was satisfied via visual inspection of studentized residuals plotted against unstandardized predicted values. Studentized deleted residuals showed one value as an outlier (-3.09) driven by a low score on the RM task (9) however leverage (0.03) and Cook's distance (0.29) were satisfactory. One participant presented high Cook's D (.78) due to their uncharacteristically low Alexithymia score (25) within the ASC sample. Using a more conservative cut-off of Cook's D (4/N) the threshold for Cook's D was set at 0.084 application of which removed the two cases identified above. Assumptions of normality were satisfied via inspection of a P-P plot and histogram.

The regression model was non-significant suggesting Alexithymia scores (standardised beta -.06) in ASC do not predict performance on an emotion processing task, in this case the RM task (F (1, 44) = .157, p= .694 R^2 = .004)

6.3.6 What were the associations between measures?

Given that no significant group differences were present in retrodiction ability, but groups were distinct in scores of self-report autistic traits and Alexithymia traits, Pearson's correlations were used to investigate any associations between scores on these measures across the spectrum. A correlation matrix of measures used can be seen below in table 6.5 and plots can be seen in appendix K.

Table 6.5: *Correlation matrix of assessment tasks*

		Eyes task	RM score	AQ score	TAS score
Pearson's r	Eyes task	—	0.369**	-0.296**	-0.257*
	RM score		—	-0.143	-0.088
	AQ scores			—	0.712**

Note: * p < .01, ** p < .001

There were no significant relationships between RM score and AQ or TAS scores. There were positive relationships between eyes task scores and RM scores as would be expected and AQ scores and TAS scores which would also be expected. Interestingly given the previous non-significance in group differences of eyes task performance correlations showed significant weak negative relationships between eyes task scores and both AQ and TAS scores.

6.3.7 What are the effects of Alexithymia on task performance?

Splitting participants into high Alexithymia traits (≥62), possible Alexithymia traits (52-61) and low Alexithymia traits (≤51) appeared to show little trend on performance of RM ability particularly in a linear fashion following severity (figure 6.6).

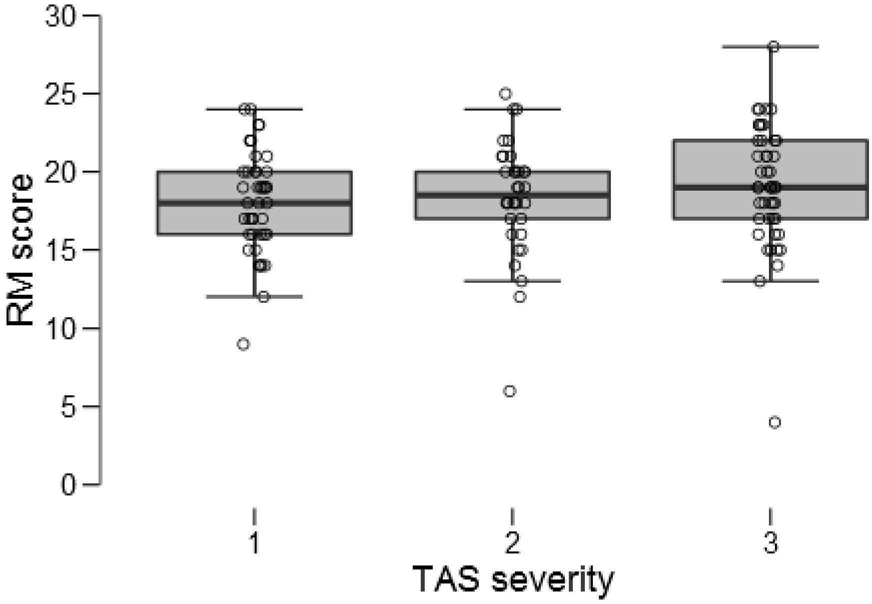


Figure 6.6: *Boxplots of retrodictive mindreading scores within Alexithymia severity bands (1= severe Alexithymia, 2= possible Alexithymia, 3= low Alexithymia*

Investigations of RM ability according to TAS severity via independent one way ANOVA showed no main effect of severity $F(2,120)=.889$, $p=.414$,

Alexithymia severity had a significant effect on performance on the eyes task with variation between severity groups (F (2, 119) = 3.21, p=0.044, η^2= .051**)**. Difference contrasts show the difference resides between the mild Alexithymia group (Mean=26.80, SD=4.17) and severe Alexithymia group (Mean=24.42, SD=5.50) and medium Alexithymia group (Mean=24.30, SD=5.87) p=.013. The difference in Eyes task scores between mild, medium and high severity Alexithymia can be seen in figure 6.7 below.

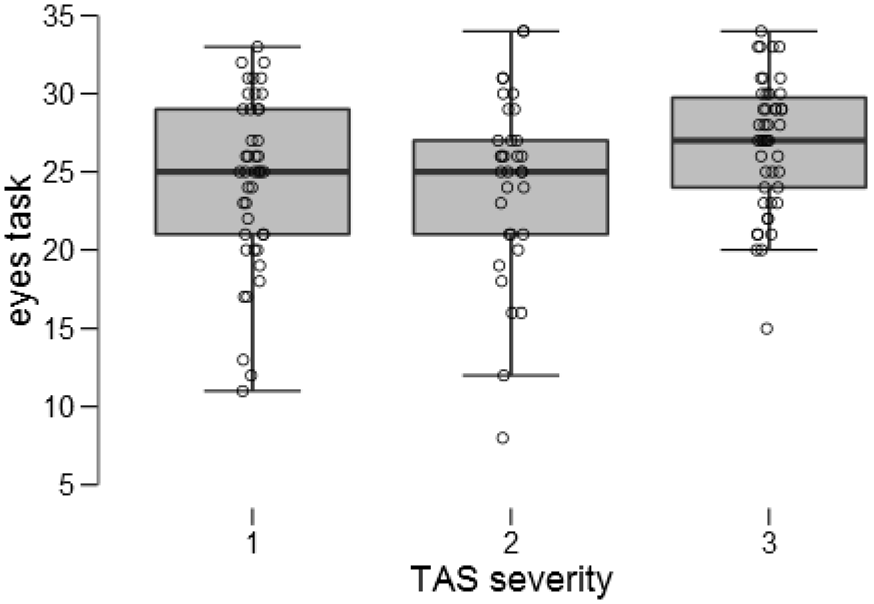


Figure 6.7: *Boxplots of Eyes task scores within Alexithymia severity bands (1= severe Alexithymia, 2= possible Alexithymia, 3= low Alexithymia*

However there is a clear trend of autism severity increasing with Alexithymia severity (see figure 6.8). An independent samples one way ANOVA showed significant differences in AQ scores between Alexithymia severity F (2,120) = 56.93, p<0.001.A planned contrast was carried out comparing AQ scores in high Alexithymia severity to those in medium and mild severity showing significant differences (t (120) = 9.80, p<0.001). AQ scores were significantly higher in high severity Alexithymia (Mean=37.81, SD=8.13) than those in medium (Mean=24.24, SD=9.62) and low severity (Mean=17.35, SD=9.68)

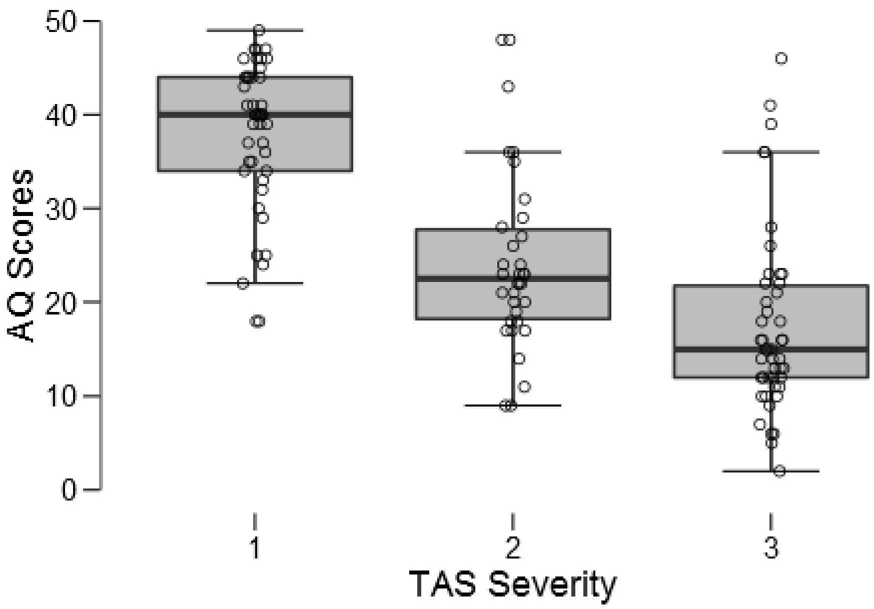


Figure 6.8: *Boxplots of AQ scores within Alexithymia severity bands (1= severe Alexithymia, 2= possible Alexithymia, 3= low Alexithymia*

The results show Alexithymia severity presents in a linear trend with autism severity, this would be expected given previous literature and the relationship reported previously. However, the linear relationship between Alexithymia and autism traits does not present in as pronounced a fashion for either RM ability or eyes task scores where differences between severities are less notable.

6.4 Discussion

This research aimed to investigate emotion recognition and understanding in an ASC sample and comparison control sample. The research included new stimuli of spontaneous reactions captured in naturalistic reciprocal social interchange which were designed to better reflect typical social interactions; this should provide better assessments of abilities or difficulties. The research also investigated the links between autistic traits and Alexithymia, where growing research is highlighting Alexithymia's role in emotion recognition difficulties.

The research made three predictions: based on the more complex task requiring retroactive use of information and social attributions, it was predicted the control group would correctly retrodict ('what has happened to this person?') significantly more events than the ASC group. The results did not support this hypothesis as there were non-significant differences in RM ability between the ASC and control group. There were however, instances of differences between recognition of specific expressions, namely better recognition of the maths question in the ASC sample than control sample. There were also differences in inter-expression recognition rates between the groups; for example the control group showed significantly better recognition for negative expressions than positive, a difference that was not significant in the ASC group. This pattern of recognition rates between the expressions is to be expected given the previous literature that shows specific difficulties on negatively valenced expressions in ASC (Ashwin et al., 2006; Bal et al., 2010; Corden et al., 2008). The control group's superior recognition of negative feedback relative to positive feedback is not found in the ASC group where research has typically shown difficulty in recognising negatively valenced expressions, as a result this minimised the difference between negative and positive feedback reactions.

It was also predicted the ASC group would present significantly higher Alexithymia scores than the typically developing group. The results supported this hypothesis showing significantly higher Alexithymia scores in the ASC sample than the control sample. This effect also translated to self-report autism traits across the entire sample, where participants with high alexithymic traits had significantly higher AQ scores than those with medium or low alexithymic traits. This is consistent with previous literature showing strong comorbidity between ASC and Alexithymia (Berthoz & Hill 2005; Hill & Berthoz 2004; Bird & Cook 2013). However, the effects of Alexithymia on performance in the RM task were not consistent with previous literature on emotion processing abilities (Parker, Taylor & Bagby 1994; McDonald & Prkachin 1990; Prkachin et al., 2009; Pollatos & Gramann 2011; Pollatos et al., 2008; Cook et al., 2013). Results showed no effect of Alexithymia severity on RM performance. Such a finding is contrary to previous research and has implications for the Alexithymia hypothesis; if Alexithymia is expected to contribute to emotion processing abilities worse scores on the RM task would be expected in the severe Alexithymia group than the medium or mild group. To directly test the Alexithymia hypothesis within autism a regression was conducted using Alexithymia scores to predict RM scores within only the ASC sample. Results suggested Alexithymia scores do not significantly predict RM performance. This is problematic for the Alexithymia hypothesis as the ASC group self-identified as significantly higher in Alexithymia traits than controls, it would be expected a group self-identifying as higher in Alexithymia traits would show a negative association on an emotion processing task. Particularly as the Alexithymia hypothesis suggests the differences in emotion processing abilities reside in the specific overlap of ASC traits and Alexithymia traits which appeared to be the case in this sample. There was an effect of Alexithymia severity on eyes task performance with those reporting mild Alexithymia performing better than those reporting medium or severe alexithymia. This difference observed in the eyes task but not the RM task presents problems for the RM task as it was expected an arguably more social task in nature would find differences between alexithymia severities.

Finally it was predicted the ASC group would make significantly less correct emotional inferences (‘how did this person feel?’) than the typically developing group due to Alexithymia’s influence on empathic abilities. This hypothesis was not supported as ASC participants made situationally appropriate emotional attributions significantly more than would be expected in all conditions, this included when they had correctly retrodicted the event and when they incorrectly retrodicted the event. This was also consistent across both posed and spontaneous expressions. Although there were still significantly more consistent observed attributions than would be expected after an incorrect retrodiction, there was an overall decrease in the number of consistent attributions. Controls gave less consistent attributions after an incorrect retrodiction compared to after correctly retrodicting the event. A similar pattern was present in the ASC group with less consistent attributions after incorrectly retrodicting the event than after correctly retrodicting the event.

The decline in consistent emotion attributions, although not to below significance, would still suggest a correct understanding of socially appropriate emotional responses is part of the formula in attributing emotional states to others. For example observing an individual crying is usually associated with sadness and pain, however if you were to see that individual cradling a new born baby the tears take on a new context and the emotional attribution changes to joy. The example is crude because tears of joy are typically easily differentiated from tears of sadness, however the example serves to highlight how context can aid in assigning appropriate emotional states and that this context has been lacking from much of the previous research in the literature (Calder et al., 2000; Elfenbein & Ambady 2002; Hall & Matsumoto 2004; Kessler et al., 2008; Matsumoto et al., 2002; Shioiri et al., 1999). This may be one potential explanation as to why no group differences have been found in overall performance between the ASC and control groups. It is possible the stimuli and method of assessment used provide a greater opportunity for autistic individuals to find the extra context that is available in typical social interchange, they can then use this to minimise any difficulties that may have been present under more artificial circumstances.

The above explanation while potentially standing for the RM results, does not adequately address why no group differences were present in the eyes task, which has a robust effect (Baron-Cohen et al., 2001; 2015; Vellante et al., 2013). There is confidence that the sample gathered are autistic, with diagnoses and self-report traits significantly differentiating the two groups. Similarly, the comorbid Alexithymia with ASC and group differences also serves to corroborate legitimate group differences based on autism diagnosis. Recent research using the full (36 images) eyes task has shown significant differences between control groups (mean score 26.48) and ASC groups (mean score 23.49) (Baron-Cohen et al., 2015); however these scores are not dissimilar to those presented above (control mean 25.78, ASC mean 24.52). As Baron-Cohen and colleagues (2015) demonstrated a sex difference in eyes task performance within controls but not an ASC sample, this was considered as a potential contributing factor due to the uneven sex ratio in the sample collected (52.08% female in ASC, 74.67% females in control). This proved not to be a contributing factor, as no differences were present between the sexes in performance on the eyes task. Incidentally the direction of the effect generally in the literature is control females outperforming males (McClure et al., 2000; Thayer & Johnson 2000; Montagne, Kessels, Frigerio, de Haan & Perrett et al., 2005; Hoffmann et al., 2010) and in Baron-Cohen and colleagues (2015) research specifically. This would have helped towards significance in the current research with the distributions of the sexes as they were within the groups (more control females bringing the control average up inflating group differences).

Previous correlations have demonstrated associations between eyes task performance and AQ across collapsed ASC and control groups (Baron-Cohen et al., 2001), or only in females with autism (Baron-Cohen et al., 2015). This was demonstrated on a particularly large sample of females (N=217), although the current research did demonstrate similar male to female ratio within the ASC sample it may be that the larger female sample reported previously contributed to significance. In the cases of both of the research highlighted the direction of the relationship was the same and strength was similar to that reported above (-.53 and -.32 respectively). Prior research has demonstrated a lack of difference between ASC and control groups on the eyes task when controlling for Alexithymia while also demonstrating significant differences between those with and without Alexithymia (Oakley, Brewer, Bird & Catmur 2016). The lack of difference between ASC and control groups on the RM task and between Alexithymia severities suggests that in the current methods the RM task might lack specificity. There is the potential in a specific aim that expanding the number of expression types and removing the stimuli spontaneity as a variable to allow more expressions in a manageable experimental procedure could identify differences between both ASC and control groups and Alexithymia severities.

With ASC diagnosis not influencing performance on tasks, the sampling method might be a contributing factor. Considering an overwhelming majority of the ASC sample were recruited from the Cambridge autism research volunteer database (CARD) (83%) this may select a sample that is much more experienced with experimental procedures and tasks. Volunteers of the CARD receive monthly E-mails of all approved research, volunteers self-select which research project they want to take part in, this could result in an over-representation of participants who frequently take part in research of a specific nature (such as emotion processing). This could inadvertently train participants on these tasks improving performance relative to controls. There is also the possibility that a self-selecting sample which opts in to research databases is naturally higher functioning; for comparison only 34.1% of the control sample was recruited through the CARD. In a related issue, the IQ of the entire sample was particularly high, it is worth mentioning IQ was self-report if known, this method of collection might self-select for individuals who have a particularly high IQ and have subsequently been tested and therefore know this information. Thus it is possible the actual IQ of the entire sample would fall much closer to the normative range but this is speculation. Nevertheless the reported IQ that was observed may have influenced the research, allowing certain coping mechanisms in the ASC sample, where previous research has shown the importance of IQ in emotion processing (Loveland et al., 1997, Buitelaar, van der Wees, Swaab-Barneveld & van der Gaag, 1999)

The findings provide mixed support for the Alexithymia hypothesis of autism, on one hand the results show strong support for Alexithymia comorbidity in ASC through the presence of more Alexithymia traits in the ASC sample and increasing Alexithymia severity with AQ scores across the entire sample corroborating previous research (Berthoz & Hill 2005; Hill & Berthoz 2004; Bird & Cook 2013). However the presence of more Alexithymia traits in the ASC group did not bring about group differences in performance. In fact only when Alexithymia severity itself was investigated did differences emerge between severity bands. Thus the research does add to previous literature in highlighting the links between Alexithymia and ASC but fails to find results that implicate Alexithymia, particularly in autism, as a major contributor to emotion recognition difficulties.

Similarly the research does not find supporting evidence that emotion recognition difficulties are as pervasive as reported in the literature (e.g. Harms et al., 2010). The factors discussed above such as the sample recruited, new stimuli set, and method of assessment, may have played a part in better reflecting the demands of typical social interaction allowing greater context to aid recognition. It was anticipated the task would be more difficult than previous used in the literature, as such the stimuli used was limited to the four best recognised expressions from the prior experiments. This was done because it was believed making the task easier was more likely to unearth any differences than a task that is too hard and will produce floor effects. It was also believed after RM performance predicted AQ scores in chapter 5, that the design used in that experiment provided enough difficulty and specificity to differentiate between those with an ASC diagnosis and those without. All expressions showed acceptable recognition rates above chance, as such for future research it might be worth considering expanding the expression categories used. This is proposed for two reasons: firstly, simply adding more expressions increases the difficulty of the task and moves away from basic categories such as positive and negative. Secondly, the response patterns showed when giving attributions participants tended to recognise monopoly money as positive and surprised. This effectively narrows the feasible range of answer from four to two and chance rate to 50%. By including more expressions across the valence spectrum it might be that the process of elimination opportunity is reduced and the task becomes more difficult. This in turn could detect any difficulties in an ASC sample which appear to be more subtle; at least in the current sample under the current methods.

Expanding upon the current research, future directions could investigate group differences with the broader expression library as discussed; there would also be room to investigate emotional mimicry between those with an ASC diagnosis and a typically developing sample. This could be expanded between the degree of emotional mimicry assessed by facial change in response to posed and spontaneous expressions, this is particularly pertinent given the differential display patterns of posed and spontaneous expressions highlighted in chapter 3. This could have implications for the correct understanding of expressions (in the case of artificial stimuli) and subsequent expression understanding in others (in real world settings) this particular point was briefly addressed in the introduction and would warrant further investigation given the comorbid Alexithymia reported in this study.

To summarise, in this chapter the focus was investigating group differences between an ASC and control sample on recognition rates of a new dynamic spontaneous stimuli set. The results showed no significant group differences in the RM task or emotional inferences to situations. There was also no difference between the groups on performances on the eyes task, however investigating differences between Alexithymia severities on eyes task performance showed significant group differences with mild Alexithymia performing significantly better than medium or severe. In line with previous research there was a strong link between Alexithymia and ASC. Alexithymia scores did not predict RM ability within the autistic sample, questioning the accuracy of the Alexithymia hypothesis. Similarly Alexithymia severity across the whole sample showed no effects on RM performance. The improved recognition of spontaneous expressions over posed is consistent with findings in chapter 4; this is bolstered by the differential display patterns between posed and spontaneous expressions shown in chapter 3, which extended further to differential viewing patterns in chapter 5, but these viewing styles did not translate to recognition rates between posed and spontaneous expressions in chapter 5. Recognition generally fell around chance rates, suggesting the task may be beyond the developmental stage of the children tested.

These findings suggests future research with adults should endeavour to use high quality spontaneous expressions as these improve recognition rates; presumably by better reflecting typical social interaction. The lack of group differences suggest those previously reported may be over-exaggerated, potentially through methodological assessment or the current results may be under estimated through sampling; replication is required to confirm if the sampling or improved methodological rigour is responsible for the reported findings.

