Touch and Play? Investigating The Value of Touchscreens for Gamer Experience

Halloran, J & Minaeva, A

Original citation & hyperlink:
Halloran, J & Minaeva, A 2019, 'Touch and Play? Investigating The Value of Touchscreens for Gamer Experience', Entertainment Computing, vol. 32, 100312. https://dx.doi.org/10.1016/j.entcom.2019.100312

DOI 10.1016/j.entcom.2019.100312
ISSN 1875-9521
ESSN 1875-953X

Publisher: Elsevier

Touch and Play? Investigating The Value of Touchscreens for Gamer Experience

John Halloran and Anna Minaeva
School of Computing, Engineering and Mathematics
Coventry University
Priory Street, Coventry, BN1 5FB
+44 (0)24 7688 7688
{john.halloran}(corresponding author){minaevaa}@coventry.ac.uk

ABSTRACT

Touchscreens - mobile phones, tablets, phablets, laptops - are now omnipresent. They are increasingly used as a gaming platform: puzzle games, role play games and first-person shooters are just some of the genres to have appeared on this platform. Despite this, there is only limited research on the particular value of touchscreens for gamer experience. This paper discusses a raft of experiments designed to explore this issue. We compared games played on touchscreen, with the same games played on two other platforms: console and PC. We measured three dependent variables related to gamer experience: ease of controls, ease of task completion, and satisfaction. We found that the value of touchscreens for gamer experience depends on the interaction of three factors: characteristics of players (their gaming background and preferences); types of games (their genre and design); and platform (their controls and affordances). We discuss how these interactions can be further understood and explored, and lay out a set of sensitivities and hazards to inform the future design of touchscreen games.

Keywords: Games; Touchscreens; Gamer experience; Experiment

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Touch and Play? Investigating The Value of Touchscreens for Gamer Experience

XXX
XXX
XXX
XXX
XXX
XXX

ABSTRACT

Touchscreens - mobile phones, tablets, phablets, laptops - are now omnipresent. They are increasingly used as a gaming platform: puzzle games, role play games and first-person shooters are just some of the genres to have appeared on this platform. Despite this, there is only limited research on the particular value of touchscreens for gamer experience. This paper discusses a raft of experiments designed to explore this issue. We compared games played on touchscreen, with the same games played on two other platforms: console and PC. We measured three dependent variables related to gamer experience: ease of controls, ease of task completion, and satisfaction. We found that the value of touchscreens for gamer experience depends on the interaction of three factors: characteristics of players (their level, gaming background and preferences); types of games (their genre and design); and platform (their controls and affordances). We discuss how these interactions can be further understood and explored, and lay out a set of sensitivities and hazards to inform the future design of touchscreen games.

1. INTRODUCTION

This paper asks how we can find out the value of a particular platform – in this case, touchscreens – for gamer experience, in such a way as to inform innovation in the design of touchscreen computer games. Touchscreens are now ubiquitous, and it has been claimed that the 'swipe and tap' interaction style is highly intuitive and 'natural'. There has been optimism about the potential of touchscreens for games, with claims that this platform could supplant consoles [1], and that touchscreen games can feel like 'magic' [2]. While touchscreens have made an impact for games, PC and consoles of various types are still very popular, and may be preferred by some gamers. At the same time, touchscreens are still the preserve of 'casual' games. To investigate the question of the potential of touchscreens for games, we explore their value for gamer experience by comparing the same games across three platforms, to see how gamer experience might differ, for what reasons, and what are the implications for how far and in what ways games can be successfully designed for touchscreens.

People play games because they offer a rewarding affective experience. The content of games is key for this: games offer experiences of racing in magical vehicles, inhabiting and building a vast world, fighting a war, or guiding a character through a fast-moving environment laden with obstacles, for example. However, content is not the only issue: usability factors are also crucial, particularly the controls that allow engagement with content. We attempt to map affective, content and control issues to each other to help explicate specific issues in touchscreen game design and to elucidate how these may differ

to other platforms. As part of this we propose a simple three-level gamer experience framework informed by existing literature.