Chapter 7: General Discussion

7.1 Summary of the Findings

The studies presented in this thesis investigated the production of posed and spontaneous expressions, their recognition in a typically developing adult population, the recognition and viewing style in typically developing children and the performance of ASC adults and controls on a RM task. In chapter 3, it is believed the first research is presented that investigates whole face display patterns of matching posed and spontaneous expressions with FACS data captured in social interchange. Similar work was carried out by Namba et al., (2016) but this was based on spontaneous expressions that were captured in response to specifically selected films; the drawbacks of such a method were discussed in chapter 2 section 2.6. Similarly, FACS analysis was used in Valstar et al. (2006) but this was based primarily on brow movements not entire faces.

In chapter 4 the newly created expressions were validated in an online survey with typically developing adults. The free response emotion inferences given by participants were coded and cross-tabulated which showed emotion inferences deemed consistent to specific reaction types (e.g. happiness to positive feedback/ sadness to negative feedback) after both correct and incorrect event retrodiction. Chapter 4 showed good recognition above chance for all expressions except no repeat, and a global improvement in spontaneous expression recognition over posed. Controlling for expression positivity through valence did not influence the recognition rates between expressions. There was also a borderline significant negative correlation between Alexithymia traits in the displayer and recognition of their expressions.

In chapter 5, once again it is believed the first results are reported investigating viewing styles of posed and matching spontaneous expressions with eye-tracking data, with the exception of Calvo and colleagues (2013) although the definition of non-genuine expressions in their research resulted in artificial blended images. The results in chapter 5 showed differential viewing patterns based on the stimuli type with significantly more fixations and longer durations to posed expressions. There were no significant differences in the recognition of posed and spontaneous expressions which suggests the viewing styles do not influence recognition. Investigation of viewing style and RM performance also predicted AQ scores.

Finally in chapter 6 the RM paradigm and new stimuli created were employed with an ASC sample and controls. Results showed no significant difference on the RM task which is in line with some previous literature showing less marked difficulties on emotion tasks (Tracy et al., 2011; Jones et al., 2011; Da Fonseca et al., 2009; Lacroix et al., 2009; Spezio et al., 2007; Neumann et al., 2006; Piggot et al., 2004). There was also a strong overlap of Alexithymia traits and ASC traits in line with previous literature (Berthoz & Hill 2005; Hill & Berthoz 2004; Bird & Cook 2013) however, there was no significant effect of Alexithymia severity on performance on the RM task, and specifically within the ASC sample Alexithymia score did not predict RM ability. This is contrary to the previous literature linking alexithymia with emotion processing difficulties in ASC (Parker, Taylor & Bagby 1994; McDonald & Prkachin 1990; Prkachin et al., 2009; Pollatos & Gramann 2011; Pollatos et al., 2008; Cook et al., 2013). However, investigating RM severity in the collapsed entire sample did demonstrate significant differences between mild and both medium and severe Alexithymia on the eyes task. In chapters 4 and 6 there was a consistent result of better recognition of spontaneous expressions than posed expressions, contrary to previous research (Hess & Blairy, 2001; Wagner 1990; Wagner et al., 1992; Naab & Russell, 2007). This finding was replicated in two different demographic samples: typically developing adults and adults with a diagnosis of ASC. The difference in recognition of spontaneous and posed expressions was reduced in typically developing children, suggesting the intricacies of expression spontaneity become more important throughout development; potentially in line with increased social demands.

7.1.1 The impact of stimuli type on expression production and recognition

The differences between posed and spontaneous expressions were apparent in chapter 3. Through factor analysis of FACS codes, it was found that posed expressions did not present a coherent factor structure stronger than random data for four of the expressions (maths, monopoly, no repeat and not recording). This was substantially more than spontaneous expressions of which only positive feedback presented a weaker factor structure than random data. The suggestion is that posed expressions are not created in the same way that spontaneous expressions are, this is shown in the lack of patterns across participants in display style which occur in spontaneous expressions.

The effect may be due to two reasons: it is possible the individual differences in trying to recreate an expression, results in many different physical approximations. There was also the potential that posed expressions appear in different intensities that are more subtle and not recognised by FaceReader. However during validation in chapter 4 participants gave intensity ratings of the expressions and no difference was found in the ratings of intensity given to posed and spontaneous expressions. Therefore it seems more plausible that the inconsistent display patterns in posed expressions are caused by the lack of ability to directly recreate the expression as it would be spontaneously. Although there is no research to date that has specifically compared posed expressions to spontaneous through FACS analysis, the results are in line with previous that demonstrate differential displays of posed and spontaneous expressions (Dibeklioğlu et al., 2012; Dibeklioğlu et al., 2010; Valstar et al., 2006; Williams et al., 2001).

The consistent display patterns in spontaneous expressions appeared to influence recognition rates in subsequent research, as there was shown to be better recognition overall of spontaneous expressions than posed in chapters 4 and 6. This result would be expected given the implications of consistent display patterns in spontaneous expressions, the spontaneous expressions formed into clearer more consistent structures than posed did. If those patterns were more readily identifiable by FaceReader it is expected they would be better recognised by humans. However, the improved recognition of spontaneous expressions was not unanimous across all expression types; there was consistently worse recognition of spontaneous positive feedback than posed positive feedback. Positive feedback was also poorly recognised generally, this was unexpected given happiness (the expected response to positive feedback) has such a well-documented ceiling effect in the literature (Ashwin et al., 2007; Bormann-Kischkel et al., 1995; Gross 2008; Riby & Hancock., 2008; Rosset et al., 2008; Wallace et al., 2008; Hoffmann et al., 2010). It was hypothesized that poor recognition of positive feedback and the improvement when posed were due to familiarity to posed happiness; because happiness functions as a social lubricant it is displayed far more often, even non-genuinely. It is believed this familiarity to posed happiness has resulted in better recognition of posed positive feedback.

Much like the altered display patterns influenced recognition rates, they also attracted altered viewing styles. In chapter 5 the results of viewing behaviour to posed and spontaneous expressions in typically developing children ranging from 6 years of age to 12 were reported. There was evidence of differing viewing patterns depending on the type of expression shown, the children made significantly more fixations and spent significantly longer fixated on posed expressions. This matched predictions of fixations based on the previous studies, where the less consistent display patterns (and worse recognition of posed expressions) lead to the hypothesis that these images are not presenting with high signal clarity. As a result it was predicted viewing patterns would appear erratic. This appeared to be the case with participants not finding clear regions to fixate on for posed expressions, instead making significantly more fixations as they scan for pertinent information. Although not predicted, the significantly increased time spent viewing posed expressions could also support this assertion suggesting that increased viewing time is more in response to complexity of the expression than clarity, as was presumed. Most notable differences between posed and spontaneous expressions was a large increase in the amount of time spent viewing the eyes, mouth and face when the stimuli was posed, and more time viewing the body when the stimuli was spontaneous.

The overall improved recognition of spontaneous reactions shown in chapter 4 and 6 is contrary to previous literature (Hess & Blairy, 2001; Wagner 1990; Wagner et al., 1992; Naab & Russell, 2007), leading to questions as to why the result was found in this research and at each stage of this research that included adults. It is believed the method of evocation used in this research is more valid, the RM paradigm requires expressions to be in response to something; thus expressions captured are as natural as can be under controlled conditions. Very little research that has investigated the differences of posed and spontaneous expressions has opted for methods such as those used in this thesis, instead capturing expressions in isolated conditions or asking people to relive memories, such methods have been discussed and critiqued previously. The results showing clearer expressions with better recognition and altered viewing styles of those expressions seem to corroborate the case made in chapter 2 for a more valid stimuli set. However it is worth noting that no such trend was shown in research with children, in fact children showed no significant difference in recognition of any direction, which is also contrary to previous research.

The literature discussed in chapter 2 section 2.3 and chapter 5 introduced the development of emotion processing and viewing styles. Between the age ranges of 6 to 12 children should have developed to holistic processing where facial features are incorporated in a coherent whole but second order-relations such as the space between facial features is not yet mature (Bruce et al., 2000; Gilchrist & McKone 2010). The task of viewing dynamic videos presents much more information of a second-order relation with angle of target to screen not always full frontal and movement of jaw, lips, eyelids and eyebrows all altering the relative appearance of these features to each other. It is likely this extra information caused the viewing style changes, but it is not yet possible for children to piece this information together with their developing second-order relation processing abilities.

The results in this thesis would suggest that posed expressions are created in a physiologically distinct manner than spontaneous expressions. When shown to adults with developed processing abilities this appears to influence recognition rates, with spontaneous expressions overall showing better recognition but individually between the expressions created and used in this research there were instances of both posed and spontaneous recognition improvements. It is hypothesized the posed-spontaneous recognition difference reflects the increased likelihood that certain expressions such as positive and negative expressions can be frequently posed for social needs. It is this frequency of posing that differentiates expressions better recognised in a posed or spontaneous format; with those more frequently posed being better recognised when posed for two reasons; first, those expressions have been fine tuned in the displayer in a posed manner for necessity. Second, it would be expected the social utility of posing those expressions means they are frequently displayed, and consequently seen, ensuring familiarity and improved recognition. Altered viewing styles were evident in children, however it is expected viewing styles would differ further in adults given the mature second-order relations and results which suggest differential recognition in adults seemingly matching differential display patterns when posed and spontaneous. Practically, these findings provide some weight to the claims made at the beginning of this thesis that assuming posed expressions are satisfactory in emotion recognition tasks is problematic. Although the differences are subtle and lack consistency in direction, the results are clear that posed and spontaneous expressions differ in production and recognition in adults, and viewing styles in children. To ignore these results, particularly when assessing emotion recognition abilities, could lead to artificial inflation or reduction when reporting competencies in samples.

7.1.2 The impact of Alexithymia on expression production and recognition

The results suggest Alexithymia has a complicated relationship with expression production. Neither autism traits nor Alexithymia traits presented significant relationships with posed expression activity (displays), however the relationship between Alexithymia and expression activity (displays) was negative and more pronounced. This is contrary to previous work, which has shown altered expression production in ASC (Brewer et al., 2016). There was a strong overlap between ASC and Alexithymia, similar to previous reports (Berthoz & Hill 2005; Hill & Berthoz 2004; Bird & Cook 2013). However, when analysing the activity of spontaneous expressions the effects of autism traits and Alexithymia reversed, with a non-significant relationship between Alexithymia and spontaneous expression activity, but a medium negative significant relationship between ASC and spontaneous expression activity. The directions of these results seem to suggest that Alexithymia (although not significant) appears to trend towards creating less evocative posed expressions, on the contrary there was a significant relationship showing increased autism traits appear with increased spontaneous expression evocation.

The interpretation of the above results is speculative given the small sample size (n=19) but introduces an interesting aspect to the Alexithymia and ASC overlap. These are interesting preliminary findings that suggest those with higher alexithymic traits produce less evocative posed expressions; of course the opposite is just as plausible, that individuals who produce less evocative expressions may, through altered biofeedback mechanisms, present with higher Alexithymic traits. This appears to manifest alongside the separate effect within ASC that causes spontaneous expressions to be more evocative. As already stated these results are from a limited sample size and only hint at significance, this is also data from a typically developing sample, it might be that these independent results for separate expression types are not present in an ASC sample or appear in entirely different directions.

Hypothetically, the interpretation would suggest that those with co-morbid ASC and Alexithymia struggle to effectively create posed expressions but also produce overly expressive spontaneous expressions. More research is required to better investigate if this is the case in an ASC sample but could also allow a better understanding of the social difficulties frequently reported within ASC. The less evocative posed expressions due to Alexithymia traits, may limit the degree of social skills which could be particularly associated with displaying posed emotions which aid in social cohesion. Additionally, the production of more evocative spontaneous expressions within ASC might further exacerbate any perceptions of social difficulties as overly expressive emotions can be seen as awkward (Faso et al., 2014; Grossman et al., 2013). The combination of expressions perceived as awkward when natural and a reduced ability to produce recognisable posed expressions may act as a double pronged social limiter in co-morbid ASC and Alexithymia.

When considering Alexithymia and recognisability of expressions, an interesting reverse effect was found than would be expected from the expression production results discussed above. When typically developing adults viewed the expressions, results showed a borderline significant medium negative relationship between Alexithymia in the displayer and recognisability, however this was mainly demonstrated in spontaneous expressions not posed. This is contradictory to the results above which suggested Alexithymia influenced posed expression production but not spontaneous. It is possible that those with Alexithymia traits produce expressions just as intense (according to AU activity) but the display pattern could be entirely different which would not be found under the current correlational analysis which was more exploratory in purpose. These results open up new research avenues to consider the expression pattern in those with Alexithymia and those without. There appears to be a relationship between Alexithymia and posing expressions, but also between Alexithymia and spontaneous expression patterns.

Having discussed the relationship between Alexithymia in the displayer and expressivity and recognisability; this section will now discuss the relationship of Alexithymia in the recogniser and Alexithymia in ASC. Within the typically developing sample there were medium positive correlations between AQ scores and Alexithymia scores, suggesting a reasonably strong overlap. Both of AQ and Alexithymia scores (borderline significant), presented weak negative relationships with expression recognition. The relationship was more robust with AQ scores than Alexithymia, suggesting that at least in a typically developing sample Alexithymia does contribute to emotion recognition difficulties but not to a greater degree than autism traits. Once again, as above the relationships were driven by significance with spontaneous expressions but not posed.

Within an ASC sample, the co-morbidity of Alexithymia was more pronounced with a significant strong positive correlation; this was also confirmed via one-way ANOVA of Alexithymia severity across three categories, mild, medium and severe Alexithymia. There were significant differences in AQ scores between mild and medium Alexithymia and medium and severe Alexithymia showing strong support for the co-morbidity proposed in the Alexithymia hypothesis (Bird & Cook 2013). However, the effect of Alexithymia on performance in the RM task was non-significant As a measure of concurrent validity against the RM task, the eyes task was also administered which showed significantly better performance in mild alexithymia than medium and severe.

Throughout the research carried out in this thesis alexithymia was consistently associated with Autism, however when analysed within an ASC sample Alexithymia showed no overall relationship in a predictive sense of RM ability. Given the consistent association between Alexithymia and autism, and the significantly higher Alexithymia scores in the ASC sample it would be expected that Alexithymia as the key contributor to emotion recognition difficulties in autism would be present in the results but showed no meaningful influence on the ASC sample. Separately, in the entire sample Alexithymia severity did influence eyes task performance but not RM performance. This would suggest that the RM task either requires less emotional understanding that is influenced by Alexithymia (which is unlikely given it specifically requires the ability to identify socially appropriate emotional responses). Alternatively, the task lacks specificity, which may require an increase in difficulty given that when shown to adults recognition rates were comfortably above chance recognition rates for most expression types.

7.1.3 Facial emotion recognition in ASC

As was discussed above in the typically developing adult sample there was a significant weak negative correlation between AQ scores and emotion recognition performance on the RM task, this was driven by spontaneous expression recognition. This was an expected result which confirmed that autism traits and performance on an emotion processing task are related. It also helped to validate the new stimuli used in the RM task showing it to be subtle enough in display allowing the emergence of any difficulties should they be present. In chapter 5 the viewing styles of typically developing children to the differing stimuli types were recorded, autism traits were also recorded via the AQ. A multiple regression was carried out investigating if viewing styles and performance on the RM task predicted AQ scores. As would be expected RM score was a significant negative predictor of AQ scores, however viewing styles also predicted AQ scores with more time spent viewing the face predicting lower AQ scores. Contrary to what would be expected, the ratio of viewing the eyes vs the mouth while non-significant was positive in direction with more time viewing the eyes associated with higher AQ scores. Although this result was non-significant it is directionally entirely contradictory to what previous research would suggest where there appears to be more focus on the mouth than the eyes associated with ASC (klin et al., 2002; Pelphrey 2002; Baron-Cohen et al., 1997; 2001).

It is difficult to draw conclusions from the results predicting AQ scores for multiple reasons; first, this sample was typically developing and so at best is suggestive of a potential trend in an ASC sample. Second, the most surprising result (viewing eyes associated AQ scores) was not statistically significant and so similarly at best is worthy of further investigation but conclusions cannot be drawn from that alone. Third, the results are specific to the stimuli used and task set, these viewing styles may only be accurate in the context of the current research. This last point in particular, subject to further investigation, could mean that viewing the eyes has been overrated in importance. In reality, it may be that natural expressions such as the ones used in this thesis require an entirely different viewing style, a point that has been raised in previous work with similar methods (Pillai et al., 2012; 2014; Cassidy et al., 2014).

In chapter 6 group differences in RM task performance were investigated. Contrary to the results in chapter 4 and 5 which showed a negative relationship between ASC and task performance, there were no group differences in RM ability or the eyes task. This was surprising given the previous results and that the ASC and control group showed significant differences in AQ scores corroborating diagnosis. Correlational analyses showed a significant negative relationship between AQ scores and eyes task performance, this suggests there is a relationship between autism severity and eyes task performance but this does not present strongly enough between those with a diagnosis and those without to show group differences. Unlike the eyes task, RM ability was not significantly associated with AQ scores, despite a significant medium positive correlation between RM ability and eyes task performance.

These results suggest that the RM task, although similar in nature to previous measures such as the eyes task, measures a different ability. This ability appears to be isolating the semantic and contextual content of an expression, which relies on a greater understanding of emotional affect than recognition does. This can be further evidenced by the rates at which control and ASC participants provided consistent and inconsistent emotional inferences. Whilst results showed ASC participants still gave more consistent inferences than would be predicted, they still gave approximately 3% less consistent inferences to posed and spontaneous expressions after correctly guessing the event that caused the reaction. Although this difference is marginal it is unclear if this is because of a particularly high functioning ASC sample or a previous overestimation of the difficulties reported within ASC. Superficially it would suggest there is a less robust understanding of what emotions are appropriate to what context within ASC, specifically this is potentially the influence of co-morbid Alexithymia with ASC which might play a larger role on the ability to assign an appropriate emotion to prior events than to retrodict the event itself.

Ultimately no differences in RM ability or eyes task performance were present between ASC and control participants, this is contrary to some research which shows difficulties in ASC (Harms et al., 2010; Philip et al., 2010; Ashwin et al., 2006; Bal et al., 2010; Corden et al., 2008; Wallace et al., 2008;

Borasten et al., 2007; Howard et al., 2000). What is consistent with previous research are the inter-expression recognition rates in ASC, where no difference was observed between negative expressions and positive, a difference that was significant in the control sample and reflects the tendency to show poor recognition of negative expressions in ASC (Ashwin et al., 2006; Bal et al., 2010; Corden et al., 2008). However there is also much research that has shown no differences between ASC and control participants (Loveland et al., 2008; Neumann et al., 2006; Rutherford & Towns 2008; Ogai et al., 2003; Teunisse & de Gelder 2001), In their review Harms and colleagues (2010) noted that intact FER is present in HFA samples and attributed this to compensatory mechanisms. As noted in section 6.4 the ASC sample recruited were high functioning with a majority having completed an undergraduate degree and a mean IQ of 136.94. Such a sample is likely to have the developed compensatory mechanisms that harms and colleagues proposed, similarly as previous research with the RM paradigm has shown (Cassidy et al., 2014), dynamic delivery can aid in the recognition of more complex expressions. It was proposed in section 6.1 that allowing participants to view the expression development could reduce the apparent difficulties associated with FER in ASC, this is because more information is available which may be more valuable to high functioning ASC participants who rely on compensatory mechanisms which likely includes more contextual information.

There are two main points raised from this research, first the difficulties in emotion recognition associated with ASC are not replicated. This may be because of the sample recruited which was high functioning and educated; it could also be contributed to the paradigm, which may be better suited to HFA individuals who through compensatory mechanisms, can source emotional information from multiple modalities to aid recognition. Second, the research showed no significant predictive ability of Alexithymia on emotion recognition as measured by the RM task within the ASC sample, if the lack of differences found between groups is a result of the sample recruited it would suggest the severity of Alexithymia within ASC can be overcome in particularly high functioning individuals. Alternatively, if the lack of group differences is a result of the stimuli and task type this would similarly downplay the importance of co-morbid Alexithymia with autism in relation to emotion recognition abilities; however this position is not supported by the lack of differences reported on the eyes task. Onlythe correlation between eyes task performance and AQ scores (and lack of correlation between RM scores and AQ scores) could present some supporting evidence of the RM task including substantively different stimuli that can allow the implementation of coping mechanisms, which reduces any expected correlations between RM ability and AQ scores to non-significance.

The key finding within this thesis would suggest the emotion recognition deficits in ASC have previously been overestimated, it is believed the lack of differences presented between the ASC sample and control sample is brought about by 1) the improved methodology using more ecologically valid stimuli and 2) the potential of a particularly high functioning ASC sample. Although negative correlations were present between AQ scores and eyes task scores, which does suggest there is a relationship between autism traits and emotion recognition ability, the current results and method point to this difference being less pronounced than previously thought. To further investigate this claim it is recommended that more research is conducted to replicate the (lack of) effect with further ASC samples.

7.2 Limitations of the Research

There are limitations associated with the research, some of which have been identified in individual chapters; however, the major limitations will be discussed here. In Chapter 3 when the expressions were created and analysed using FaceReader, the analytic process used required static images, this was discussed in chapter 2 and subsequently again in chapter 3 as an issue because static images do not accurately reflect the expression development. However, the analysis applied is not suitable to dynamic stimuli, and ultimately difference based significance testing would not be possible as these rely on a mean which would be no better than a singular expressive point identified. There are options to identify multiple time points and compare these, but this ultimately results in more levels of the IV, this would result in underpowered analyses with barely interpretable results. One option as discussed is the use of growth curves in multi-level modelling or SEM and developmental trajectories (Thomas et al., 2009; Kashy & Donnellan 2008) however these would only be practical with approximations of expression type clarity over time, for example, "how much does this expression look like happiness throughout the episode?" This still does not address the issues of including AU activity, which can consist of many variables.

Ultimately it may be that trying to quantify the makeup of expressions in this manner relies on a more qualitative approach that isn't grounded in statistical testing or is more suited to triangulation. Such an approach would likely consist of developmental graphs of the five or six most active AU's for each expression type, with similar graphs for the approximate prevalence of each of the six basic emotions throughout the expressions development. Including this kind of evidence alongside that presented in the factor structures would allow a more valid claim of expression differences based in observations of dynamic development and empirical evidence of patterns.

Another major limitation of the research is the lack of inclusion of a gold standard confirmatory diagnostic measure such as the ADOS or ADI. Although the groups showed significant differences on both the AQ and TAS-20 measures, it is common practice for research to include a more robust measure of ASC to confirm diagnosis. These were not included for specific reasons, these were mostly due to feasibility. The ADOS is particularly time consuming taking approximately an hour to administer and roughly another hour to ensure accurate coding, it also requires administration face to face. For this reason, it was decided the ADOS would not be included, this is because with the sample recruited it would require another 100+ hours in administration and coding. Similarly requiring face to face ADOS administration it is unlikely the sample size recruited would be available, further limiting the research which required a reasonable sample to investigate the 2x2x4 ANOVA.

Finally, the order of task administration may have had some impact on the performance, particularly when the eyes task is included as in chapter 6. Participants were asked demographic questions, completed the AQ and TAS-20, and then 32 trials of the RM task and finally the eyes task. This means by completion participants had the potential to answer upwards of 150 questions; because the research was specifically interested in how performance would be on the RM task this was completed before the eyes task. It is possible that by the end of the experiment participants were just unable to focus on the eyes task. However results showed there was an increase in the mean scores on the eyes task of the ASC sample relative to those reported previously (Baron-Cohen et al., 2015). The control sample did display a decrease in eyes task performance relative to prior results, potentially suggesting they could not maintain attention throughout the task like the ASC participants. Whether the increase in the ASC participants' scores is due to practice effects from participating in research previously (recruited through CARD) or a sampling bias of particularly high IQ individuals is unclear. For control participants it is difficult to confirm without counterbalancing that fatigue effects are responsible for the mild decrease in eyes task performance relative to prior results. Ultimately the decision to have the RM task completed first was to collect higher quality data and with new stimuli sets in favour of replicating an already robust effect in the eyes task.

7.3 Theoretical Implications

Although this thesis investigated Alexithymia, subscribing to the Alexithymia hypothesis of emotion recognition difficulties in ASC, there is also scope to discuss theory of mind (ToM). Of the other theories introduced in section 1.3 such as the extreme male brain theory, the methods used have limited input to appraise the theory beyond performance between the sexes, which incidentally showed no differences. Similarly, to consider weak central coherence there would preferably need to be a measure of eye tracking between ASC and non-ASC individuals to observe if attention is focussed to the details rather than scanning multiple areas of the face. Finally, without brain imaging technology or some measure of arousal it is not possible to identify amygdala activity or subsequent associated physiological arousal that would indicate amygdala activity. As such, the theoretical implications will be considered in the case of the recognition rates of expressions and reported valence etc. which provide the opportunity to evaluate the theoretical basis of emotions as distinct kinds or constructed categories based on variance of arousal and valence. Subsequently this allows further consideration of the ToM and the evidence for and against theory-theory and simulation-theory. Finally the inclusion of Alexithymia measures in three of the four experiments allows appraisal of the merits of the Alexithymia hypothesis.

7.3.1 *Theories of emotion*

The research conducted in this thesis presents some interesting results that have implications for both the naturalist Darwin-Ekman approach and the constructivist Barrett-Russell approach. The display patterns that emerged across individuals in chapter 3 would provide support for the idea that expressions of emotion fall into distinct categories. The inconsistent research of expression categorisation was used as evidence for a circumplex like emotion structure (Russell & Barrett, 1999) however the results in chapter 3 point to differential displays between expression types that is statistically quantifiable. This would provide some support for the idea of distinct emotion categories as hypothesized by Darwin-Ekman theorists.

The reported valence for the expressions by viewers in chapter 4 could be seen as evidence for a constructed approach to emotions that fall on a valence spectrum. This is because expressions with more positive connotations such as monopoly money, positive feedback and no repeat all received positive valence ratings whereas expressions with negative connotations such as being asked a maths question, negative feedback, repeat experiment and not recording all received negative valence ratings. These ratings differed slightly, such as positive feedback being rated as more positively valenced than monopoly money however they presented no difference in intensity. Barret-Russell theorists would suggest very little variation on one axis of the circumplex (within positive expressions and negative expressions not between) and no variation on the second axis should result in a similar emotion attribution and display. This didn't appear to be the case, the causal situations of the expressions were identifiable at an above chance rate and the consistent emotional state was inferred more than inconsistent options.

Some results do provide evidence for a constructed approach, For example, of the emotion inferences made, errors were more likely to fall along valence lines, corroborating previous research of high inter-correlation between similarly valenced emotions (Feldman, 1993; Watson & Tellegen, 1985; Watson & Clark, 1984). In this research it could be asserted that errors falling along similarly valenced items are supportive of a general recognition of positive and negative valence rather than specific emotions categories. But this can't explain why the monopoly money expression which was rated as one of the most positively valenced items presented much better recognition than positive feedback which was similarly positively valenced. The same difference in recognition applies to maths question which was well recognised and not recording which was markedly worse, these two expressions where rated with similar valence and intensity.

The lack of equivalent recognition scores of causal events but errors of emotion inference that fall along valence lines provides contradictory evidence to the theory of constructed emotions. If emotions are constructed and specific kinds are not inherently natural or innate it would be expected the production of expressions would produce fewer differences in structural patterns. That would also be expected to translate to similar recognition rates among positively valenced expressions and negatively valenced expressions. The results demonstrated this was not the case, as both positive and negative valenced items were located at the top and bottom end of the recognition scale. Perhaps most important in this thesis, is the lack of a difference between the ASC group and control group. Previous work has demonstrated that additional context when viewing emotions can aid recognition (Gendron et al., 2013), The RM task engages the contextual aspect of emotion displays by tasking individuals to think what might have caused reactions which can further feed into emotion inferences. Similarly the newly developed stimuli provides extra context by allowing expressions to unfold in real time as they are experienced, potentially explaining the lack of group differences.

7.3.2 Theory of mind

There are better implications to be drawn for ToM, as the RM task does require ToM. Firstly it is required to consider what would make an individual react in a certain way, and then subsequently mentally assume that situation to try to approximate an emotional state. Within the sample recruited, there was a significant negative correlation between eyes task score and AQ score, however this did not translate to group differences. There was however no correlation between RM ability and AQ scores. The presence of a relationship between eyes task scores and AQ scores but no group differences between ASC and control would suggest the difficulties in ToM associated with ASC are not as prevalent as previously suggested, specifically in the case of high functioning individuals. The RM score is comprised of the correct recognition of the antecedent event that caused the viewed reaction, what that score does not encapsulate is the inference of emotion to that expression, as this was asked after the recognition of the event, there is a ToM aspect to this secondary question which requires the mental assumptions of another state.

When inferences are considered, the ASC group still chose the correct matching emotional state significantly more than would be expected but this was 3% less in frequency than controls to posed expressions and 3% less to spontaneous expressions after correctly retrodicting the event. Interestingly after incorrectly retrodicting the event the ASC group gave a consistent emotion inference to the incorrect retrodiction (for example wrongly guessing maths question but still saying the person looked like they were thinking) 7% more frequently than controls to posed expressions. Such rigidness to contextually consistent inferences suggests the ASC group was more reliant on their retrodiction to subsequently deduce an emotional state. Still, this finding is in line with the expression pattern and recognition results, suggesting ASC participants do show milder difficulties when they are presented with stimuli of subtle expressions forcing them to commit to any prior assumptions they have made about context.

It would appear from the results the errors that fall along valence lines are specific to inference of emotional states when asked how someone else might feel. This may be indicative of general valence lines in emotion production and recognition; however inferring someone else's emotional state after an eliciting event requires knowledge of appropriate contextual emotions. The most likely and salient source of this knowledge is from the self, much like simulation theory postulates, an internal simulation of how the self would feel is applied to the target. But there is no certainty that everyone responds the same way. To assess the results in respect of theory-theory and simulation-theory it might be most appropriate to consider the events as targets for retrodiction and their potential familiarity to participants. Events more likely to occur in social context such as receiving positive and negative feedback would expect consistent inferences because they are more likely to have been incorporated into a theory. In the same manner if more obscure eliciting events such as repeat experiment and not recording present more inconsistent emotion inferences this could be construed as supporting evidence for theory-theory which would not be as developed in understanding and predicting behaviour in obscure situations that have never been encountered. The results did reflect this with more consistent emotion inferences to events that are less obscure.

Although the above interpretation provides some support for a theory-theory basis of mentalising, the result could also be explained to support simulation-theory. The higher frequency of consistent emotion inferences to less obscure events would be expected in either theory, it is suggested that certain basic rules underpin mentalizing in simulation theory to save the costly resources of simulation. In the context of this research the increased consistent inferences to less obscure events may be attributable to given rules that are accepted as truths, not requiring simulation. Not until more obscure events are encountered is simulation employed which relies on the simulated behaviour of the self to extrapolate to others. The complexity of the simulation in living obscure events may well cause simulation error which could explain the lower consistency, it is also possible that the simulation is correct but the event is so obscure that individual inferences differ greatly resulting in a wider range of inferences that do not converge.

There is a strong body of evidence for ToM difficulties in ASC (Baron-Cohen et al., 1997; 1996; 1985; Frith & Frith 2005), although this research did not find any results of particular strength to support the theory, which is more than likely attributable to the sample recruited. Future studies of the same design with an ASC sample not majority recruited from the CARD (which appeared to be educated to a higher standard with high IQ) might produce different results between groups and show stronger patterns of inference between the groups which could hold more implications for the ToM. The ToM refers specifically to the ability to assume the mental states of others and predict behaviour, which is directly the task set in the RM task although rather than prediction it tasks retrodiction. However, other aspects involved in recognising and vitally understanding an emotion encompass more than just ToM ability - this was introduced in section 1.3.4.4 where the case was made for empathy difficulties globally contributing to emotion difficulties in ASC. The ToM does not account for enough of the process of recognising and understanding the emotion of others, to do this emotional empathy would need to be included which is more closely associated to the Alexithymia hypothesis than the ToM.

7.3.3 The Alexithymia hypothesis

The Alexithymia hypothesis is where this research can have the most grounded implications. Alexithymia was measured in the production (chapter 3), validation (chapter 4), and investigation of FER difficulties in ASC (chapter 6), in each of the experiments there was reasonable overlap between Alexithymia traits and autism traits this was most pronounced in chapter 6 where diagnosed ASC individuals were sampled. This reasonable overlap in typically developing individuals and considerable overlap in individuals diagnosed with ASC supports the previous literature that suggests Alexithymia is indeed present in a considerable proportion of the ASC population (Berthoz & Hill 2005; Hill & Berthoz 2004; Bird & Cook 2013). If we are to consider emotion processing as a reciprocal action, (that the emotions we show shape and govern the emotions shown back to us) then it is important to consider the role of Alexithymia in expression production as well as recognition. As discussed in section 7.1.2 there were separate associations between ASC and Alexithymia expression production. Alexithymia was associated with less evocative posed expressions whilst ASC were associated with more evocative spontaneous expressions.

Investigating the recognition of those expressions there was worse recognition of the spontaneous expressions as Alexithymia increased in the displayer. This is surprising given that no association was found between Alexithymia traits and spontaneous expression displays. There is then the potential that spontaneous expressions displayed by individuals with Alexithymia are no different in AU clarity but may manifest in different patterns potentially explaining the higher number of factor structures within spontaneous expressions. Alternatively expressions produced by those with ASC and co-morbid Alexithymia may be poorly recognised for being either unclear when posed or overly intense when spontaneous. This in turn could influence the expressions that are shown in response and leave social interaction in a state of miscommunication.

The effects of Alexithymia on emotion recognition in the expression recipient were also investigated. This is perhaps most pertinent to the Alexithymia hypothesis, typically developing adults showed a borderline significant overall negative relationship with emotion recognition, this was increased to significance when only spontaneous expressions were considered. Alexithymia traits in the general population were negatively associated with the ability to recognise spontaneous expressions. It is unclear why this result was found given that there was better recognition of spontaneous expressions overall and that spontaneous expressions showed more consistent display patterns suggesting they should be more easily recognised. It is not the case that expressions created by individuals with alexithymic traits are worse recognised by those with Alexithymia, as discussed above Alexithymia is associated with posed expression production but spontaneous expression recognition. It may be that the altered spontaneous expression production which is associated with ASC (chapter 3) has a greater impact on the recognition abilities of individuals with ASC and Alexithymia traits (chapter 4).

However this did not translate to individuals with an ASC diagnosis (chapter 6) where no group differences were found on the RM task or eyes task according to diagnosis (but the groups presented significantly different AQ scores and Alexithymia scores). When the sample was grouped regardless of diagnosis, and then subsequently split into severity of Alexithymia, there was evidence of group differences between low, possible and high Alexithymia. No effect of alexithymia was present on RM scores. Investigating the spread of AQ scores within Alexithymia severity showed a linear relationship as would be expected with more severe Alexithymia traits associated with more severe autistic traits. It is unclear then why Alexithymia would not follow this trend relative to RM performance, the Alexithymia hypothesis is based on the premise that a sub group of ASC individuals will also score highly in Alexithymia. This was indeed the case but no differences were present in RM score or eyes task score between the groups. The presence of an ASC group who majority self-reported as either medium or severe in alexithymia traits would expect to support the alexithymia hypothesis. .

In regards to the Alexithymia hypothesis, the results presented on expression development in relation to Alexithymia are limited and should be considered preliminary in any interpretations. A larger sample size with more pronounced Alexithymia traits would be needed to better understand the effects of

Alexithymia on expression production and subsequent recognition. Future attempts to carry out such research should also avoid co-morbid ASC to further understand the effects of Alexithymia independent of ASC. In relation to recognition specifically, the ASC group self-identified as significantly more alexithymic than controls but no group differences were present in RM or eyes task performance. When investigating Alexithymia severity, group differences did emerge on the eyes task but not the RM task, This is contrary to expectations given that the RM task was expected to require a greater understanding of socially appropriate emotional displays. A co-morbidity was found consistently between Alexithymia and ASC, therefore the Alexithymia hypothesis can account for a certain degree of FER difficulties in ASC but this pertains to the eyes task specifically. As for why this may be the case, it could be the RM task incorporates more contextual information to aid recognition and understanding, this is would appear to be the case in comparison to the eyes task with its limited visual information, static greyscale images. Alternatively, the RM task may prove too simple a task and require more emotion states and options to provide better specificity.

Despite no group differences being present in this research, it is believed that with an ASC sample more representative of the ASC population generally (rather than particularly high-functioning and educated individuals with an avid interest in research) that some group differences would emerge. However it is not expected under the same design that those differences would be as pronounced as other research reports. The Alexithymia hypothesis is supported by strong co-morbidity in both the general population and those with an ASC diagnosis, and differences in severities on the eyes task. Based on the current results there does appear to be some evidence for alexithymia explaining emotion recognition/processing difficulties. This is because alexithymia severities identified differences on the eyes task where ASC diagnosis could not. However, the specific hypothesis of alexithymia underpinning difficulties within autism was not supported, such an ASC sample with high alexithymia traits would be expected to provide supporting evidence for this hypothesis. Future research should attempt to increase the demands of a RM task and recruit a more typical ASC sample before discounting the alexithymia hypothesis of emotion difficulties in autism entirely.

7.4 Practical Applications

Of course the applications of the research are perhaps most importantly within the field of autism. The lack of differences between the ASC and control sample in this work highlights the need in future research to consider the sample and if it is representative of the majority as a whole (and also potentially re-think the real world impact of certain difficulties associated with autism to those on the higher-functioning end of the spectrum.). It also highlights the need to re-evaluate the methods used previously and if these are designed in a way that emphasize difficulties that may not be as pronounced under real world conditions. It is hoped the methods employed in this research prompts others to consider what is the best way to assess competencies which can guide future interventions thinking about emotion processing more holistically as social interaction and understanding. It is the aim to have the stimuli created for use in this thesis freely available for use in research, this would include the 266 posed and spontaneous video reaction captured and the additional 266 static frames isolated.

The introduction of this stimuli set comes at a time where there is a growing need for naturalistic expressions, and a better understanding of natural expressions. This is particularly prevalent in the technology and computer sciences fields. A recently published review of dynamic datasets highlighted the growing need for dynamic stimuli sets of spontaneous expressions (Krumhuber, Skora, Küster & Fou 2017). Key aspects of focus highlighted were for a greater need of experimental control in creating and capturing spontaneous expressions, and that expressions should be in a multi-modal format. Also noted was the prevalence of research using dynamic stimuli sets in computer science research over the last 15 years (1543), and that in social sciences over the same period (124). This research addresses some of those concerns raised and also provides evidence to further corroborate that spontaneous expressions manifest differently, as a result the previously held ideas on how expressions should be viewed and what they should look like need to be re-evaluated.

The findings in regards to spontaneous and posed expressions have practical applications in certain interventions. One notable area of application is the growing increase in the use of social robots to aid individuals with autism (Kim et al, 2013; Cabibihan, Javed, Ang & Aljunied 2013; Diehl, Schmitt, Villano & Crowell 2012; Scassellati, Admoni & Matarić 2012). The benefit of using robots with autistic individual is their predictability which allows a lowered state of anxiety for the autistic individual to engage in social interaction. The benefit of these results in such a context would allow engagement with expressions that can more closely resemble natural expressions to better prepare for interaction with humans, this can allow engagement with expressions in either format, posed or spontaneous with the best recognition rates to familiarise the emotion. As a further use the introduction of posed and spontaneous expressions as a concept could hold valuable knowledge for future social skills that not all expressions are genuine and some may be for humorous intent.

Similarly the RM task requires the understanding of socially appropriate responses and emotions, typically autistic individuals prefer to plan their days to avoid unexpected change. The use of the RM paradigm can be incorporated into this planning to consider the possible interactions that could occur and how could people respond? This allows the individual to develop the skill of thinking how could people respond to given events, allowing them to be better prepared and reduce anxiety in the hope of improving the quality and frequency of social interactions.

7.5 Future Directions

There are some potential avenues of research implementing the proposed design and stimuli; one such example is to examine the allocation of attention to stimuli via eye tracking measures within an ASC sample. There is still debate in the literature regarding the claim that ASC individuals pay less attention to the eyes during emotion processing. Some research claims there is less attention to the eyes (Klin et al., 2002) and face (Rutherford & Towns 2008, Neumann et al., 2006), while other research shows the effect to be far less pronounced (Leung, Ordqvist, Falkmer, Parsons & Falkmer, 2013). There is the potential to investigate this area with the revised paradigm and stimuli given that results in this thesis suggested there are different production of posed and spontaneous expressions, and subsequently viewing styles and recognition rates it would seem a natural progression to investigate the viewing styles to natural stimuli in ASC investigating if the results from chapter 6 are replicated in a sample more representative of the breadth of ASC rather than those particularly high functioning.

There is also the opportunity to incorporate psychophysiological measures, this allows for hypotheses investigating the role of arousal mitigating altered visual pathways in ASC. Current theories, such as Porges' Polyvagal Theory (1995; 2003; 2007; 2009) implicate the inability of individuals with ASC to regulate their autonomic arousal via the Ventral Vagus nerve. Typically the more advanced Ventral nerve with its myelinated sheath acts as a vagal brake to the excitatory Dorsal nerve which activates in situations related to survival (Porges 2007; 2003).

Activation of the Ventral nerve which allows self-soothing in social situations is measured via Respiratory Sinus Arrhythmia (RSA) (Bal et al., 2010; Van Hecke et al., 2009). High amplitude RSA is representative of greater neural control over cardiac rhythm (Porges 2007), this control is the self-soothing technique to limit physiological excitation, allowing social interactions to take place without negative affect arousal influencing judgements and behaviour. There is evidence of lower RSA amplitudes in ASC children compared to controls when viewing stimuli of individuals reading a story (Van Hecke et al., 2009). Furthermore higher RSA amplitudes were related to higher social skills and fewer problem behaviours (Van Hecke et al., 2009). There is also evidence that ASC children who exhibited better vagal control of the heart also recognised emotion faster (Bal et al., 2010). The inability of ASC individuals to have as much control over the ventral Vagus nerve would appear to be disallowing them the calm state of mind that facilitates TD individuals.

Expanding upon previous work (Van Hecke et al., 2009; Bal et al., 2010), an interesting avenue to pursue would be to analyse the data of visual perusal to regions of interest, and cross reference this with measures of psychophysiological arousal. This could provide results potentially detailing the arousal behaviour of ASC individuals in response to certain regions of emotion expressions and facial stimuli. The stimuli and task used in the thesis would align with such an experiment in providing realistic expression in social context which should allow better understanding of how attention is allocated and why. This could have early implications for the literature surrounding the atypical perusal of emotional stimuli in individuals with ASC.