The work makes use of an experimental methodology which allows us to measure variables related to the three levels, and compare ratings on these variables for the same game played on different platforms. The within-subjects designs were run with adults all of whom had experience of regular gaming (mainly university students). The experiments were run in the same way, allowing analyses not just of how and why a given game is preferred on one or other platform; but also of how games of different kinds rate specifically on touchscreen.

Our findings show that there is value in considering the affective experience of touchscreen games as emerging out of design issues in terms of content and usability. This relationship plays out in particular ways for touchscreens and is influenced by player background of other platforms, their expectations in terms of content and control, and the game mechanics relating to implementation for the platform. Our research shows how good touchscreen game design transcends comparison with other platforms, and needs to be considered as a design space in its own right with its own unique possibilities. To this end, we offer a set of design hazards and design sensitivities to help inform innovation.

2. BACKGROUND

This review surveys what is currently known about touchscreen games, starting with an overview of gamer acceptance issues, problems concerning controls, and how genre is important for the implementation of games for touchscreen. We move on to gamer experience, looking at how this has been understood and measured. A particular focus is on how far and in what ways conceptual frameworks for explicating gamer experience include consideration of how game design, including platform implementation, is implicated.

A touchscreen is a display that can also serve as an input device, using touch (or a pen / stylus) as input, and does not require external input devices such as mouse or keyboard. Touchscreen devices require the user to interact with the screen directly by using a range of gestures including tap, double-tap, touch and hold, drag, pinch, squeeze, swipe, flick, and shake [3]. They have CPU and graphics characteristics suitable for running games with good framerates.

However, the success of touchscreen interaction specifically for games may depend on how the interaction is implemented. For example, Browne and Anand [4] show that generic touchscreen gestures may differ from the specific set required by the game, and this can make for confusion. A related issue is that games are often 'ported' from consoles, and physical buttons are re-implemented as virtual ones [5]. Gerling *et al* [6] point out control redesign due to porting can alter game mechanics: gamers may prefer other platforms as a result. Lee *et al* [7] compared touch-based gaming with PC, showing that where gamers have prior experience of PC or console games, this may affect their response to touchscreen controls in negative ways. Porting may result in restriction of interaction to a subset of the available gesture set and lead to overdependence on one gesture (tapping). While this is repetitive, completion times may be slowed by the converse: needing to make a range of finger movements, some unfamiliar [8]. A further related problem impacting acceptance of touchscreens is that virtual buttons lack haptic feedback [9]. In response, some writers have suggested adoption of devices including pens to help provide this [10, 11]. In contrast, Dempsey *et al* [12] suggest that in the absence of haptic feedback, measuring force application on touchscreens could improve

tactile experience with them. Finally, quite apart from these issues, hardware may sometimes be perceived as inferior to other platforms, despite being adequate to run games [13].

Thus, touchscreens sometimes face resistance from gamers, who may request that tablets have controller support due to perceived issues with virtual controls [14]. Game developers have responded by providing substitutes including MOGA mobile controllers connected through Bluetooth [15]. However, this 'hybrid' direction begs the question of whether touchscreen controls are necessarily problematic, or whether there could be new design directions.

It has been argued that the success of a touchscreen game may depend on its genre [16]. Games which require precision and manipulation of objects, such as first person shooters (FPS) and platformers, may be less suitable for touch controls, since their arrangement may become overcomplicated, as well as occluding parts of screens [17]. In contrast, other genres are considered to work better, including real time strategy (RTS) games, turn-based role play games (RPG), and puzzle games. Rogers [2] gives examples of successful games which are not ported and use 'native' gestures: in physics-based puzzle games such as *Angry Birds* or *Cut the Rope*, all interactions are accomplished through simple combinations of taps and swipes. These allow game elements to interact directly with accelerometer and touchscreen [17]. *Angry Birds* and *Cut The Rope* are good examples of how games can be designed around the distinctive affordances of touchscreens to successfully resolve the relationship between platform implementation and gamer experience. Indeed, it has been argued that any successful game has to integrate the affordances offered by the platform [18].