7.6 Conclusions

This thesis aimed to create a new stimuli set that better represented the demands of everyday social interaction, and subsequently use this to investigate the often conflicting results around emotion processing abilities in ASC. First when creating the stimuli it was shown that the spontaneous expressions conformed to more consistent display patterns across individuals than posed expressions (chapter 3). In chapter 4, continuing from the consistent display patterns shown in chapter 3, typically developing adults showed significantly better recognition of spontaneous emotions than posed, an effect later replicated in subsequent studies with ASC populations (chapter 6). In chapter 5 there was shown to be different viewing styles to posed and spontaneous expressions. Children made significantly more fixations and longer durations fixated to posed expressions; it was hypothesized this was due to the ambiguous display patterns in posed expressions which resulted in more scanning of the face. Lastly in chapter 6 the differences in emotion processing abilities through use of the RM task were investigated. Results showed there were no significant differences between the groups on RM task performance or on the eye task. A lack of difference on the RM task alone could have implications for the type of tasks used previously. Specifically, questioning if the artificiality of previously used expressions and task demands limit the amount of social information available for use in compensatory mechanisms in ASC. The lack of differences present in the eyes task, which has a fairly well documented effect within ASC, draw into question the typicality of the ASC sample recruited. Replications are required to investigate the differential demands of the stimuli created and RM task relative to previous methods. The stimuli created in this thesis are available for use in future research and their use is encouraged to more accurately assess emotion processing, and crucially, appropriate understanding.

References

Aaker, J., Drolet, A., & Griffin, D. (2008). Recalling mixed emotions. *Journal of Consumer Research*, *35*(2), 268-278.

Abell, F., Krams, M., Ashburner, J., Passingham, R., Friston, K., Frackowiak, R., Happé, F., Frith, C. & Frith, U. (1999). The neuroanatomy of autism: a voxel-based whole brain analysis of structural scans. *Neuroreport, 10*(8), 1647-1651.

Adolphs, R. (2002). Neural systems for recognizing emotion. *Current opinion in neurobiology*, *12*(2), 169-177.

Adolphs, R., & Tranel, D. (2003). Amygdala damage impairs emotion recognition from scenes only when they contain facial expressions. *Neuropsychologia*, *41*(10), 1281-1289.

Adolphs, R., Baron-Cohen, S., & Tranel, D. (2002). Impaired recognition of social emotions following amygdala damage. *Journal of cognitive neuroscience*, *14*(8), 1264-1274.

Adolphs, R., Damasio, H., & Tranel, D. (2002). Neural systems for recognition of emotional prosody: a 3-D lesion study. *Emotion*, *2*(1), 23.

Adolphs, R., Russell, J. A., & Tranel, D. (1999). A role for the human amygdala in recognizing emotional arousal from unpleasant stimuli. *Psychological Science*, *10*(2), 167-171.

Adolphs, R., Sears, L., & Piven, J. (2001). Abnormal processing of social information from faces in autism. *Journal of Cognitive neuroscience*, *13*(2), 232-240.

Adolphs, R., Spezio, M. L., Parlier, M., & Piven, J. (2008). Distinct face-processing strategies in parents of autistic children. *Current Biology*, *18*(14), 1090-1093.

Ambadar, Z., Schooler, J. W., & Cohn, J. F. (2005). Deciphering the enigmatic face the importance of facial dynamics in interpreting subtle facial expressions. *Psychological Science, 16*(5), 403-410.

American Psychiatric Association. (1952). *Diagnostic and statistical manual of mental disorders* (1st ed.). Washington, DC:

American Psychiatric Association. (1980). *Diagnostic and statistical manual of mental disorders* (3rd ed.). Washington, DC:

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (3rd ed., Rev.). Washington, DC:

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC:

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC:

Ashwin, C., Baron-Cohen, S., Wheelwright, S., O'Riordan, M., & Bullmore, E. T. (2007). Differential activation of the amygdala and the 'social brain' during fearful face-processing in Asperger Syndrome. *Neuropsychologia, 45*(1), 2-14.

Ashwin, C., Chapman, E., Colle, L., & Baron-Cohen, S. (2006). Impaired recognition of negative basic emotions in autism: A test of the amygdala theory. *Social neuroscience*, *1*(3-4), 349-363.

Asperger, H. (1991/1994). *Autistic psychopathy in childhood* (trans). In Frith, U. (Ed.), *Autism and Asperger syndrome*. Cambridge: Cambridge University Press.

Austin, E. J. (2005). Personality correlates of the broader autism phenotype as assessed by the Autism Spectrum Quotient (AQ). *Personality and Individual Differences*, *38*(2), 451-460.

Auyeung, B., Baron-Cohen, S., Ashwin, E., Knickmeyer, R., Taylor, K., & Hackett, G. (2009). Fetal testosterone and autistic traits. *British Journal of Psychology*, *100*(1), 1-22.

Auyeung, B., Baron-Cohen, S., Wheelwright, S., & Allison, C. (2008). The autism spectrum quotient: Children's version (AQ-Child). *Journal of autism and developmental disorders*, *38*(7), 1230-1240.

Auyeung, B., Taylor, K., Hackett, G., & Baron-Cohen, S. (2010). Foetal testosterone and autistic traits in 18 to 24-month-old children. *Molecular autism*, *1*(1), 11.

Averill, J. R. (1982) *Anger and aggression: An essay on emotion*. New York: Springer-Verlag New York

Bachevalier, J., & Loveland, K. A. (2006). The orbitofrontal–amygdala circuit and self-regulation of social–emotional behavior in autism. *Neuroscience & Biobehavioral Reviews*, *30*(1), 97-117.

Back, E., & Jordan, T. R. (2014). Revealing variations in perception of mental states from dynamic facial expressions: a cautionary note. *Plos One*, *9*(1), e84395.

Back, E., Jordan, T. R., & Thomas, S. M. (2009). The recognition of mental states from dynamic and static facial expressions. *Visual cognition*, *17*(8), 1271-1286.

Back, E., Ropar, D., & Mitchell, P. (2007). Do the eyes have it? Inferring mental states from animated faces in autism. *Child development*, *78*(2), 397-411.

Bagby, R. M., Parker, J. D., & Taylor, G. J. (1994). The twenty-item Toronto Alexithymia Scale—I. Item selection and cross-validation of the factor structure. *Journal of psychosomatic research*, *38*(1), 23-32.

Bagby, R. M., Taylor, G. J., & Parker, J. D. (1994). The twenty-item Toronto Alexithymia Scale—II. Convergent, discriminant, and concurrent validity. *Journal of psychosomatic research*, *38*(1), 33-40.

Bailey, A., Le Couteur, A., Gottesman, I., Bolton, P., Simonoff, E., Yuzda, E., & Rutter, M. (1995). Autism as a strongly genetic disorder: evidence from a British twin study. *Psychological medicine*, *25*(01), 63-77.

Baird, G., Charman, T., Baron-Cohen, S., Cox, A., Swettenham, J., Wheelwright, S., & Drew, A. (2000). A screening instrument for autism at 18 months of age: a 6-year follow-up study. *Journal of the American Academy of Child & Adolescent Psychiatry*, *39*(6), 694-702.

Baird, G., Charman, T., Cox, A., Baron-Cohen, S., Swettenham, J., Wheelwright, S., & Drew, A. (2001). Screening and surveillance for autism and pervasive developmental disorders. *Archives of Disease in Childhood*, *84*(6), 468-475.

Bal, E., Harden, E., Lamb, D., Van Hecke, A. V., Denver, J. W., & Porges, S. W. (2010). Emotion recognition in children with autism spectrum disorders: Relations to eye gaze and autonomic state. *Journal of autism and developmental disorders*, *40*(3), 358-370.

Baron-Cohen, S. (1989). The autistic child's theory of mind: A case of specific developmental delay. *Journal of child psychology and psychiatry*, *30*(2), 285-297.

Baron-Cohen, S. (2002). The extreme male brain theory of autism. *Trends in cognitive sciences*, *6*(6), 248-254.

Baron-Cohen, S. (2010). Empathizing, systemizing, and the extreme male brain theory of autism. *Progress in brain research*, (186), 167-175

Baron-Cohen, S. (2012). Autism and the technical mind. *Scientific American*, *307*(5), 72-75.

Baron-Cohen, S., Bowen, D. C., Holt, R. J., Allison, C., Auyeung, B., Lombardo, M. V., ... & Lai, M. C. (2015). The "reading the mind in the eyes" test: complete absence of typical sex difference in~ 400 men and women with autism. *PLoS One*, *10*(8), e0136521.

Baron-Cohen, S., Golan, O., Wheelwright, S., & Hill, J. (2004). *Mind reading emotions library*. [Computer software]. London, England: Jessica Kingsley Publishers.

Baron-Cohen, S., Hill, J. J., Golan, O., & Wheelwright, S. (2002). Mindreading made easy. *Cambridge Medicine*, *17*, 28-29.

Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high functioning adults with autism or Asperger syndrome. *Journal of Child psychology and Psychiatry*, *38*(7), 813-822.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind?". *Cognition*, *21*(1), 37-46.

Baron-Cohen, S., Richler, J., Bisarya, D., Gurunathan, N., & Wheelwright, S. (2003). The systemizing quotient: an investigation of adults with Asperger syndrome or high–functioning autism, and normal sex differences. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *358*(1430), 361-374.

Baron-Cohen, S., Ring, H. A., Bullmore, E. T., Wheelwright, S., Ashwin, C., & Williams, S. C. R. (2000). The amygdala theory of autism. *Neuroscience & Biobehavioral Reviews*, *24*(3), 355-364.

Baron-Cohen, S., Riviere, A., Fukushima, M., French, D., Hadwin, J., Cross, P., Bryant, C., & Sotilla, M. (1996). Reading the mind in the face: a cross-cultural and developmental study. *Visual Cognition*, *3*(1), 39-60.

Baron-Cohen, S., Scott, F. J., Allison, C., Williams, J., Bolton, P., Matthews, F. E., & Brayne, C. (2009). Prevalence of autism-spectrum conditions: UK school-based population study. *The British Journal of Psychiatry*, *194*(6), 500-509.

Baron-Cohen, S., Wheelwright, S., & Jolliffe, A. T. (1997). Is there a "language of the eyes"? Evidence from normal adults, and adults with autism or Asperger syndrome. *Visual Cognition*, *4*(3), 311-331.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001a). The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of child psychology and psychiatry*, *42*(2), 241-251.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001b). The autism-spectrum quotient (AQ): Evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of autism and developmental disorders*, *31*(1), 5-17.

Barrett, L. F. (2004). Feelings or words? Understanding the content in self-report ratings of experienced emotion. *Journal of personality and social psychology*, *87*(2), 266.

Barrett, L. F. (2006). Are emotions natural kinds?. *Perspectives on psychological science*, *1*(1), 28-58.

Barrett, L. F. (2006). Solving the emotion paradox: Categorization and the experience of emotion. *Personality and social psychology review*, *10*(1), 20-46.

Barrett, L. F. (2014). The conceptual act theory: A précis. *Emotion Review*, *6*(4), 292-297.

Barrett, L. F. (2017). The theory of constructed emotion: an active inference account of interoception and categorization. *Social cognitive and affective neuroscience*, *12*(1), 1-23.

Bartsch, K., & Wellman, H. (1989). Young children's attribution of action to beliefs and desires. *Child development*, 946-964.

Bastos, A. M., Usrey, W. M., Adams, R. A., Mangun, G. R., Fries, P., & Friston, K. J. (2012). Canonical microcircuits for predictive coding. *Neuron*, *76*(4), 695-711.

Bauminger, N., & Shulman, C. (2001). *Friendship in high-functioning children with autism: Child's and parents' perspectives.* Paper presented at the Promised Childhood Congress, April, Israel.

Beaupré, M. G., Cheung, N., & Hess, U. (2000). The Montreal set of facial displays of emotion [Slides]. *Available from Ursula Hess, Department of Psychology, University of Quebec at Montreal, PO Box, 8888*.

Becker, B., Mihov, Y., Scheele, D., Kendrick, K. M., Feinstein, J. S., Matusch, A., ... & Shah, N. J. (2012). Fear processing and social networking in the absence of a functional amygdala. *Biological psychiatry*, *72*(1), 70-77.

Berenbaum, H., & Oltmanns, T. F. (1992). Emotional experience and expression in schizophrenia and depression. *Journal of abnormal psychology*, *101*(1), 37.

Berthoz, S., & Hill, E. L. (2005). The validity of using self-reports to assess emotion regulation abilities in adults with autism spectrum disorder. *European Psychiatry*, *20*(3), 291-298.

Biehl, M., Matsumoto, D., Ekman, P., Hearn, V., Heider, K., Kudoh, T., & Ton, V. (1997). Matsumoto and Ekman's Japanese and Caucasian Facial Expressions of Emotion (JACFEE): Reliability data and cross-national differences. *Journal of Nonverbal behavior*, *21*(1), 3-21.

Birch, S. A., & Bloom, P. (2003). Children are cursed: An asymmetric bias in mental-state attribution. *Psychological Science*, *14*(3), 283-286.

Bird, G., & Cook, R. (2013). Mixed emotions: the contribution of Alexithymia to the emotional symptoms of autism. *Translational psychiatry*, *3*(7), e285.

Bird, G., Press, C., & Richardson, D. C. (2011). The role of Alexithymia in reduced eye-fixation in autism spectrum conditions. *Journal of autism and developmental disorders*, *41*(11), 1556-1564.

Bird, G., Silani, G., Brindley, R., White, S., Frith, U., & Singer, T. (2010). Empathic brain responses in insula are modulated by levels of Alexithymia but not autism. *Brain*, *133*(5), 1515-1525.

Birmingham, E., Bischof, W. F., & Kingstone, A. (2009). Get real! Resolving the debate about equivalent social stimuli. *Visual Cognition*, *17*(6-7), 904-924.

Birmingham, E., Cerf, M., & Adolphs, R. (2011). Comparing social attention in autism and amygdala lesions: effects of stimulus and task condition. *Social neuroscience*, *6*(5-6), 420-435.

Black, J. (2002). Darwin in the world of emotions. *Journal of the Royal Society of Medicine*, *95*(6), 311-313.

Blair, R. J. R. (2005). Responding to the emotions of others: dissociating forms of empathy through the study of typical and psychiatric populations. *Consciousness and cognition*, *14*(4), 698-718.

Bonanno, G. A., Keltner, D., Noll, J. G., Putnam, F. W., Trickett, P. K., LeJeune, J., & Anderson, C. (2002). When the face reveals what words do not: facial expressions of emotion, smiling, and the willingness to disclose childhood sexual abuse. *Journal of personality and social psychology*, *83*(1), 94.

Bonanno, G., & Keltner, D. (2004). Brief Report The coherence of emotion systems: Comparing "on-line" measures of appraisal and facial expressions, and self-report. *Cognition and Emotion*, *18*(3), 431-444.

Boraston, Z., Blakemore, S. J., Chilvers, R., & Skuse, D. (2007). Impaired sadness recognition is linked to social interaction deficit in autism. *Neuropsychologia*, *45*(7), 1501-1510.

Bormann-Kischkel, C., Vilsmeier, M., & Baude, B. (1995). The development of emotional concepts in autism. *Journal of Child Psychology and Psychiatry*, *36*(7), 1243-1259.

Borod, J. C., Pick, L. H., Hall, S., Sliwinski, M., Madigan, N., Obler, L. K., Welkowitz, J., Canino, E., Erhan, H. M., Goral, M., Morrison, C., & Tabert, M. (2000). Relationships among facial, prosodic, and lexical channels of emotional perceptual processing. *Cognition & Emotion*, *14*(2), 193-211.

Bourke, C., Douglas, K., & Porter, R. (2010). Processing of facial emotion expression in major depression: a review. *Australian and New Zealand Journal of Psychiatry*, *44*(8), 681-696.

Bowler, D. M. (1992). "Theory of Mind" in Asperger's Syndrome. *Journal of Child Psychology and Psychiatry*, *33*(5), 877-893.

Boyatzis, C. J., Chazan, E., & Ting, C. Z. (1993). Preschool children's decoding of facial emotions. *The Journal of Genetic Psychology*, *154*(3), 375-382.

Bradley, M. M., & Lang, P. J. (2000). Emotion and motivation. *Handbook of psychophysiology*, *2*, 602-642.

Braverman, M., Fein, D., Lucci, D., & Waterhouse, L. (1989). Affect comprehension in children with pervasive developmental disorders. *Journal of autism and developmental disorders*, *19*(2), 301-316.

Breiter, H. C., Etcoff, N. L., Whalen, P. J., Kennedy, W. A., Rauch, S. L., Buckner, R. L., Strauss, M. M., Hyman, S. E. & Rosen, B. R. (1996). Response and habituation of the human amygdala during visual processing of facial expression. *Neuron*, *17*(5), 875-887.

Brewer, R., Biotti. F., Catmur, C., Press, C., Happé, F., Cook, R. & Bird, G. (2016). Can neurotypical individuals read autistic facial expressions? Atypical production of emotional facial expressions in Autism Spectrum Disorders. *Autism Research*, *9(*2), 262-271.

Bruce, V., Campbell, R. N., Doherty-Sneddon, G., Langton, S., McAuley, S., & Wright, R. (2000). Testing face processing skills in children. *British Journal of Developmental Psychology*, *18*(3), 319-333.

Buck, R. W. (1978). The slide-viewing technique for measuring nonverbal sending accuracy: A guide for replication. *JSAS Catalog of Selected Documents in Psychology*, *8*, 62

Buck, R. W., Savin, V. J., Miller, R. E., & Caul, W. F. (1972). Communication of affect through facial expressions in humans. *Journal of Personality and Social Psychology*, *23*(3), 362.

Buckner, R. L., & Carroll, D. C. (2007). Self-projection and the brain. *Trends in cognitive sciences*, *11*(2), 49-57.

Bucks, R. S., & Radford, S. A. (2004). Emotion processing in Alzheimer's disease. *Aging & mental health*, *8*(3), 222-232.

Buitelaar, J. K., Van der Wees, M., Swaab–Barneveld, H. & Van der Gaag, R. J. (1999). Theory of mind and emotion-recognition functioning in autistic spectrum disorders and in psychiatric control and normal children. *Development and psychopathology*, *11*(1), 39-58.

Buitelaar, J. K., Van der Wees, M., Swaab-Barneveld, H., & Van der Gaag, R. J. (1999). Verbal memory and performance IQ predict theory of mind and emotion recognition ability in children with autistic spectrum disorders and in psychiatric control children. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *40*(6), 869-881.

Bydlowski, S., Corcos, M., Jeammet, P., Paterniti, S., Berthoz, S., Laurier, C., Chambry, J. & Consoli, S. M. (2005). Emotion-processing deficits in eating disorders. *International journal of eating disorders*, *37*(4), 321-329.

Cabibihan, J. J., Javed, H., Ang, M., & Aljunied, S. M. (2013). Why robots? A survey on the roles and benefits of social robots in the therapy of children with autism. *International journal of social robotics*, *5*(4), 593-618.

Cadieux, N. L., & Greve, K. W. (1997). Emotion processing in Alzheimer's disease. *Journal of the International Neuropsychological Society*, *3*(5), 411-419.

Calder, A. J., Keane, J., Manes, F., Antoun, N., & Young, A. W. (2000). Impaired recognition and experience of disgust following brain injury. *Nature neuroscience*, *3*(11), 1077-1078.

Callaghan, T., Rochat, P., Lillard, A., Claux, M. L., Odden, H., Itakura, S., ... & Singh, S. (2005). Synchrony in the onset of mental-state reasoning: Evidence from five cultures. *Psychological Science*, *16*(5), 378-384.

Calvo, M. G., Gutiérrez-García, A., Avero, P., & Lundqvist, D. (2013). Attentional mechanisms in judging genuine and fake smiles: Eye-movement patterns. *Emotion*, *13*(4), 792.

Calvo, M. G., Marrero, H., & Beltrán, D. (2013) 'When does the brain distinguish between genuine and ambiguous smiles? An ERP study'. *Brain and Cognition* 81 (2), 237–246

Camras, L. A. (1992). Expressive development and basic emotions. *Cognition & Emotion*, *6*(3-4), 269-283.

Cannon, W. B. (1927). The James-Lange theory of emotions: A critical examination and an alternative theory. *The American journal of psychology*, *39*(1/4), 106-124.

Carroll, J. M., & Russell, J. A. (1997). Facial expressions in Hollywood's portrayal of emotion. *Journal of Personality and Social Psychology*, *72*(1), 164.

Carruthers, P., & Smith, P. K. (Eds.). (1996). *Theories of theories of mind*. Cambridge University Press.

Carstensen, L. L., & Turk-Charles, S. (1994). The salience of emotion across the adult life span. *Psychology and aging*, *9*(2), 259.

Cassidy, S. A., Stenger, B., Van Dongen, L., Yanagisawa, K., Anderson, R., Wan, V., Baron-Cohen, S., & Cipolla, R. (2016). Expressive visual text-to-speech as an assistive technology for individuals with autism spectrum conditions. *Computer Vision and Image Understanding*, *148*, 193-200.

Cassidy, S., Mitchell, P., Chapman, P., & Ropar, D. (2015). Processing of spontaneous emotional responses in adolescents and adults with autism spectrum disorders: effect of stimulus type. *Autism Research*, *8*(5), 534-544.

Cassidy, S., Ropar, D., Mitchell, P., & Chapman, P. (2014). Can adults with autism spectrum disorders infer what happened to someone from their emotional response?. *Autism Research*, *7*(1), 112-123.

Castelli, F. (2005). Understanding emotions from standardized facial expressions in autism and normal development. *Autism, 9*(4), 428-449.

Castelli, F., Frith, C., Happé, F., & Frith, U. (2002). Autism, Asperger syndrome and brain mechanisms for the attribution of mental states to animated shapes. *Brain, 125*(8), 1839-1849.

Caulfield, F., Ewing, L., Burton, N., Avard, E., & Rhodes, G. (2014). Facial trustworthiness judgments in children with ASD are modulated by happy and angry emotional cues. *PloS one, 9*(5), e97644.

Chapman, H. A., Kim, D. A., Susskind, J. M., & Anderson, A. K. (2009). In bad taste: Evidence for the oral origins of moral disgust. *Science, 323*(5918), 1222-1226.

Christianson, S. A. (1992). Remembering emotional events: Potential mechanisms. *The handbook of emotion and memory: Research and theory*, 307-340.

Clark-Polner, E., Johnson, T. D., & Barrett, L. F. (2016). Multivoxel pattern analysis does not provide evidence to support the existence of basic emotions. *Cerebral Cortex, 27*(3), 1944-1948.

Cohn, J. F., & Schmidt, K. L. (2004). The timing of facial motion in posed and spontaneous smiles. *International Journal of Wavelets, Multiresolution and Information Processing, 2*(02), 121-132.

Constantino, J. N., & Todd, R. D. (2003). Autistic traits in the general population: a twin study. *Archives of general psychiatry, 60*(5), 524-530.

Constantino, J. N., & Todd, R. D. (2005). Intergenerational transmission of subthreshold autistic traits in the general population. *Biological psychiatry, 57*(6), 655-660.

Cook, J. L., Blakemore, S. J., & Press, C. (2013). Atypical basic movement kinematics in autism spectrum conditions. *Brain, 136*(9), 2816-2824.

Cook, R., Brewer, R., Shah, P., & Bird, G. (2013). Alexithymia, not autism, predicts poor recognition of emotional facial expressions. *Psychological Science, 24*(5), 723-732.

Corden, B., Chilvers, R., & Skuse, D. (2008). Avoidance of emotionally arousing stimuli predicts social–perceptual impairment in Asperger's syndrome. *Neuropsychologia, 46*(1), 137-147.

Crivelli, C., Jarillo, S., Russell, J. A., & Fernández-Dols, J. M. (2016). Reading emotions from faces in two indigenous societies. *Journal of Experimental Psychology: General, 145*(7), 830.

Cruz, J. & Gordon, R (2005),"Simulation Theory,"iIn Nadel, L. (2005), *Encyclopedia of Cognitive Science*, Hoboken, John Wiley and Sons, on-line edition (no page numbers).

D'Argembeau, A., & Van der Linden, M. (2004). Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: Influence of valence and temporal distance. *Consciousness and cognition, 13*(4), 844-858.

Da Fonseca, D., Santos, A., Bastard-Rosset, D., Rondan, C., Poinso, F., & Deruelle, C. (2009). Can children with autistic spectrum disorders extract emotions out of contextual cues?. *Research in Autism Spectrum Disorders, 3*(1), 50-56.

Da Fonseca, D., Seguier, V., Santos, A., Poinso, F., & Deruelle, C. (2009). Emotion understanding in children with ADHD. *Child psychiatry and human development, 40*(1), 111-121.

Dalton, K. M., Nacewicz, B. M., Johnstone, T., Schaefer, H. S., Gernsbacher, M. A., Goldsmith, H. H., Alexander, A. L., & Davidson, R. J. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature neuroscience, 8*(4), 519-526.

Dalton, K., M., Nacewicz, B., M., Alexander, A., L., & Davidson, R., J. (2007) "Gaze-fixation, brain activation, and amygdala volume in unaffected siblings of individuals with autism". *Biological psychiatry* 61 (4), 512-520

Darwin, C. (1872). *The expression of emotion in animals and man*. London, England: Murray.

Dawson, G., Finley, C., Phillips, S., Galpert, L., & Lewy, A. (1988). Reduced P3 amplitude of the event-related brain potential: Its relationship to language ability in autism. *Journal of autism and developmental disorders*, *18*(4), 493-504.

Dawson, G., Meltzoff, A. N., Osterling, J., Rinaldi, J., & Brown, E. (1998). Children with autism fail to orient to naturally occurring social stimuli. *Journal of autism and developmental disorders*, *28*(6), 479-485.

Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Developmental psychology*, *40*(2), 271.

De Sonneville, L. M. J., Verschoor, C. A., Njiokiktjien, C., Op het Veld, V., Toorenaar, N., & Vranken, M. (2002). Facial identity and facial emotions: speed, accuracy, and processing strategies in children and adults. *Journal of Clinical and Experimental Neuropsychology*, *24*(2), 200-213.

de Winter, J. C. F., Dodou, D., & Wieringa, P. A. (2009). Exploratory factor analysis with small sample sizes. *Multivariate Behavioral Research*, *44*(2), 147-181.

Deneve, S. (2008). Bayesian spiking neurons I: inference. *Neural computation*, *20*(1), 91-117.

Deruelle, C., Rondan, C., Gepner, B., & Tardif, C. (2004). Spatial frequency and face processing in children with autism and Asperger syndrome. *Journal of autism and developmental disorders*, *34*(2), 199-210.

Dibeklioğlu, H., Salah, A. A., & Gevers, T. (2012). Are you really smiling at me? Spontaneous versus posed enjoyment smiles. In *European Conference on Computer Vision* (pp. 525-538). Springer Berlin Heidelberg.

Dibeklioglu, H., Valenti, R., Salah, A. A., & Gevers, T. (2010). Eyes do not lie: Spontaneous versus posed smiles. In *Proceedings of the 18th ACM international conference on Multimedia* (pp. 703-706). ACM.

Diehl, J. J., Schmitt, L. M., Villano, M., & Crowell, C. R. (2012). The clinical use of robots for individuals with autism spectrum disorders: A critical review. *Research in autism spectrum disorders*, *6*(1), 249-262.

Diener, E., Sandvik, E., & Larsen, R. J. (1985). Age and sex effects for emotional intensity. *Developmental Psychology*, *21*(3), 542.

Douglas, K. M., Porter, R. J., & Johnston, L. (2012) 'Sensitivity to posed and genuine facial expressions of emotion in severe depression'. *Psychiatry Research* 196 (1), 72–78

Duchowski, A. T. (2007). Eye tracking methodology. *Theory and practice*, *328*.

Durand, K., Gallay, M., Seigneuric, A., Robichon, F., & Baudouin, J. Y. (2007). The development of facial emotion recognition: The role of configural information. *Journal of experimental child psychology*, *97*(1), 14-27.

Dutton, D. G., & Aron, A. P. (1974). Some evidence for heightened sexual attraction under conditions of high anxiety. *Journal of personality and social psychology*, *30*(4), 510.

Dworzynski, K., Ronald, A., Bolton, P., & Happé, F. (2012). How different are girls and boys above and below the diagnostic threshold for autism spectrum disorders?. *Journal of the American Academy of Child & Adolescent Psychiatry*, *51*(8), 788-797.

Dyck, M. J., Piek, J. P., Hay, D., Smith, L., & Hallmayer, J. (2006). Are abilities abnormally interdependent in children with autism?. *Journal of Clinical Child and Adolescent Psychology*, *35*(1), 20-33.

Egloff, B., Schmukle, S. C., Burns, L. R., & Schwerdtfeger, A. (2006). Spontaneous emotion regulation during evaluated speaking tasks: associations with negative affect, anxiety expression, memory, and physiological responding. *Emotion*, *6*(3), 356.

Ekman, P. & Friesen, W. V. (1976) 'Measuring facial movement'. *Environmental Psychology and Nonverbal Behavior* 1 (1), 56–75

Ekman, P. (1993). Facial expression and emotion. *American psychologist*, *48*(4), 384.

Ekman, P. (2000). Basic Emotions. In T. Dalgleish & M. Power (Eds.), *Handbook of cognition and emotion*. John Wiley & Sons.

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of personality and social psychology*, *17*(2), 124.

Ekman, P., & Friesen, W. V. (1975). *Pictures of facial affect*. Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1976). Measuring facial movement. *Environmental psychology and nonverbal behavior*, *1*(1), 56-75.

Ekman, P., & Friesen, W. V. (1978). *Manual for the facial action coding system*. Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1982). Felt, false, and miserable smiles. *Journal of nonverbal behavior*, *6*(4), 238-252.

Ekman, P., & Keltner, D. (1970). Universal facial expressions of emotion. *California Mental Health Research Digest*, *8*(4), 151-158.

Ekman, P., & O'sullivan, M. (1991). Who can catch a liar?. *American psychologist*, *46*(9), 913.

Ekman, P., Davidson, R. J., & Friesen, W. V. (1990) 'The Duchenne smile: Emotional expression and brain physiology: II'. *Journal of Personality and Social Psychology* 58 (2), 342–353

Ekman, P., Friesen, W. V., & O'Sullivan, M. (1988). Smiles when lying. *Journal of personality and social psychology*, *54*(3), 414.

Ekman, P., Friesen, W., & Hager, J. C. (2002). *New Version of the Facial Action Coding System*. Salt Lake City, UT: A Human Face Publication.

Elfenbein, H. A., & Ambady, N. (2003). Universals and cultural differences in recognizing emotions. *Current directions in psychological science*, *12*(5), 159-164.

Elfenbein, H. A., Beaupré, M., Lévesque, M., & Hess, U. (2007). Toward a dialect theory: cultural differences in the expression and recognition of posed facial expressions. *Emotion*, *7*(1), 131.

Elfenbein, H.A., & Ambady, N. (2002). Is there an ingroup advantage in emotion recognition? *Psychological Bulletin, 128*, 243–249.

Ellsworth, P. C. (1991). Some implications of cognitive appraisal theories of emotion. *International review of studies on emotion*, *1*, 143-161.

Enticott, P. G., Kennedy, H. A., Johnston, P. J., Rinehart, N. J., Tonge, B. J., Taffe, J. R., & Fitzgerald, P. B. (2014). Emotion recognition of static and dynamic faces in autism spectrum disorder. *Cognition and Emotion*, *28*(6), 1110-1118.

Faso, D. J., Sasson, N. J., & Pinkham, A. E. (2015). Evaluating posed and evoked facial expressions of emotion from adults with autism spectrum disorder. *Journal of autism and developmental disorders*, *45*(1), 75-89.

Fein, D., Lueci, D., Braverman, M., & Waterhouse, L. (1992). Comprehension of affect in context in children with pervasive developmental disorders. *Journal of Child Psychology and Psychiatry*, *33*(7), 1157-1162.

Feldman, L. A. (1993). Distinguishing depression and anxiety in self-report: Evidence from confirmatory factor analysis on nonclinical and clinical samples. *Journal of Consulting and Clinical Psychology*, *61*(4), 631.

Fletcher-Watson, S., Leekam, S. R., Benson, V., Frank, M. C., & Findlay, J. M. (2009). Eye-movements reveal attention to social information in autism spectrum disorder. *Neuropsychologia*, *47*(1), 248-257.

Folstein, S. E., Santangelo, S. L., Gilman, S. E., Piven, J., Landa, R., Lainhart, J., Hein, J. & Wzorek, M. (1999). Predictors of cognitive test patterns in autism families. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *40*(7), 1117-1128.

Fombonne, E. (2003). Epidemiological surveys of autism and other pervasive developmental disorders: an update. *Journal of autism and developmental disorders*, *33*(4), 365-382.

Freeth, M., Chapman, P., Ropar, D., & Mitchell, P. (2010). Do gaze cues in complex scenes capture and direct the attention of high functioning adolescents with ASD? Evidence from eye-tracking. *Journal of autism and developmental disorders*, *40*(5), 534-547.

Fridlund, A. J. (1991). Sociality of solitary smiling: Potentiation by an implicit audience. *Journal of Personality and Social Psychology*, *60*(2), 229.

Frith, U. (1989). *Autism: Explaining the enigma* (Vol. 1989). Blackwell Scientific Publications: Oxford.

Frith, U. (2001). Mind blindness and the brain in autism. *Neuron*, *32*(6), 969-979.

from behavioural, genetic, cognitive and neural research. *Neuropsychology Review*. 18:287–304.

Fujita, F., Diener, E., & Sandvik, E. (1991). Gender differences in negative affect and well-being: the case for emotional intensity. *Journal of personality and social psychology*, *61*(3), 427.

Gaigg, S. B. (2012). The interplay between emotion and cognition in autism spectrum disorder: implications for developmental theory. *Frontiers in integrative neuroscience*, *6*.

Gallese, V., & Goldman, A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends in cognitive sciences*, *2*(12), 493-501.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, *119*(2), 593-609.

Gallivan, J. P., Logan, L., Wolpert, D. M., & Flanagan, J. R. (2016). Parallel specification of competing sensorimotor control policies for alternative action options. *Nature neuroscience*, *19*(2), 320.

Gendron M,, Mesquita B, & Barrett L. F. (2013). Emotion perception: Putting the face in context. In: D. Reisberg (Ed.), *The Oxford handbook of cognitive psychology*. New York, NY: Oxford University Press (pp539-556)

Gendron, M., Roberson, D., van der Vyver, J. M., & Barrett, L. F. (2014). Cultural relativity in perceiving emotion from vocalizations. *Psychological science*, *25*(4), 911-920.

Gepner, B., & Féron, F. (2009). Autism: a world changing too fast for a mis-wired brain?. *Neuroscience & Biobehavioral Reviews*, *33*(8), 1227-1242.

Gepner, B., Deruelle, C., & Grynfeltt, S. (2001). Motion and emotion: A novel approach to the study of face processing by young autistic children. *Journal of autism and developmental disorders*, *31*(1), 37-45.

Gilchrist, A., & McKone, E. (2003). Early maturity of face processing in children: Local and relational distinctiveness effects in 7-year-olds. *Visual Cognition*, *10*(7), 769-793.

Golan, O., & Baron-Cohen, S. (2006). Systemizing empathy: Teaching adults with Asperger syndrome or high-functioning autism to recognize complex emotions using interactive multimedia. *Development and psychopathology*, *18*(2), 591-617.

Golan, O., Baron-Cohen, S., & Hill, J. (2006). The Cambridge mindreading (CAM) face-voice battery: Testing complex emotion recognition in adults with and without Asperger syndrome. *Journal of autism and developmental disorders*, *36*(2), 169-183.

Goldman, A. I., & Sripada, C. S. (2005). Simulationist models of face-based emotion recognition. *Cognition*, *94*(3), 193-213.

Goos, L. M., & Silverman, I. (2002). Sex related factors in the perception of threatening facial expressions. *Journal of Nonverbal Behavior, 26*(1), 27-41.

Gopnik, A., & Astington, J. W. (1988). Children's understanding of representational change and its relation to the understanding of false belief and the appearance-reality distinction. *Child development*, 26-37.

Gopnik, A., & Wellman, H. M. (1992). Why the child's theory of mind really is a theory. *Mind & Language*, *7*(1-2), 145-171.

Gopnik, A., Meltzoff, A. N., & Bryant, P. (1997). *Words, thoughts, and theories* (Vol. 1). Cambridge, MA: Mit Press.

Gordon, R. M. (1986). Folk psychology as simulation. *Mind & Language*, *1*(2), 158-171.

Gosselin, P., Kirouac, G., & Doré, F. Y. (1995) 'Components and recognition of facial expression in the communication of emotion by actors'. *Journal of Personality and Social Psychology* 68 (1), 83–96

Graham, K. & Wells, S. (2001) 'Aggression among young adults in the social context of the bar'. *Addiction Research and Theory* 9 (3), 193–219

Grecucci, A., Brambilla, P., Siugzdaite, R., Londero, D., Fabbro, F., & Rumiati, R. I. (2013). Emotional resonance deficits in autistic children. *Journal of autism and developmental disorders*, *43*(3), 616-628.

Grelotti, D. J., Klin, A. J., Gauthier, I., Skudlarski, P., Cohen, D. J., Gore, J. C., Volkmar, F. R. & Schultz, R. T. (2005). fMRI activation of the fusiform gyrus and amygdala to cartoon characters but not to faces in a boy with autism. *Neuropsychologia*, *43*(3), 373-385.

Griffiths, P. E. (1997). *What emotions really are: The problem of psychological categories* (p. 114). Chicago: University of Chicago Press.

Grimshaw, G. M., Bulman-Fleming, M. B., & Ngo, C. (2004) 'A signal-detection analysis of sex differences in the perception of emotional faces'. *Brain and Cognition* 54 (3), 248–250

Gross, C. G., & Sergent, J. (1992). Face recognition. *Current Opinion in Neurobiology*, *2*(2), 156-161.

Gross, J. J., Thompson, R. A. (2006) Emotion regulation: Conceptual foundations. In: Gross, J. J., editor. *Handbook of emotion regulation*. Guilford; New York: pp. 3–24.

Gross, T. F. (2008). Recognition of immaturity and emotional expressions in blended faces by children with autism and other developmental disabilities. *Journal of Autism and Developmental Disorders*, *38*(2), 297-311.

Grossman, R. B., Edelson, L. R., & Tager-Flusberg, H. (2013). Emotional facial and vocal expressions during story retelling by children and adolescents with high-functioning autism. *Journal of Speech, Language, and Hearing Research*, *56*(3), 1035-1044.

Gur, R. C., Sara, R., Hagendoorn, M., Marom, O., Hughett, P., Macy, L., Turner, T., Bajcsy, R., Posner, A., & Gur, R. E. (2002). A method for obtaining 3-dimensional facial expressions and its standardization for use in neurocognitive studies. *Journal of neuroscience methods, 115*(2), 137-143.

Haith, M. M., Bergman, T., & Moore, M. J. (1977). Eye contact and face scanning in early infancy. *Science*, *198*(4319), 853-855.

Hall, J. A. & Matsumoto, D. (2004) 'Gender differences in judgments of multiple emotions from facial expressions'. *Emotion* 4 (2), 201–206

Hall, J. A. (1978) ‘Gender effects in decoding non-verbal cues’. *Psychological Bulletin* 85, 845–857

Hall, J. A. (1984) ‘*Non-verbal sex differences*’. Baltimore, MD: John Hopkins University Press.

Hannant, P., Cassidy, S., Tavassoli, T., & Mann, F. (2016). Sensorimotor difficulties are associated with the severity of autism spectrum conditions. *Frontiers in integrative neuroscience*, *10*. 28

Happé, F., & Ronald, A. (2008). The ‘fractionable autism triad’: a review of evidence from behavioural, genetic, cognitive and neural research. *Neuropsychology review*, *18*(4), 287-304.

Happé, F. G. (1994). An advanced test of theory of mind: Understanding of story characters' thoughts and feelings by able autistic, mentally handicapped, and normal children and adults. *Journal of autism and Developmental disorders*, *24*(2), 129-154.

Happé, F. G. (1995). The role of age and verbal ability in the theory of mind task performance of subjects with autism. *Child development*, *66*(3), 843-855.

Happé, F. G. (1996). Studying weak central coherence at low levels: children with autism do not succumb to visual illusions. A research note. *Journal of Child Psychology and Psychiatry*, *37*(7), 873-877.

Happé, F., & Vital, P. (2009). What aspects of autism predispose to talent?. *Philosophical Transactions of the Royal Society B: Biological Sciences*,*364*(1522), 1369-1375.

Harms, M. B., Martin, A., & Wallace, G. L. (2010). Facial emotion recognition in autism spectrum disorders: a review of behavioural and neuroimaging studies. *Neuropsychology review*, *20*(3), 290-322.

Harris, P. L., Johnson, C. N., Hutton, D., Andrews, G., & Cooke, T. (1989). Young children's theory of mind and emotion. *Cognition & Emotion*, *3*(4), 379-400.

Harwood, N. K., Hall, L. J., & Shinkfield, A. J. (1999). Recognition of facial emotional expressions from moving and static displays by individuals with mental retardation. *American Journal on Mental Retardation*, *104*(3), 270-278.

Hassabis, D., Kumaran, D., Vann, S. D., & Maguire, E. A. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences*, *104*(5), 1726-1731.

Hassoun, L., Herrmann-Lingen, C., Hapke, U., Neuhauser, H., Scheidt-Nave, C., & Meyer, T. (2015). Association between chronic stress and blood pressure: Findings from the German health interview and examination survey for adults 2008–2011. *Psychosomatic medicine*, *77*(5), 575-582.

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1993). Emotional contagion. *Current directions in psychological science*, *2*(3), 96-100.

Herba, C., & Phillips, M. (2004). Annotation: Development of facial expression recognition from childhood to adolescence: Behavioural and neurological perspectives. *Journal of Child Psychology and Psychiatry*, *45*(7), 1185-1198.

Hernandez, N., Metzger, A., Magné, R., Bonnet-Brilhault, F., Roux, S., Barthelemy, C., & Martineau, J. (2009). Exploration of core features of a human face by healthy and autistic adults analyzed by visual scanning. *Neuropsychologia*, *47*(4), 1004-1012.