One claim that has been made for touchscreens is that they offer 'natural' interaction. People communicate and explore the world through gestures, expressions, and movements. Following from this, it has been argued that gestural interaction with virtual objects and surfaces can provide an experience similar to interaction with the real world [19]; such 'natural user interfaces' can reduce cognitive load on the user [20]. The claim of naturalism of gestural interaction tends to bear on the design of controls, which, as a result, should be more intuitive and require less learning than keyboard / mouse or game controller. However, there may be problems which prevent touchscreens from achieving the kind of seamlessness this implies. Some writers have questioned whether 'natural interaction' is natural [21]: the literature suggests that rather than touchscreens leveraging natural interaction for games, they offer a new form which needs to be learned, with controls which are not as consistent or developed as alternative platforms, where game genres which have been successfully implemented into touchscreens may be limited, and where there needs to be a good deal of attention paid to design [22].

Further, the 'naturalism' of game interaction and the intuitiveness this implies goes beyond controls, to how controls map to events in games, as well as the content of the game itself. Thus the notion of natural interaction as a means of leveraging an intuitive, seamless and pleasurable gamer experience is not straightforward: it may be that such seamlessness comes from learning conventional or canonical forms of games which as a result come to *feel* natural. These issues raise the question of whether and how far touchscreens are capable of offering a compelling, intuitive gamer experience on their own terms across a variety of genres, regardless of claims of intrinsic naturalism, and what the design implications might be. To explore this further, it is necessary to look at what gamer experience is, and how it is affected by platform.

2.1 Explicating gamer experience

Gamer experience - which has also been called 'digital game experience' [23], 'gaming experience' [24], or 'PX' [25] - is related to the more general concept of user experience. The latter has been characterised as the subjective relationship between user and application [26]; how it 'feels to interact' [27]; or the 'emotional experience' of interacting [28]. User experience has gained traction as a complementary approach to usability, which is concerned with the cognitive and ergonomic aspects of interfaces, particularly to improve the effectiveness and efficiency of productivity software.

However, productivity is not the aim of games. Rather, games are an end in themselves: they are *autotelic* [6]. While usability is important insofar as a user needs to be able to make sense of an interface to the extent that they can interact successfully with it, this is only an enabler of gameplay. Thus, gamer experience, rather than being complementary to usability, is central to the analysis and design of games. However, Barnett *et al* [29] argue that this makes usability *more*, not less, important to games. Laitinen [30] also argues that usability is crucial for producing a positive gamer experience. The review above supports this, by drawing attention to implementation issues which impact the experience of playing games.

The ISO definition of usability is: 'The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use' [31]. Here, satisfaction, which has also been seen as a user experience goal (see for example [27]: 23), i.e. an 'emotional experience', is complemented by effectiveness, which refers to whether or not something can be achieved (for example, finding and using a menu item); and efficiency, which means how easily it can be achieved (for example, finding and using the menu item requires only a small number of actions). In contrast, Barnett *et al* [29] argue that, for games, the three concepts should be seen as a hierarchy, with satisfaction at the top. This would mean that positive user experience is something which depends on, and emerges out of, usability factors such as effectiveness and efficiency.

This suggests a need for gamer experience to be linked to game design in terms of usability. To explore this, we survey a series of theories and conceptual frameworks whose aim is to elucidate the kinds of feelings experienced by gamers when they play games, and consider how far and in what way each of these discusses usability issues.

Not originally designed specifically to apply to gamer experience, one of the best-known theories in the area is flow [32], which proposes a state of deep engagement and loss of the sense of time which happens when skill and challenge are balanced. This means that providing challenge matched to gamer level is crucial: too great or too little a challenge relative to skill will not produce flow. Flow theory was designed to elucidate an experience in a general way (more broadly than computing technology) and does not address usability.