Herry, C., & Johansen, J. P. (2014). Encoding of fear learning and memory in distributed neuronal circuits. *Nature neuroscience*, *17*(12), 1644.

Hess, U., & Blairy, S. (2001). Facial mimicry and emotional contagion to dynamic emotional facial expressions and their influence on decoding accuracy. *International journal of psychophysiology*, *40*(2), 129-141.

Hill, E., Berthoz, S., & Frith, U. (2004). Brief report: Cognitive processing of own emotions in individuals with autistic spectrum disorder and in their relatives. *Journal of autism and developmental disorders*, *34*(2), 229-235.

Hill, T. L., Varela, R. E., Kamps, J. L., & Niditch, L. A. (2014) "Local Processing and Social Skills in Children with Autism Spectrum Disorders: The Role of Anxiety and Cognitive Functioning". *Research in Autism Spectrum Disorders* 8 (9), 1243–1251

Hjortsjö, C.H. (1969) *Man's face and mimic language*. Malmo, Sweden: Nordens Boktryckeri.

Hobson, R. P. (1986). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry*, *27*(3), 321-342.

Hoekstra, R. A., Bartels, M., Cath, D. C., & Boomsma, D. I. (2008). Factor structure, reliability and criterion validity of the Autism-Spectrum Quotient (AQ): a study in Dutch population and patient groups. *Journal of autism and developmental disorders*, *38*(8), 1555-1566.

Hoekstra, R. A., Bartels, M., Verweij, C. J., & Boomsma, D. I. (2007). Heritability of autistic traits in the general population. *Archives of pediatrics & adolescent medicine*, *161*(4), 372-377.

Hoffmann, H., Kessler, H., Eppel, T., Rukavina, S., & Traue, H. C. (2010). Expression intensity, gender and facial emotion recognition: Women recognize only subtle facial emotions better than men. *Acta psychologica*, *135*(3), 278-283.

Homer, M., & Rutherford, M. D. (2008). Individuals with autism can categorize facial expressions. *Child Neuropsychology*, 14(5), 419-437.

Hooker, C., & Park, S. (2002). Emotion processing and its relationship to social functioning in schizophrenia patients. *Psychiatry research*, 112(1), 41-50.

Hoque, M., & Picard, R. W. (2011). Acted vs. natural frustration and delight: Many people smile in natural frustration. In *Automatic Face and Gesture Recognition and Workshops (FG 2011), 2011 IEEE International Conference on* (pp. 354-359).

Hoque, M., Morency, L. P., & Picard, R. W. (2011). Are you friendly or just polite?–Analysis of smiles in spontaneous face-to-face interactions. In *International Conference on Affective Computing and Intelligent Interaction* (pp. 135-144). Springer Berlin Heidelberg.

Howard, M. A., Cowell, P. E., Boucher, J., Broks, P., Mayes, A., Farrant, A., & Roberts, N. (2000). Convergent neuroanatomical and behavioural evidence of an amygdala hypothesis of autism. *Neuroreport, 11*(13), 2931-2935.

Howe, Y., O'Rourke, J. A., Yatchmink, Y., Viscidi, E. W., Jones, R. N., & Morrow, E. M. (2015). Female autism phenotypes investigated at different levels of language and developmental abilities. *Journal of Autism and Developmental Disorders, 45*(11), 3537–3549.

Hughes, C., Leboyer, M., & Bouvard, M. (1997). Executive function in parents of children with autism. *Psychological medicine*, *27*(1), 209-220.

Hughes, C., Plumet, M. H., & Leboyer, M. (1999). Towards a cognitive phenotype for autism: increased prevalence of executive dysfunction and superior spatial span amongst siblings of children with autism. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *40*(5), 705-718.

Humphreys, K., Minshew, N., Leonard, G. L., & Behrmann, M. (2007). A fine-grained analysis of facial expression processing in high-functioning adults with autism. *Neuropsychologia*, *45*(4), 685-695.

Ibáñez, A., Riveros, R., Hurtado, E., Gleichgerrcht, E., Urquina, H., Herrera, E., Amoruso, L., Reyes. M. & Manes, F. (2012). The face and its emotion: right N170 deficits in structural processing and early emotional discrimination in schizophrenic patients and relatives. *Psychiatry research*, *195*(1), 18-26.

Iverson, J. M., & Goldin-Meadow, S. (2005). Gesture paves the way for language development. *Psychological science*, *16*(5), 367-371.

Izard, C., Fine, S., Schultz, D., Mostow, A., Ackerman, B., & Youngstrom, E. (2001). Emotion knowledge as a predictor of social behavior and academic competence in children at risk. *Psychological science*, *12*(1), 18-23.

Jacob, R. J., & Karn, K. S. (2003). Eye tracking in human-computer interaction and usability research: Ready to deliver the promises. In *The mind's eye* (pp. 573-605).

James, W. (1884). What is an emotion?. *Mind*, *9*(34), 188-205.

Jarrold, C., Gilchrist, I. D., & Bender, A. (2005). Embedded figures detection in autism and typical development: Preliminary evidence of a double dissociation in relationships with visual search. *Developmental science*, *8*(4), 344-351.

Johnson, M. H., & Morton, J. (1991). *Biology and cognitive development: The case of face recognition*. Blackwell.

Johnson, S. A., Filliter, J. H., & Murphy, R. R. (2009). Discrepancies between self-and parent-perceptions of autistic traits and empathy in high functioning children and adolescents on the autism spectrum. *Journal of autism and developmental disorders*, *39*(12), 1706-1714.

Jones, C. R., Pickles, A., Falcaro, M., Marsden, A. J., Happé, F., Scott, S. K., Sauter, D., Tregay, J., Phillips, R. J., Baird, G. & Simonoff, E. (2011). A multimodal approach to emotion recognition ability in autism spectrum disorders. *Journal of Child Psychology and Psychiatry*, *52*(3), 275-285.

Jones, J., & Pashler, H. (2007). Is the mind inherently forward looking? Comparing prediction and retrodiction. *Psychonomic bulletin & review*, *14*(2), 295-300.

Jorde, L. B., Hasstedt, S. J., Ritvo, E. R., Mason-Brothers, A., Freeman, B. J., Pingree, C., McMahon, M. W., Peterson, B., Jenson, W. R. & Mo, A. (1991). Complex segregation analysis of autism. *American journal of human genetics*, *49*(5), 932.

Juslin, P. N., & Laukka, P. (2003). Communication of emotions in vocal expression and music performance: Different channels, same code?. *Psychological bulletin*, *129*(5), 770.

Kadak, M. T., Demirel, Ö. F., Yavuz, M., & Demir, T. (2014). Recognition of emotional facial expressions and broad autism phenotype in parents of children diagnosed with autistic spectrum disorder. *Comprehensive psychiatry*, *55*(5), 1146-1151.

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous child*, *2*(3), 217-250.

Kasari, C., Chamberlain, B., & Bauminger, N. (2001). Social emotions and social relationships in autism: can children with autism compensate? In J. Burack, T. Charman, N. Yirmiya, & P. Zelazo (Eds.), *Development and autism: Perspectives from theory and research*. Hillsdale, NJ: Erlbaum Press.

Kasari, C., Sigman, M., Mundy, P., & Yirmiya, N. (1990). Affective sharing in the context of joint attention interactions of normal, autistic, and mentally retarded children. *Journal of autism and developmental disorders*, *20*(1), 87-100.

Kashy, D. A., & Donnellan, M. B. (2008). Comparing MLM and SEM approaches to analyzing developmental dyadic data: Growth curve models of hostility in families. *Modeling dyadic and interdependent data in the developmental and behavioral sciences*, 165-190.

Kennedy, D. P., & Adolphs, R. (2012a). Perception of emotions from facial expressions in high-functioning adults with autism. *Neuropsychologia*, *50*(14), 3313-3319.

Kennedy, D. P., & Adolphs, R. (2012b). The social brain in psychiatric and neurological disorders. *Trends in cognitive sciences*, *16*(11), 559-572.

Kennedy, D. P., & Squire, L. R. (2007). An analysis of calendar performance in two autistic calendar savants. *Learning & Memory, 14*(8), 533-538.

Kenny, A. (1963) *Action, Emotion and Will*. New York: Humanities Press

Kessler, H., Bachmayr, F., Walter, S., Hoffmann, H., Filipic, S., & Traue, H. C. (2008). Symmetries in a standardized set of emotional facial expressions (JACFEE). *GMS Psycho-Social Medicine*, *5*.

Kessler, H., Roth, J., von Wietersheim, J., Deighton, R. M., & Traue, H. C. (2007). Emotion recognition patterns in patients with panic disorder. *Depression and Anxiety*, *24*(3), 223.

Keysar, B., Lin, S., & Barr, D. J. (2003). Limits on theory of mind use in adults. *Cognition*, *89*(1), 25-41.

Kim, E. S., Berkovits, L. D., Bernier, E. P., Leyzberg, D., Shic, F., Paul, R., & Scassellati, B. (2013). Social robots as embedded reinforcers of social behavior in children with autism. *Journal of autism and developmental disorders*, *43*(5), 1038-1049.

Kirouac, G., & Doré, F. Y. (1984). Judgment of facial expressions of emotion as a function of exposure time. *Perceptual and Motor Skills*, *59*(1), 147-150.

Kleiner, K. A. (1987). Amplitude and phase spectra as indices of infants' pattern preferences. *Infant Behavior and Development*, *10*(1), 49-59.

Kleiner, K. A., & Banks, M. S. (1987). Stimulus energy does not account for 2-month-olds' face preferences. *Journal of Experimental Psychology: Human Perception and Performance*, *13*(4), 594.

Kleinhans, N. M., Richards, T., Weaver, K., Johnson, L. C., Greenson, J., Dawson, G., & Aylward, E. (2010) "Association between amygdala response to emotional faces and social anxiety in autism spectrum disorders". *Neuropsychologia* 48 (12), 3665-3670

Klin, A. (2000). Attributing social meaning to ambiguous visual stimuli in higher-functioning autism and Asperger syndrome: The social attribution task. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *41*(7), 831-846.

Klin, A., Jones, W., Schultz, R., & Volkmar, F. (2003). The enactive mind, or from actions to cognition: lessons from autism. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *358*(1430), 345-360.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of general psychiatry*, *59*(9), 809-816.

Klinnert, M. D. (1984). The regulation of infant behavior by maternal facial expression. *Infant Behavior and Development*, *7*(4), 447-465.

Knickmeyer, R., Baron-Cohen, S., Raggatt, P., & Taylor, K. (2005). Foetal testosterone, social relationships, and restricted interests in children. *Journal of child psychology and psychiatry*, *46*(2), 198-210.

Kohler, C. G., Turner, T., Stolar, N. M., Bilker, W. B., Brensinger, C. M., Gur, R. E., & Gur, R. C. (2004). Differences in facial expressions of four universal emotions. *Psychiatry research*, *128*(3), 235-244.

Koldewyn, K., Jiang, Y. V., Weigelt, S., & Kanwisher, N. (2013). Global/local processing in autism: Not a disability, but a disinclination. *Journal of autism and developmental disorders*, *43*(10), 2329-2340.

Kraft, T. L. & Pressman, S. D. (2012) 'Grin and bear it: The influence of manipulated facial expression on the stress response'. *Psychological Science* 23 (11), 1372–1378

Krippendorff, K. (2011) Computing Krippendorff's Alpha-Reliability. Retrieved from https://repository.upenn.edu/asc_papers/43

Krumhuber, E. G., Skora, L., Küster, D., & Fou, L. (2017). A review of dynamic datasets for facial expression research. *Emotion Review*, *9*(3), 280-292.

Kylliäinen, A., & Hietanen, J. K. (2006). Skin conductance responses to another person's gaze in children with autism. *Journal of autism and developmental disorders*, *36*(4), 517-525.

Lacroix, A., Guidetti, M., Rogé, B., & Reilly, J. (2009). Recognition of emotional and nonemotional facial expressions: A comparison between Williams syndrome and autism. *Research in Developmental Disabilities*, *30*(5), 976-985.

Lai, M. C., Lombardo, M. V., Pasco, G., Ruigrok, A. N., Wheelwright, S. J., Sadek, S. A., Chakrabarti, B. & Baron-Cohen, S. (2011). A behavioral comparison of male and female adults with high functioning autism spectrum conditions. *PloS one*, *6*(6), e20835.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). International affective picture system (IAPS): Affective ratings of pictures and instruction manual. *Technical report A-8*.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, *30*(3), 261-273.

Lange, C. (1922). *The Emotions*. Baltimore: Williams & Wilkins

Langton, S. R., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition*, *6*(5), 541-567.

Lazarus, R. S. (1991). *Emotion and adaptation*. Oxford University Press on Demand.

Ledesma, R. D., & Valero-Mora, P. (2007). Determining the number of factors to retain in EFA: An easy-to-use computer program for carrying out parallel analysis. *Practical assessment, research and evaluation*, *12*(2), 1-11.

Leppänen, J. M., & Hietanen, J. K. (2001). Emotion recognition and social adjustment in school–aged girls and boys. *Scandinavian Journal of Psychology, 42*(5), 429-435.

Leslie, A. M., & Frith, U. (1988). Autistic children's understanding of seeing, knowing and believing. *British Journal of Developmental Psychology*, *6*(4), 315-324.

Leung, D., Ordqvist, A., Falkmer, T., Parsons, R., & Falkmer, M. (2013) "Facial Emotion Recognition and Visual Search Strategies of Children with High Functioning Autism and Asperger Syndrome". *Research in Autism Spectrum Disorders* 7 (7), 833–844

Lewis, M., Haviland-Jones, J. M., & Barrett, L. F. (Eds.). (2010). *Handbook of emotions*. Guilford Press.

Likowski, K. U., Mühlberger, A., Seibt, B., Pauli, P., & Weyers, P. (2008) 'Modulation of facial mimicry by attitudes'. *Journal of Experimental Social Psychology* 44 (4), 1065–1072

Lindner, J. L., & Rosén, L. A. (2006). Decoding of emotion through facial expression, prosody and verbal content in children and adolescents with Asperger's syndrome. *Journal of autism and developmental disorders*, *36*(6), 769-777.

Losh, M., Childress, D., Lam, K., & Piven, J. (2008). Defining key features of the broad autism phenotype: A comparison across parents of multiple-and single-incidence autism families. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, *147*(4), 424-433.

Loveland, K. A., & Landry, S. H. (1986). Joint attention and language in autism and developmental language delay. *Journal of autism and developmental disorders*, *16*(3), 335-349.

Loveland, K. A., Steinberg, J. L., Pearson, D. A., Mansour, R., & Reddoch, S. (2008). Judgments of Auditory—Visual Affective Congruence in Adolescents with and without Autism: A Pilot Study of a New Task Using fMRI. *Perceptual and motor skills*, *107*(2), 557-575.

Loveland, K. A., Tunali–Kotoski, B., Chen, Y. R., Ortegon, J., Pearson, D. A., Brelsford, K. A., & Gibbs, M. C. (1997). Emotion recognition in autism: Verbal and nonverbal information. *Development and psychopathology*, *9*(03), 579-593.

Lutchmaya, S., Baron-Cohen, S., & Raggatt, P. (2002). Foetal testosterone and eye contact in 12-month-old human infants. *Infant Behavior and Development*, *25*(3), 327-335.

Macdonald, H., Rutter, M., Howlin, P., Rios, P., Conteur, A. L., Evered, C., & Folstein, S. (1989). Recognition and expression of emotional cues by autistic and normal adults. *Journal of Child Psychology and Psychiatry*, *30*(6), 865-877.

Mandy, W. P., & Skuse, D. H. (2008). Research Review: What is the association between the social-communication element of autism and repetitive interests, behaviours and activities?. *Journal of Child Psychology and Psychiatry*, *49*(8), 795-808.

Manstead, A. S. R., Wagner, H. L., & MacDonald, C. J. (1986). Deceptive and nondeceptive communications: Sending experience, modality, and individual abilities. *Journal of Nonverbal Behavior*, *10*(3), 147-167.

Martinez, A,. & Benavente, R. (1998) The AR Face Database. *CVC Technical Report* #24.

Matsumoto, D., & Ekman, P. (1988). *Japanese and Caucasian facial expressions of emotion (JACFEE)*. [Slides]. San Francisco: Intercultural and Emotion Research Laboratory, Department of Psychology, San Francisco State University.

Matsumoto, D., & Willingham, B. (2006). The thrill of victory and the agony of defeat: spontaneous expressions of medal winners of the 2004 Athens Olympic Games. *Journal of personality and social psychology*, *91*(3), 568.

Matsumoto, D., Consolacion, T., Yamada, H., Suzuki, R., Franklin, B., Paul, S., Ray, R., & Uchida, H. (2002). American-Japanese cultural differences in judgements of emotional expressions of different intensities. *Cognition and Emotion*, *16*(6), 721-747.

Matsumoto, D., Olide, A., & Willingham, B. (2009a). Is there an ingroup advantage in recognizing spontaneously expressed emotions?. *Journal of Nonverbal Behavior*, *33*(3), 181-191.

Matsumoto, D., Olide, A., Schug, J., Willingham, B., & Callan, M. (2009b). Cross-cultural judgments of spontaneous facial expressions of emotion. *Journal of Nonverbal Behavior*, *33*(4), 213-238.

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion*, *5*(2), 175.

Mayes, S. D., Gorman, A. A., Hillwig-Garcia, J., & Syed, E. (2013). Suicide ideation and attempts in children with autism. *Research in Autism Spectrum Disorders*, *7*(1), 109-119.

Mazefsky, C. A., & Oswald, D. P. (2007). Emotion perception in Asperger's syndrome and high-functioning autism: The importance of diagnostic criteria and cue intensity. *Journal of Autism and Developmental Disorders, 37*(6), 1086-1095.

McBain, R., Norton, D., & Chen, Y. (2009) 'Females excel at basic face perception'. *Acta Psychologica* 130 (2), 168–173

McClure, E. B. (2000). A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. *Psychological Bulletin, 126*(3), 424-453.

McDonald, P. W., & Prkachin, K. M. (1990). The expression and perception of facial emotion in Alexithymia: a pilot study. *Psychosomatic Medicine*, *52*(2), 199-210.

McIntosh, D. N., Reichmann-Decker, A., Winkielman, P., & Wilbarger, J. L. (2006). When the social mirror breaks: deficits in automatic, but not voluntary, mimicry of emotional facial expressions in autism. *Developmental science, 9*(3), 295-302.

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science, 198*(4312), 75-78.

Mihov, Y., Kendrick, K. M., Becker, B., Zschernack, J., Reich, H., Maier, W., ... & Hurlemann, R. (2013). Mirroring fear in the absence of a functional amygdala. *Biological Psychiatry, 73*(7), e9-e11.

Miller, L. A., Hsieh, S., Lah, S., Savage, S., Hodges, J. R., & Piguet, O. (2012). One size does not fit all: face emotion processing impairments in semantic dementia, behavioural-variant frontotemporal dementia and Alzheimer's disease are mediated by distinct cognitive deficits. *Behavioural neurology*, *25*(1), 53-60.

Mitchell, P., & Ropar, D. (2004). Visuo-spatial abilities in autism: A review. *Infant and Child Development*, *13*(3), 185-198.

Montagne, B., Kessels, R. P., Frigerio, E., de Haan, E. H., & Perrett, D. I. (2005). Sex differences in the perception of affective facial expressions: do men really lack emotional sensitivity?. *Cognitive Processing*, *6*(2), 136-141.

Moriguchi, Y., Decety, J., Ohnishi, T., Maeda, M., Mori, T., Nemoto, K., Matsuda, H. & Komaki, G. (2006). Empathy and judging other's pain: an fMRI study of Alexithymia. *Cerebral Cortex*, *17*(9), 2223-2234.

Moriguchi, Y., Maeda, M., Igarashi, T., Ishikawa, T., Shoji, M., Kubo, C., & Komaki, G. (2007). Age and gender effect on Alexithymia in large, Japanese community and clinical samples: a cross-validation study of the Toronto Alexithymia Scale (TAS-20). *BioPsychoSocial medicine*, *1*(1), 7.

Morton, J., & Johnson, M. H. (1991). CONSPEC and CONLERN: a two-process theory of infant face recognition. *Psychological review*, *98*(2), 164.

Moses, L. J., & Flavell, J. H. (1990). Inferring false beliefs from actions and reactions. *Child development*, *61*(4), 929-945.

Moskacheva, M. A., Kholmogorova, A. B., & Garanyan, N. G. (2015). Alexithymia and empathy. *Counseling Psychology and Psychotherapy*, *2014*(4), 98-114.

Motley, M. T., & Camden, C. T. (1988). Facial expression of emotion: A comparison of posed expressions versus spontaneous expressions in an interpersonal communication setting. *Western Journal of Communication (includes Communication Reports)*, *52*(1), 1-22.

Mottron, L., Burack, J. A., Iarocci, G., Belleville, S., & Enns, J. T. (2003). Locally oriented perception with intact global processing among adolescents with high-functioning autism: evidence from multiple paradigms. *Journal of Child Psychology and Psychiatry*, *44*(6), 904-913.

Mottron, L., Burack, J. A., Stauder, J. E., & Robaey, P. (1999). Perceptual processing among high-functioning persons with autism. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *40*(2), 203-211.

Mueser, K. T., Doonan, R., Penn, D. L., Blanchard, J. J., Bellack, A. S., Nishith, P., & DeLeon, J. (1996). Emotion recognition and social competence in chronic schizophrenia. *Journal of abnormal psychology*, *105*(2), 271.

Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and developmental Disorders*, *20*(1), 115-128.

Murphy, M., Bolton, P. F., Pickles, A., Fombonne, E., Piven, J., & Rutter, M. (2000). Personality traits of the relatives of autistic probands. *Psychological medicine*, *30*(6), 1411-1424.

Muskett, T., Perkins, M., Clegg, J., & Body, R. (2010). Inflexibility as an interactional phenomenon: Using conversation analysis to re-examine a symptom of autism. *Clinical linguistics & phonetics*, *24*(1), 1-16.

Naab, P. J. & Russell, J. A. (2007) 'Judgments of emotion from spontaneous facial expressions of new Guineans'. *Emotion* 7 (4), 736–744

Nacewicz, B. M., Dalton, K. M., Johnstone, T., Long, M. T., McAuliff, E. M., Oakes, T. R., Alexander, A. L. & Davidson, R. J. (2006). Amygdala volume and nonverbal social impairment in adolescent and adult males with autism. *Archives of general psychiatry*, *63*(12), 1417-1428.

Namba, S., Makihara, S., Kabir, R. S., Miyatani, M., & Nakao, T. (2016). Spontaneous Facial Expressions Are Different from Posed Facial Expressions: Morphological Properties and Dynamic Sequences. *Current Psychology*, 1-13.

Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive psychology*, *9*(3), 353-383.

Nelson, N. L., & Russell, J. A. (2013). Universality revisited. *Emotion Review*, *5*(1), 8-15.

Nemiah, J. C., Freyberger, H. & Sifneos, P. E. (1976). Alexithymia: a view of the psychosomatic process. *Modern trends in psychosomatic medicine*, *3*, 430-439.

Neumann, D., Spezio, M. L., Piven, J., & Adolphs, R. (2006). Looking you in the mouth: abnormal gaze in autism resulting from impaired top-down modulation of visual attention. *Social cognitive and affective neuroscience*, *1*(3), 194-202.

Nishimura, M., Rutherford, M. D., & Maurer, D. (2008). Converging evidence of configural processing of faces in high-functioning adults with autism spectrum disorders. *Visual Cognition*, *16*(7), 859-891.

Nishitani, N., Avikainen, S., & Hari, R. (2004). Abnormal imitation-related cortical activation sequences in Asperger's syndrome. *Annals of neurology*, *55*(4), 558-562.

Oakley, B. F., Brewer, R., Bird, G., & Catmur, C. (2016). Theory of mind is not theory of emotion: A cautionary note on the Reading the Mind in the Eyes Test. *Journal of Abnormal Psychology*, *125*(6), 818.

Oerlemans, A. M., Droste, K., van Steijn, D. J., de Sonneville, L. M., Buitelaar, J. K., & Rommelse, N. N. (2013). Co-segregation of social cognition, executive function and local processing style in children with ASD, their siblings and normal controls. *Journal of autism and developmental disorders*, *43*(12), 2764-2778.

Ogai, M., Matsumoto, H., Suzuki, K., Ozawa, F., Fukuda, R., Uchiyama, I., ... & Takei, N. (2003). fMRI study of recognition of facial expressions in high-functioning autistic patients. *Neuroreport*, *14*(4), 559-563.

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Tanji, K., Suzuki, K., ... & Yamadori, A. (2003). Thinking of the future and past: The roles of the frontal pole and the medial temporal lobes. *Neuroimage*, *19*(4), 1369-1380.

Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: relationship to theory of mind. *Journal of child Psychology and Psychiatry*, *32*(7), 1081-1105.

Parker, J. D., Taylor, G. J., & Bagby, M. (1993). Alexithymia and the recognition of facial expressions of emotion. *Psychotherapy and psychosomatics*, *59*(3-4), 197-202.

Partala, T., Surakka, V., & Vanhala, T. (2006). Real-time estimation of emotional experiences from facial expressions. *Interacting with Computers*,*18*(2), 208-226

Pelphrey, K. A., Morris, J. P., McCarthy, G., & LaBar, K. S. (2007). Perception of dynamic changes in facial affect and identity in autism. *Social cognitive and affective neuroscience*, *2*(2), 140-149.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of autism and developmental disorders*, *32*(4), 249-261.

Perner, J., Leekam, S. R., & Wimmer, H. (1987). Three-year-olds' difficulty with false belief: The case for a conceptual deficit. *British journal of developmental psychology*, *5*(2), 125-137.

Philip, R. C. M., Whalley, H. C., Stanfield, A. C., Sprengelmeyer, R., Santos, I. M., Young, A. W., ... & Hall, J. (2010). Deficits in facial, body movement and vocal emotional processing in autism spectrum disorders. *Psychological medicine*, *40*(11), 1919-1929.

Philippot, P., & Feldman, R. S. (1990). Age and social competence in preschoolers' decoding of facial expression. *British Journal of Social Psychology*, *29*(1), 43-54.

Piggot, J., Kwon, H., Mobbs, D., Blasey, C., Lotspeich, L., Menon, V., Brookheimer, S. & Reiss, A. L. (2004). Emotional attribution in high-functioning individuals with autistic spectrum disorder: a functional imaging study. *Journal of the American Academy of Child & Adolescent Psychiatry*, *43*(4), 473-480.

Pillai, D., Sheppard, E., & Mitchell, P. (2012). Can people guess what happened to others from their reactions?. *PloS one*, *7*(11), e49859.

Pillai, D., Sheppard, E., Ropar, D., Marsh, L., Pearson, A., & Mitchell, P. (2014). Using other minds as a window onto the world: guessing what happened from clues in behaviour. *Journal of autism and developmental disorders*, *44*(10), 2430-2439.

Piven, J., Palmer, P., Jacobi, D., Childress, D., & Arndt, S. (1997a). Broader autism phenotype: evidence from a family history study of multiple-incidence autism families. *American Journal of Psychiatry*, *154*(2), 185-190.

Piven, J., Palmer, P., Landa, R., Santangelo, S., Jacobi, D., & Childress, D. (1997b). Personality and language characteristics in parents from multiple-incidence autism families. *American journal of medical genetics*, *74*(4), 398-411.

Piven, J., Wzorek, M., Landa, R., Lainhart, J., Bolton, P., Chase, G. A., & Folstein, S. (1994). Personality characteristics of the parents of autistic individuals. *Psychological medicine*, *24*(3), 783-795.

Plaisted, K., Saksida, L., Alcántara, J., & Weisblatt, E. (2003). Towards an understanding of the mechanisms of weak central coherence effects: Experiments in visual configural learning and auditory perception. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *358*(1430), 375-386.

Plaisted, K., Swettenham, J., & Rees, L. (1999). Children with autism show local precedence in a divided attention task and global precedence in a selective attention task. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *40*(5), 733-742.

Pollatos, O., & Gramann, K. (2011). Electrophysiological evidence of early processing deficits in Alexithymia. *Biological Psychology*, *87*(1), 113-121.

Pollatos, O., Schubö, A., Herbert, B. M., Matthias, E., & Schandry, R. (2008). Deficits in early emotional reactivity in Alexithymia. *Psychophysiology*, *45*(5), 839-846.

Pons, F., Lawson, J., Harris, P. L., & De Rosnay, M. (2003). Individual differences in children's emotion understanding: Effects of age and language. *Scandinavian journal of psychology*, *44*(4), 347-353.

Porges, S. W. (1995) "Orienting in a Defensive World: Mammalian Modifications of Our Evolutionary Heritage. A Polyvagal Theory". *Psychophysiology* 32 (4), 301–318

Porges, S. W. (2003) "The Polyvagal Theory: Phylogenetic Contributions to Social Behavior". *Physiology & Behavior* 79 (3), 503–513

Porges, S. W. (2007) "The Polyvagal Perspective". *Biological psychology* 74 (2), 116–143

Porges, S. W. (2009) "The Polyvagal Theory: New Insights into Adaptive Reactions of the Autonomic Nervous System". *Cleveland Clinic journal of medicine, 76* (Suppl 2), S86–S90

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind?. *Behavioral and brain sciences*, *1*(4), 515-526.

Press, C., Richardson, D., & Bird, G. (2010). Intact imitation of emotional facial actions in autism spectrum conditions. *Neuropsychologia*, *48*(11), 3291-3297.

Preston, S. D., & De Waal, F. B. (2002). Empathy: Its ultimate and proximate bases. *Behavioral and brain sciences*, *25*(1), 1-20.

Pring, L., & Hermelin, B. (2002). Numbers and letters: exploring an autistic savant's unpractised ability. *Neurocase*, *8*(4), 330-337.

Prior, M., & Hoffmann, W. (1990). Brief report: Neuropsychological testing of autistic children through an exploration with frontal lobe tests. *Journal of Autism and Developmental Disorders, 20*(4), 581-590.

Prkachin, G. C., Casey, C., & Prkachin, K. M. (2009). Alexithymia and perception of facial expressions of emotion. *Personality and Individual Differences*, *46*(4), 412-417.

Pujol, J., Harrison, B., Ortiz, H., Deus, J., Soriano-Mas, C., Lopez-Sola, M., Yücel, M., Perich, X., & Cardoner, N. (2009) "Influence of the Fusiform Gyrus on Amygdala Response to Emotional Faces in the Non-Clinical Range of Social Anxiety". *Psychological medicine* 39 (07), 1177–1187

Reid, V. M., Dunn, K., Young, R. J., Amu, J., Donovan, T., & Reissland, N. (2017). The human fetus preferentially engages with face-like visual stimuli. *Current Biology*, *27*(12), 1825-1828.

Renty, J. O., & Roeyers, H. (2006). Quality of life in high-functioning adults with autism spectrum disorder: The predictive value of disability and support characteristics. *Autism*, *10*(5), 511-524.

Riby, D. M., & Hancock, P. J. (2008). Viewing it differently: Social scene perception in Williams syndrome and autism. *Neuropsychologia*, *46*(11), 2855-2860.

Rinehart, N. J., Bradshaw, J. L., Moss, S. A., Brereton, A. V., & Tonge, B. J. (2000). Atypical interference of local detail on global processing in high-functioning autism and Asperger's disorder. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *41*(6), 769-778.

Ristic, J., Mottron, L., Friesen, C. K., Iarocci, G., Burack, J. A., & Kingstone, A. (2005). Eyes are special but not for everyone: The case of autism. *Cognitive Brain Research*, *24*(3), 715-718.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annu. Rev. Neurosci.*, *27*, 169-192.

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive brain research*, *3*(2), 131-141.

Roedema, T. M., & Simons, R. F. (1999). Emotion-processing deficit in Alexithymia. *Psychophysiology*, *36*(3), 379-387.

Roeyers, H., Buysse, A., Ponnet, K., & Pichal, B. (2001). Advancing advanced mind-reading tests: Empathic accuracy in adults with a pervasive developmental disorder. *Journal of Child Psychology and Psychiatry, 42*(02), 271-278.

Rosset, D. B., Rondan, C., Da Fonseca, D., Santos, A., Assouline, B., & Deruelle, C. (2008). Typical emotion processing for cartoon but not for real faces in children with autistic spectrum disorders. *Journal of autism and developmental disorders*, *38*(5), 919-925.

Rottenberg, J., & Vaughan, C. (2008). Emotion expression in depression: Emerging evidence for emotion context-sensitivity. In A. Vingerhoets & I. Nyklicek (Eds.), *Emotion regulation: Conceptual and clinical issues* (pp. 125–139). New York: Springer Science and Business Media.

Rump, K. M., Giovannelli, J. L., Minshew, N. J., & Strauss, M. S. (2009). The development of emotion recognition in individuals with autism. *Child development*, *80*(5), 1434-1447

Russell, J. A. (1994). Is there universal recognition of emotion from facial expression? A review of the cross-cultural studies. *Psychological bulletin*, *115*(1), 102.

Russell, J. A., & Barrett, L. F. (1999). Core affect, prototypical emotional episodes, and other things called emotion: dissecting the elephant. *Journal of personality and social psychology*, *76*(5), 805.

Russell, J. A., Bachorowski, J. A., & Fernández-Dols, J. M. (2003). Facial and vocal expressions of emotion. *Annual review of psychology*, *54*(1), 329-349.

Rutherford, M. & Towns, A. M. (2008) "Scan Path Differences and Similarities during Emotion Perception in Those with and without Autism Spectrum Disorders". *Journal of autism and developmental disorders* 38 (7), 1371–1381

Sasson, N. J., Turner-Brown, L. M., Holtzclaw, T. N., Lam, K. S., & Bodfish, J. W. (2008). Children with autism demonstrate circumscribed attention during passive viewing of complex social and nonsocial picture arrays. *Autism Research*, *1*(1), 31-42.

Saxe, R., & Kanwisher, N. (2003). People thinking about thinking people: the role of the temporo-parietal junction in "theory of mind". *Neuroimage*, *19*(4), 1835-1842.

Scassellati, B., Admoni, H., & Matarić, M. (2012). Robots for use in autism research. *Annual review of biomedical engineering*, *14*, 275-294.

Schachter, S., & Singer, J. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological review*, *69*(5), 379.

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2008). Episodic simulation of future events. *Annals of the New York Academy of Sciences*, *1124*(1), 39-60.

Scherer, K. R. (2009). The dynamic architecture of emotion: Evidence for the component process model. *Cognition and emotion*, *23*(7), 1307-1351.

Scherer, K. R., Banse, R., & Wallbott, H. G. (2001). Emotion inferences from vocal expression correlate across languages and cultures. *Journal of Cross-cultural psychology*, *32*(1), 76-92.

Schmidt, K. L., Ambadar, Z., Cohn, J. F., & Reed, L. I. (2006) 'Movement differences between deliberate and spontaneous facial expressions: Zygomaticus Major Action in smiling'. *Journal of Nonverbal Behavior*30 (1), 37–52

Schmidt, K. L., Cohn, J. F., & Tian, Y. (2003) 'Signal characteristics of spontaneous facial expressions: Automatic movement in solitary and social smiles'. *Biological Psychology* 65 (1), 49–66

Schneider, F., Gur, R. C., Koch, K., Backes, V., Amunts, K., Shah, N. J., Bilker, W., Gur., R. E & Habel, U. (2006). Impairment in the specificity of emotion processing in schizophrenia. *American Journal of Psychiatry*, *163*(3), 442-447.

Schultz, R. T. (2005). Developmental deficits in social perception in autism: the role of the amygdala and fusiform face area. *International Journal of Developmental Neuroscience*, *23*(2), 125-141.

Schumann, C. M., Barnes, C. C., Lord, C., & Courchesne, E. (2009). Amygdala enlargement in toddlers with autism related to severity of social and communication impairments. *Biological psychiatry*, *66*(10), 942-949.

Schwarzer, G., Huber, S., & Dümmler, T. (2005). Gaze behavior in analytical and holistic face processing. *Memory & Cognition*, *33*(2), 344-354.

Scott, F. J., Baron-Cohen, S., Bolton, P., & Brayne, C. (2002). Brief report prevalence of autism spectrum conditions in children aged 5-11 years in Cambridgeshire, UK. *Autism*, *6*(3), 231-237.

Searle, J. R. (1983). *Intentionality: An essay in the philosophy of mind*. Cambridge university press.

Senju, A., Csibra, G., & Johnson, M. H. (2008). Understanding the referential nature of looking: Infants' preference for object-directed gaze. *Cognition*, *108*(2), 303-319.

Shanton, K., & Goldman, A. (2010). Simulation theory. *Wiley Interdisciplinary Reviews: Cognitive Science*, *1*(4), 527-538.

Shariff, A. F., & Tracy, J. L. (2011). What are emotion expressions for?. *Current Directions in Psychological Science*, *20*(6), 395-399.

Shatz, M., Wellman, H. M., & Silber, S. (1983). The acquisition of mental verbs: A systematic investigation of the first reference to mental state. *Cognition*, *14*(3), 301-321.

Shioiri, T., Someya, T., Helmeste, D., & Wa Tang, S. (1999). Cultural difference in recognition of facial emotional expression: contrast between Japanese and American raters. *Psychiatry and clinical neurosciences*, *53*(6), 629-633.

Sifneos, P. E. (1996). Alexithymia: past and present. *The American journal of psychiatry*, *153*(7), 137.

Sigman, M. D., Kasari, C., Kwon, J. H., & Yirmiya, N. (1992). Responses to the negative emotions of others by autistic, mentally retarded, and normal children. *Child development*, 796-807.

Simonoff, E., Pickles, A., Charman, T., Chandler, S., Loucas, T., & Baird, G. (2008). Psychiatric disorders in children with autism spectrum disorders: prevalence, comorbidity, and associated factors in a population-derived sample. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*(8), 921-929.

Singer, T., Seymour, B., O'doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science*, *303*(5661), 1157-1162.

Smith, M. J. L., Montagne, B., Perrett, D. I., Gill, M., & Gallagher, L. (2010). Detecting subtle facial emotion recognition deficits in high-functioning autism using dynamic stimuli of varying intensities. *Neuropsychologia*, *48*(9), 2777-2781.

Speer, L. L., Cook, A. E., McMahon, W. M., & Clark, E. (2007). Face processing in children with autism effects of stimulus contents and type. *Autism*, *11*(3), 265-277.

Spengler, S., Bird, G., & Brass, M. (2010). Hyperimitation of actions is related to reduced understanding of others' minds in autism spectrum conditions. *Biological psychiatry*, *68*(12), 1148-1155.

Spezio, M. L., Adolphs, R., Hurley, R. S., & Piven, J. (2007). Abnormal use of facial information in high-functioning autism. *Journal of autism and developmental disorders*, *37*(5), 929-939.

Stel, M., van den Heuvel, C., & Smeets, R. C. (2008). Facial feedback mechanisms in autistic spectrum disorders. *Journal of autism and developmental disorders*, *38*(7), 1250-1258.

Stewart, M. E., Barnard, L., Pearson, J., Hasan, R., & O'Brien, G. (2006). Presentation of depression in autism and Asperger syndrome: A review. *Autism*, *10*(1), 103-116.

Susskind, J. M., Lee, D. H., Cusi, A., Feiman, R., Grabski, W., & Anderson, A. K. (2008). Expressing fear enhances sensory acquisition. *Nature neuroscience*, *11*(7), 843.

Szatmari, P., Georgiades, S., Duku, E., Zwaigenbaum, L., Goldberg, J., & Bennett, T. (2008). Alexithymia in parents of children with autism spectrum disorder. *Journal of autism and developmental disorders*, *38*(10), 1859-1865.

Talarico, J. M., LaBar, K. S., & Rubin, D. C. (2004). Emotional intensity predicts autobiographical memory experience. *Memory & cognition*, *32*(7), 1118-1132.

Tanaka, J. W., Kay, J. B., Grinnell, E., Stansfield, B., & Szechter, L. (1998). Face recognition in young children: When the whole is greater than the sum of its parts. *Visual Cognition*, *5*(4), 479-496.

Tantam, D., Monaghan, L., Nicholson, H., & Stirling, J. (1989). Autistic children's ability to interpret faces: A research note. *Journal of Child Psychology and Psychiatry*, *30*(4), 623-630.

Tardif, C., Lainé, F., Rodriguez, M., & Gepner, B. (2007). Slowing down presentation of facial movements and vocal sounds enhances facial expression recognition and induces facial–vocal imitation in children with autism. *Journal of Autism and Developmental Disorders, 37*(8), 1469-1484.

Teunisse, J. P., & de Gelder, B. (2001). Impaired categorical perception of facial expressions in high-functioning adolescents with autism. *Child Neuropsychology*, *7*(1), 1-14.

Thayer, J. F., & Johnson, B. H. (2000) Sex differences in judgement of facial affect: a multivariate analysis of recognition errors. *Scandinavian Journal of Psychology* 41, 243–246.

Thomas, M. S., Annaz, D., Ansari, D., Scerif, G., Jarrold, C., & Karmiloff-Smith, A. (2009). Using developmental trajectories to understand developmental disorders. *Journal of speech, language, and hearing research*,*52*(2), 336-358.

Thompson, R. F., & Spencer, W. A. (1966). Habituation: a model phenomenon for the study of neuronal substrates of behavior. *Psychological review*, *73*(1), 16.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., & Nelson, C. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry research, 168*(3), 242-249.

Tracy, J. L., Robins, R. W., & Schriber, R. A. (2009). Development of a FACS-verified set of basic and self-conscious emotion expressions. *Emotion*, *9*(4), 554.

Tracy, J. L., Robins, R. W., Schriber, R. A., & Solomon, M. (2011). Is emotion recognition impaired in individuals with autism spectrum disorders?. *Journal of autism and developmental disorders*, *41*(1), 102-109.

Treffert, D. A. (2009). The savant syndrome: an extraordinary condition. A synopsis: past, present, future. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *364*(1522), 1351-1357.

Tybur, J. M., Lieberman, D., & Griskevicius, V. (2009). Microbes, mating, and morality: individual differences in three functional domains of disgust. *Journal of personality and social psychology*, *97*(1), 103.

Uljarevic, M., & Hamilton, A. (2013). Recognition of emotions in autism: a formal meta-analysis. *Journal of autism and developmental disorders*, *43*(7), 1517-1526.

Valstar, M. F., Pantic, M., Ambadar, Z., & Cohn, J. F. (2006). Spontaneous vs. posed facial behavior: automatic analysis of brow actions. In *Proceedings of the 8th international conference on Multimodal interfaces*(pp. 162-170). ACM.