Gameflow [33] is a post-flow conceptual framework for games. It describes 8 elements which, if sufficiently present, can give rise to flow. The elements are challenge; concentration (the game provides challenge worth attending to); player skills (which must be supported and extended); control (players should feel a sense of this); clear goals; feedback; immersion (deep but effortless involvement); and social interaction (where applicable). This framework again points to the importance of balancing challenge and skills, while emphasizing that games need to provide feedback and support control. The framework emphasizes player background, game design and control as key for producing

a positive experience and thus seems broadly about what gives rise to satisfaction, but does not focus on usability details, for example specific types of physical or virtual controls.

The Gameflow framework includes immersion, a key gamer experience concept which has received much attention in its own right. Cairns *et al* [34] differentiate immersion from flow. It is seen as a 'graded experience' which can exist at different levels from engagement through engrossment to 'being in the game', where 'nothing else matters'. In contrast, flow is an 'all-or-nothing' sense of being 'in the zone'. Immersion is often transient, whereas flow can be sustained over long periods [35]. Moving away from a focus on flow, this work suggests that gamer experience is one of different levels of immersion, each of which is rewarding in itself. Again, these writers are more concerned to explicate the affective aspects that make a game compelling rather the implementation of the game in terms of usability.

Poels *et al* [36] see flow as one dimension among several. They propose 9 'game experience dimensions', including two types of immersion: imaginative immersion (absorption in the story); and sensory immersion (the presence of the game world). The other dimensions are enjoyment (fun, pleasure); flow (concentration, absorption); suspense (challenge, tension, thrill); competence (pride, accomplishment); negative affect (frustration, disappointment); control (autonomy, power, freedom); and social experience (enjoyment with others). Once more, while an experience that broadly corresponds to 'satisfaction' is implied, usability issues are not discussed.

While these conceptual frameworks differ on the centrality of flow, they all indicate the richness of affective responses important for games, and common factors such as control, involvement, skill, and immersion emerge. All, regardless of their differences, concentrate on identifying and describing gamer experience, with less reference to the usability specifics of game design at the level of implementation to produce such responses. CEGE, or 'core elements of the gaming experience' [24] seems more concerned with this relationship. Focussing on games which use avatars, this framework is organised around two top-level concepts, 'puppetry', and 'video-game'. Puppetry concerns the fact that the gamer is represented as an avatar (a puppet) and simultaneously controls this (as the puppet-master). Puppetry includes several sub-concepts such as goals, actions, point-of-view, previous experience, and controllers. Video-game refers to the design of the game, and this has sub-concepts of game-play, rules, scenario, environment, graphics and sound. Thus, CEGE tends to look at how an avatar is controlled and viewed and is less explicit about the experiential outcome. However, specific usability details are not addressed.

PLAY [37] has material relating to experience, game content, and control, explicitly making use of the term 'usability'. It has seven key concepts: Game Play; Skill Development; Tutorial, Strategy & Challenge; Game Story / Immersion; Coolness; Usability / Game Mechanics; and Controller / Keyboard. Like CEGE, it integrates concepts which are both player-oriented, for example immersion, and technology-oriented, including controller / keyboard. However, as with the other frameworks discussed above, it does not go into specific usability examples at the level of control and interface design.