Valstar, M., & Pantic, M. (2010). Induced disgust, happiness and surprise: an addition to the mmi facial expression database. In *Proc. 3rd Intern. Workshop on EMOTION (satellite of LREC): Corpora for Research on Emotion and Affect* (p. 65).

Van Der Geest, J. N., Kemner, C., Verbaten, M. N., & Van Engeland, H. (2002). Gaze behavior of children with pervasive developmental disorder toward human faces: a fixation time study. *Journal of Child Psychology and Psychiatry*, *43*(5), 669-678.

Van Hecke, A., Lebow, J., Bal, E., Lamb, D., Harden, E., Kramer, A., Denver, J., Bazhenova, O., & Porges, S. W. (2009) “Electroencephalogram and Heart Rate Regulation to Familiar and Unfamiliar People in Children with Autism Spectrum Disorders”. *Child development* 80 (4), 1118–1133

Vellante, M., Baron-Cohen, S., Melis, M., Marrone, M., Petretto, D. R., Masala, C., & Preti, A. (2013). The “Reading the Mind in the Eyes” test: systematic review of psychometric properties and a validation study in Italy. *Cognitive neuropsychiatry*, *18*(4), 326-354.

Volker, M. A., Lopata, C., Smith, D. A., and Thomeer, M. L. (2009) 'Facial Encoding of children with high-functioning autism spectrum disorders'. *Focus on Autism and Other Developmental Disabilities* 24 (4), 195–204

Vuilleumier, P. (2005). How brains beware: neural mechanisms of emotional attention. *Trends in cognitive sciences*, *9*(12), 585-594.

Wagner, H. L. (1990) 'The spontaneous facial expression of differential positive and negative emotions'. *Motivation and Emotion* 14 (1), 27–43

Wagner, H. L., Lewis, H., Ramsay, S., & Krediet, I. (1992). Prediction of facial displays from knowledge of norms of emotional expressiveness. *Motivation and Emotion*, *16*(4), 347-362.

Wagner, H. L., MacDonald, C. J., & Manstead, A. S. (1986). Communication of individual emotions by spontaneous facial expressions. *Journal of Personality and Social Psychology*, *50*(4), 737.

Wagner, J. B., Hirsch, S. B., Vogel-Farley, V. K., Redcay, E., & Nelson, C. A. (2013). Eye-tracking, autonomic, and electrophysiological correlates of emotional face processing in adolescents with autism spectrum disorder. *Journal of autism and developmental disorders*, *43*(1), 188-199.

Wallace, S., Coleman, M., & Bailey, A. (2008). An investigation of basic facial expression recognition in autism spectrum disorders. *Cognition and Emotion*, *22*(7), 1353-1380.

Watson, D., & Clark, L. A. (1984). Negative affectivity: the disposition to experience aversive emotional states. *Psychological bulletin*, *96*(3), 465.

Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological bulletin*, *98*(2), 219.

Wellman, H. M., & Banerjee, M. (1991). Mind and emotion: Children's understanding of the emotional consequences of beliefs and desires. *British Journal of Developmental Psychology*, *9*(2), 191-214.

Wheelwright, S., Auyeung, B., Allison, C., & Baron-Cohen, S. (2010). Defining the broader, medium and narrow autism phenotype among parents using the Autism Spectrum Quotient (AQ). *Molecular autism*, *1*(1), 10.

White, S. W., & Roberson-Nay, R. (2009). Anxiety, social deficits, and loneliness in youth with autism spectrum disorders. *Journal of autism and developmental disorders*, *39*(7), 1006-1013.

Whitehouse, A. J., Maybery, M. T., Hickey, M., & Sloboda, D. M. (2011). Brief report: Autistic-like traits in childhood predict later age at menarche in girls. *Journal of autism and developmental disorders*, *41*(8), 1125-1130.

Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in My insula: the common neural basis of seeing and feeling disgust. *Neuron*, *40*(3), 655-664.

Williams, L. M., Senior, C., David, A. S., Loughland, C. M., & Gordon, E. (2001). In search of the" Duchenne Smile": Evidence from eye movements. *Journal of Psychophysiology*, *15*(2), 122.

Wilson, C. E., Freeman, P., Brock, J., Burton, A. M., & Palermo, R. (2010). Facial identity recognition in the broader autism phenotype. *PLoS One*, *5*(9), e12876.

Wing, L. (1981). Language, social, and cognitive impairments in autism and severe mental retardation. *Journal of autism and developmental disorders*, *11*(1), 31-44.

Wing, L., & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: Epidemiology and classification. *Journal of autism and developmental disorders*, *9*(1), 11-29.

Witkin, H. A., Oltman, P. K., Raskin, E., & Karp, S. A. (1971). *Manual for embedded figures test, children's embedded figures test, and group embedded figures test.* Palo Alto, Calif.: Consulting Psychologists Press, Inc.

Woodworth, R.S., & Sherrington, C.S. (1904). A pseudaffective reflex and its spinal path. *Journal of Physiology*, *31*(3–4), 234–43. In Barrett, L. F. (2017). The theory of constructed emotion: an active inference account of interoception and categorization. *Social cognitive and affective neuroscience*, *12*(1), 1-23.

Yi, L., Fan, Y., Quinn, P. C., Feng, C., Huang, D., Li, J., ... & Lee, K. (2013). Abnormality in face scanning by children with autism spectrum disorder is limited to the eye region: Evidence from multi-method analyses of eye tracking data. *Journal of vision*, *13*(10), 5-5.

Yuill, N., & Lyon, J. (2007). Selective difficulty in recognising facial expressions of emotion in boys with ADHD. *European child & adolescent psychiatry*, *16*(6), 398-404.

Zuckerman, M., Koestner, R., Colella, M. J., & Alton, A. O. (1984). Anchoring in the detection of deception and leakage. *Journal of Personality and Social Psychology*, *47*(2), 301.

Zwaigenbaum, L. (2012). What's in a name: changing the terminology of autism diagnosis. *Developmental Medicine & Child Neurology*, *54*(10), 871-872.

Appendix A: Stimuli development certificate of ethical approval

Certificate of Ethical Approval

Applicant:

David Walker

Project Title:

Developing spontaneous and posed emotional expressions through an interview based interaction.

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

27 May 2015

Project Reference Number:

P32659

Appendix B: Prompt script

Prompt 1 positive feedback:
First the block design subtask of the WASI-II was introduced to the participant, explained and completed. Upon completion the participant was given positive feedback.
"*Wow that was really fast, faster than average well done"*
On occasions where participants found the task particularly difficult the feedback was tailored to ensure the praise was still acceptable and not beyond belief as presenting feedback unbelievable in content can be refuted. In such cases the individuals' performance was acknowledged.
"*Once you completed the nth trial your performance became much faster and you were faster than average well done*"
Prompt 2 Monopoly money:
Once the participant had responded to the positive feedback on the block design task they were rewarded with monopoly money for performing well.
"*Based on your performance, I have a reward for you *hand over monopoly money*"*
Prompt 3 Maths question:
After the participants' response to the monopoly money had ceased, the participant was informed they would now be asked a series of five maths questions and that they may find some more difficult than others depending on their ability.
"What is 5 multiplied by 3?
"What is 15 multiplied by 2?"
"What is 20 minus 7?"
"What is 12 plus 8?"
"What is 616 divided by 7?"
Prompt 4: Negative feedback:
"*Based on your performance I would expect you to perform a little faster on the maths questions it wasn't so quick*"
The exact feedback given at this point was also subject to minor alterations to ensure participants accepted the feedback rather than outright refuting it.
"*Whilst your performance on the first four was fast, compared to others and your previous performance on the block design I would expect you to perform faster on the last question*"
Prompt 5: Not recording:
At this point the participant was informed the experiment was completed and the audio recorder was to be turned off. The researcher then stated the audio recorder had failed to record the experiment.

"*Okay that's this section completed I'll just turn off the audio recorder *researcher checks audio recorder* ohh no, it's stopped recording, only eight seconds have been recorded*"
Prompt 6: Repeat experiment:
The researcher then asked the participant if they would be willing to repeat the entire experiment.
"*Umm, would it be okay if we did it again? It would mean you would have to complete the questionnaires again too, in case you had a question at any point*"
Prompt 7: No repeat:
Lastly the participant was informed there was no need to repeat the experiment:
"*No it's okay it's fine we don't have to do it again.*"

Appendix C: Emotion report sheet

Below are some scenarios, could you please explain how you felt during each scenario. You may use the list of examples provided at the bottom or choose an alternate response if you so wish.

1. How did you feel when you were told your performance on the block design task was above average?
   ____

2. How did you feel when you performance was rewarded with monopoly money?
   ____

3. How did you feel when you were asked the last maths question? (what is 616/7)
   ____

4. How did you feel when you were told your performance on the maths questions was below what was expected of you?
   ____

5. How did you feel when the researcher told you the Dictaphone had not been recording?
   ____

6. How did you feel when the researcher asked you to start the experiment from the beginning again?
   ____

7. How did you feel when the researcher explained the recording had worked and there was no need to repeat the experiment?
   ____

Afraid	Angry
Bored	Bothered
Disbelieving	Disgusted
Excited	Fond
Happy	Hurt
Interested	Kind
Liked	Romantic
Sad	Sneaky
Sorry	Sure
Surprised	Thinking
Touched	Unfriendly
Unsure	Wanting

Appendix D: Renewed consent and debrief information

Consent for use of stimuli

By signing this form I acknowledge the true purpose of the research has been explained to me, the stimuli gathered has been explained to me by the researcher and I understand the intended purpose of the stimuli gathered. I agree to have the stimuli used as described below.

This will involve:

- Editing (as described by the researcher)

- Use as stimuli displaying spontaneous natural emotional reactions in future research.

- Tick this box to give consent for your stimuli to be used in future research as explained ☐

  - **Below are some extra consent options concerning the stimuli in publication and research sharing purposes please tick to indicate consent:**
  - Have the stimuli appended in image format to published research papers ☐
  - Have the stimuli appended in video format to published research or conference talks ☐
  - Adding the stimuli to a database of emotions to be shared with other researchers explicitly for research purposes ☐

Participants signature:______________________ Date:____/____/_____
Print name:_______________________________

Researchers Signature:_____________________

Debrief sheet

First of all I would like to thank you for your participation in my research. The true aim of the study was to develop high quality naturalistic spontaneous expressions of emotion to be used in future research. It was necessary to deceive you as to the true nature of the research to obtain high quality naturalistic expressions, something that is lacking in the autism literature. Unfortunately if you were aware of being recorded throughout the entire interaction and were aware the purpose was to specifically capture naturalistic emotion expressions the intensity and validity of those expressions would be compromised. Previous research has shown inconsistencies in the ability within autistic populations to accurately recognise expressions of emotion (Kennedy & Adolphs 2012), however this finding is inconsistent in the literature (Tracy et al. 2011). The inconsistency is believed to be attributable to differing stimuli and autism sub-types in addition to differing methodologies (Harms, Martin & Wallace 2010). As the research within autism progresses it is becoming clear that individuals with autism often feel isolated and this can lead to thoughts of suicide and in some cases attempts (Cassidy et al. 2014). Therefore there is a need for research within the field to progress and improve measures to accurately assess the difficulties faced by individuals with autism. One such progression is the need for a stimuli set that has naturally expressed emotions more indicative of the nuanced interaction that individuals with autism are likely to face in real world social interactions. The present research aimed to achieve this by gathering spontaneous reactions to certain social cues with the displayer unaware they were being recorded for that express purpose. It is hoped the stimuli gathered will allow comparisons of both dynamic stimuli and static in addition to subtle complex emotions and basic emotions across a variety of intensities as would be expected in the real world.

Cassidy, S., Bradley, P., Robinson, J., Allison, C., McHugh, M., & Baron-Cohen, S. (2014). “Suicidal ideation and suicide plans or attempts in adults with Asperger's syndrome attending a specialist diagnostic clinic: a clinical cohort study.”. *The Lancet Psychiatry*, *1*(2), 142-147.
Harms, M. B., Martin, A., & Wallace, G. L. (2010). “Facial emotion recognition in autism spectrum disorders: a review of behavioural and neuroimaging studies”. *Neuropsychology review*, 20(3), 290-322.
Kennedy, D., P., & Adolphs, R. (2012) “Perception of Emotions from Facial Expressions in High-Functioning Adults with Autism”. *Neuropsychologia* 50 (14), 3313–3319
Tracy, J. L., Robins, R. W., Schriber, R. A., & Solomon, M. (2011) “Is Emotion Recognition Impaired in Individuals with Autism Spectrum Disorders?”. *Journal of autism and developmental disorders* 41 (1), 102–109

For more information about autism you can visit these organisations:

http://www.autism.org.uk/

http://www.nhs.uk/conditions/autistic-spectrum-disorder/Pages/Introduction.aspx

http://www.autismresearchcentre.com/

If you have any further questions please do not hesitate to contact the researcher.
Contact details:
Researcher: David Walker - Walker29@uni.coventry.ac.uk
Supervisor: Dr Sarah Cassidy - ab6948@coventry.ac.uk

Appendix E: SPREE request form

The full Spontaneous and Posed Reactive Expressions of Emotion (SPREE) stimuli set consisting of 133 posed expressions and 133 spontaneous expressions in full colour video format with an additional 133 posed and 133 spontaneous full colour images of the isolated most expressive frame are freely available for use in future research. It is required you agree with the terms of use outlined below:

The images must not be altered without the permission of the owner and the exact manner of alterations must be agreed.

E-mailing the below address with request to access the stimuli set will indicate your agreement to the terms.

Davidjwalker24@gmail.com

At which point the link to the stimuli set will be e-mailed to you.

The author would be grateful to know of any findings generated through the use of the stimuli set.

Appendix F: Stimuli validation certificate of ethical approval

Certificate of Ethical Approval

Applicant:

David Walker

Project Title:

Validation of a spontaneous expressions of emotion stimuli set.

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

24 August 2015

Project Reference Number:

P35865

Appendix G: CYR (Chapter 5) Submission and ethical confirmation

CENTRE FOR RESEARCH IN PSYCHOLOGY, BEHAVIOUR & ACHIEVEMENT

Coventry Young Researchers 2016
Event: 1st – 5th August 2016
Experiment Abstract Submission
Deadline: 08/01/2016 5pm
Email completed form to

Experiments can be for children (under 6 years, or aged 6-12 years) and/or adults. Please bear in mind that experimental tasks should be fun and engaging and cannot take more than 20 minutes. A limited number of background measures will be administered in a separate experimental session to be shared between experimenters. There will also be a separate call for pilot studies and dissemination activities (e.g., posters, projections, videos) later in the year.

Experimenters are expected to be present for the whole of the event and to contribute to the wider organization and delivery of the event in some way.

Experimenter(s)

David Walker - Second year PhD student.

Scientific Title

Can Children Deduce Social Scenarios Based on Emotional Responses: A Retrodictive Mindreading Eye Tracking study.

Scientific Abstract (max 250 words)

The ability to infer which social situation is likely to have resulted in a specific emotional response is a key facet of effective social communication. This ability, termed retrodictive mindreading, is an emerging avenue of research in social cognition. There is evidence to suggest difficulties in this ability are present in individuals on the autism spectrum, where the increased difficulty of the task more accurately replicates true social interaction and requires semantic understanding of the stimuli presented. Currently there is little research investigating this ability in children and the combination of this method with eye-tracking is still novel in the literature. The current research aims to employ a new stimulus of broader expressions whilst monitoring the visual scan paths and fixations of participants. Assessing participants verbal and performance IQ along with autistic traits and Alexithymia, will allow analysis into the influence these conditions have on the overall success of retrodictive mindreading ability. Further any variations in visual field attention or scan path differences that may be associated with said ability are to be analysed. Participants will view videos (length 1s-10s) of 7 prompt categories (examples include being asked a maths question, being given positive feedback, being given negative feedback) each posed and spontaneous, resulting in 56 expressions in total. Participants will have to infer based on the video what prompt they believed caused the reaction in the video. In addition participants will answer various questions relating to perceived intensity and what emotion they believe is present. These will be administered on the Tobii (1750) eye tracker. The AQ (child) and TAS-20 scales are due to be completed by the parent and WASI-II separately.

Background measures

Autism Spectrum Quotient (child) - Auyeung, B., Baron-Cohen, S., Wheelwright, S., & Allison, C. (2008). The autism spectrum quotient: Children's version (AQ-Child). *Journal of autism and developmental disorders*, *38*(7), 1230-1240.
This takes approximately 10-15 minutes to complete and consists of 50 questions to be completed by the parent. IT measures autistic traits in children from age 4 onwards but does not indicate a diagnosis. The

The 20 item Toronto Alexithymia scale - Parker, J. D., Taylor, G. J., & Bagby, R. M. (2003). The 20-Item Toronto Alexithymia Scale: III. Reliability and factorial validity in a community population. *Journal of psychosomatic research*, *55*(3), 269-275.
This takes approximately 5 minutes to complete, Alexithymia is a condition whereby inviduals have difficulty experiencing and understanding emotions. It consists of questions such as "I am often confused about which emotion I am feeling" and "I am often puzzled by sensations in my body" This scale is to be completed by the parents.
Wechsler abbreviated scales of intelligence – II - Wechsler, D. (1999). WASI manual. San Antonio: Psychological Corporation
This takes approximately 30 minutes and provides a reliable estimate of general cognitive ability across four tasks: vocabulary, block design, similarity and matrix reasoning. This task is to be completed by the child.

Lay title (max 6 words)

Mind Reading – Can you guess what happened to someone from their reaction?

Lay abstract (max 100 words)

How good are you at mind reading? We need to work out how people feel and make sense of their behavior every day. However, we do not know how this fascinating ability develops in childhood. This research is exploring children's ability to guess what caused another person's reaction. For example did they just hear a nice comment, or did they just get some toy money?! While watching the videos the researchers will measure where you look at on the screen using a special computer, called an eye tracker. This will allow us to understand how children view and understand different types of realistic social situations.

Lay debrief (max 100 words)

We are interested in how children learn to infer emotions in everyday social situations, and what affects this ability for example, where you look in the video, whether the video was posed deliberately for the camera or more natural, and how intense you thought the reaction in the video was. We are also interested in how children's general social, communicative and emotional behavior influences these abilities. Through this research we hope to find out how ability to interpret others emotions in realistic social situations develops in children.

I want to work with participants individually /

(delete as appropriate)

Facilities needed

Table, power supply, isolated space without distractions, silence

Number of participants desired and age range:

	Children < 6 years	Children aged 6-12 years	Adults
Minimum number:		30	
Maximum number:		100	

Do you have enhanced disclosure from the DBS? No

**If yes, please provide certificate number:*
and date of check:

Idea for a non-experimental activity

In addition to the experimental tasks we have individual and group activities related to behavioural and brain science. Please suggest a fun activity that would link to your experimental task.

Show videos about inattentional blindness, explaining that when attention is focused in one area we lose information that would seemingly appear to be much more obvious than originally thought.
Example video: https://www.youtube.com/watch?v=vJG698U2Mvo
This could be expanded on by splitting the kids into two groups one group watching the players dressed in white and one watching those dressed in black to see if this affects the blindness.

Finally this could be followed by a second video: https://www.youtube.com/watch?v=IGQmdoK_ZfY
Where the children repeat the task, expected to spot the gorilla but will more than likely miss other factors in the video again.

Hi all,

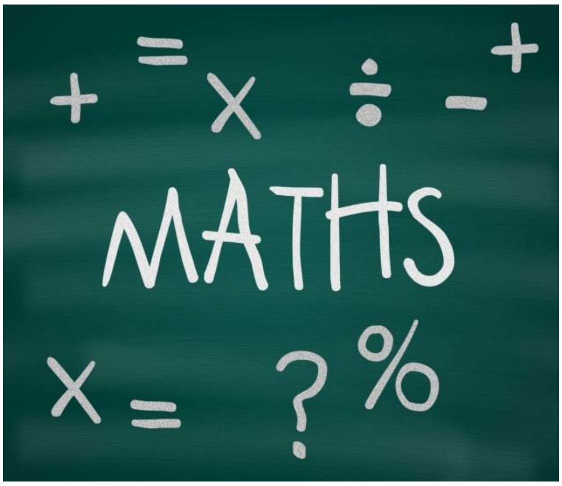
Things are coming along nicely with planning for CYR2016 – ethics has been approved, the first CYR newsletter has been sent out, we've bought lots of fun things and prizes.

I'd like to get together and update everyone on where things are with the planning and calls for help where needed. Please sign up to the attached doodle poll and we'll settle on the date/time when most people can attend
http://doodle.com/poll/t4d6vp2bgzi2kuhw

Also let me know if there's anything specific you would like to discuss at this meeting.

Thanks,

Appendix H: Example Retrodictive mindreading options shown after videos



Appendix I: Example emotion guidance sheet

Thinking

Surprised

Sad

Happy

Appendix J: ASC and retrodiction certificate of ethical approval

Coventry University

Certificate of Ethical Approval

Applicant:

David Walker

Project Title:

Can Adults with Autistic Spectrum Conditions Retrodict Events from Reactions?

This is to certify that the above named applicant has completed the Coventry University Ethical Approval process and their project has been confirmed and approved as Medium Risk

Date of approval:

11 January 2017

Project Reference Number:

P48943

Appendix K: Correlation plot of assessment measures and task performance