Playability is an important concept bearing on gamer experience which has been discussed by a range of writers. Järvinen *et al* [38] discuss four components of playability. Functional playability includes the control mechanisms that relate to the game and this has 'a family resemblance to usability in the traditional sense'. Structural playability concerns the sequencing of events both at macro (level / environment transitions) and

micro (smaller scale events like weapons changes or avatar movements). Audiovisual playability focusses on the audiovisual style (cartoon-like or realistic). Social playability is about user cultures and social interactions which help make a game enjoyable. Desurvire *et al* [39] also discuss four component concepts, 'playability heuristics', but theirs are different. Game play is the set of challenges to be overcome to win. Game story concerns the game's narrative development. Game mechanics focusses on the interaction of game objects (including avatars) with their environment. Game usability concerns the design of the interface and input and output devices. Korhonen and Koivisto's [40] playability heuristics are focussed on mobile phones and as well as mobility include, in their 'core playability model', gameplay, and game usability. The latter concern status of characters (a type of feedback), clear goals and support for a range of players. Nacke [41] proposes a playability framework which also integrates usability: this framework maps 'abstract' experience concepts such as 'gameplay quality' and 'social /metagame quality' to 'concrete' or 'practical' implementation issues including technology and machine / system quality. User (sic) experience is seen as a 'theoretical construct' with a 'practical application'. The implication is that a user experience depends on how well it is implemented.

Figure 1 summarises this review of theories, concepts and conceptual frameworks for gamer experience in terms of their coverage. It proposes three levels: gamer experience (Level 1), and two game design levels. The first of these (Level 2) covers game design issues to do with narrative and events such as game play, game story and structural playability. The second (Level 3) concerns how the game is implemented, covering interfaces and input / output devices. The implication of this scheme is that for gamer experience to be positive, game design depends not only on content (Level 2), but also on how successfully the design is realized for platform hardware and affordances (Level 3).

		Framework									
Level	1 Experience	Flow (Csikszentmihalyi, 1990)	Gameflow (Sweetser and Wyeth, 2005)	Immersion (Cairns *et al*, 2014)	Dimensions of Digital Game Experience (Poels *et al*, 2007)	CEGE (Calvillo-Gámez *et al*, 2010)	Components of playability Järvinen *et al* (2002)	Playability Heuristics (Desurvire *et al*, 2004)	Playability Heuristics (Korhonen and Koivisto, 2006)	PLAY (Desurvire *et al*, 2009)	Hierarchical Game Usability (Nacke, 2009)
	2 Design: content										

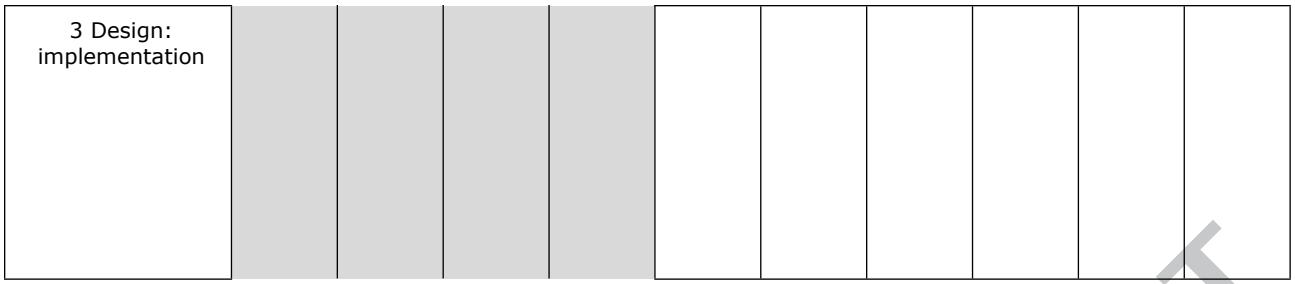

Figure 1: Relationships between affective and design factors in gamer experience theories and frameworks

It can be seen that the majority of the frameworks and theories reviewed are of two distinct types. One set (including flow and immersion) focusses on the feelings experienced when playing games. In contrast, the other (including CEGE and different sets of playability heuristics) tends to concentrate on design issues relating to those feelings. Only the two frameworks to the right clearly span all three levels. However, of those frameworks that do address implementation, none does so in terms of specific design issues for particular platforms. While it was not necessarily the purpose of any of the frameworks reviewed to offer this, our work may help inform it.

There has been much work to validate gamer experience frameworks by operationalizing gamer experience concepts, allowing observation and measurement. Gamer experience frameworks are thus often empirically informed, using a range of research methods and instruments including observation and questionnaires / surveys [42, 43, 44], focus groups, and experiments. IJsselsteijn *et al* [45] developed a game experience questionnaire (GEQ) to measure competence, affect (positive and negative), challenge, immersion, flow and tension / annoyance. Procci *et al*. [46] use a survey called the Dispositional Flow Scale to measure flow experience in games: gamers played specified games regularly and rated 9 categories including challenge/skill balance and sense of control using Likert scales. Calvillo-Gámez *et al* [24] developed a questionnaire to measure CEGE (CEGEQ). Harpsted *et al* [47] and Poels *et al* [23] used focus groups to identify player behaviour patterns and statistically analyzed relationships between users' engagement and reward functions present in the game. Such empirical instruments and approaches have great value for establishing metrics related to how and why game designs are enjoyable.

Experimental methods have allowed researchers to investigate aspects of gamer experience through comparison. CEGEQ [24] can be run on different games the responses to which can be statistically analysed to understand how experiences vary. Engl and Nacke [8] hypothesized that the 'context' of mobile gameplay should impact gamer experience, and experimentally compared the same game played at home or on-the-go, again using a questionnaire (GEQ) to produce data. They identified differences in immersion and affect. Lankes and Bernhaupt [48] compared emotional facial expressions in different virtual settings, revealing that context affects how far expressions are used to assess the emotional quality of a situation. Addressing usability, Barnett *et al* [29] compared usability of games for first time user experience (FTUE) by providing conditions with and without guidance. There was no significant difference, indicating that this game was immediately usable (i.e., instantly learnable). Martel and Muldner [49] investigated 'control schemes', experimentally comparing two types: coupled (where camera view and the direction the viewer moves are the same); and decoupled (the player can look around freely regardless of the direction of their movement). They found that coupled schemes result in better performance, immersion, and player preference scores.

2.2 Summary and Issues

The literature shows that there are a number of issues for touchscreens as a platform for games, to do with prior gamer experience, porting, the behaviour of ported games and the response to them; and the suitedness of touchscreens to different kinds of games. There is a range of work on gamer experience. Some writers concentrate on identifying the range of affective responses gamers experience in order to try to define the reasons gamers play and what they get from games. Other work, in contrast, focusses on game design in terms of the content of the game, also touching on controls. Some frameworks attempt to encompass design and experience, explicating links, and experimental comparison has been carried out to understand more about how usability issues relate to gamer experience. To understand gamer experience for touchscreens further, in such a way as to inform design, implies further research on these links, with a focus on the implementation challenges touchscreen games present and how and why gamer experience on touchscreens differs to that on other platforms. Thus, we offer work which uses an experimental methodology to measure and compare gamer experience of touchscreens across three levels – affect, game design, and game implementation - with two other platforms: console and PC. This approach allows us to pinpoint influences on touchscreen gamer experience which differ from other platforms, and to draw out implications for touchscreen game design in the future.

3. INVESTIGATING THE VALUE OF TOUCHSCREENS FOR GAMES

3.1 Study Design

The aim of our research is to elucidate links between platforms and gamer experience, in such a way as to suggest how the design of games for touchscreens, particularly their implementation, can be improved in order to enhance gamer experience. To investigate this, following an exploratory observational pilot study, we designed an experimental methodology which allowed us to compare gamer experience of the same game across different platforms. The reasons for doing this were to attempt to isolate effects of platforms on gamer experience; to explore whether there is platform 'interference' or loyalty which affects gamer experience; and to assess what it is a platform contributes to – or worsens – in terms of gamer experience.

We ran four experiments in a sequence, each time focussing on a different genre: platformer, puzzle, racer, and FPS. While the experiments were similarly designed and run, they were not identical. For most, (but not all), we were able to compare touchscreen with both console and PC.

The selection criteria for the games chosen were that the game should (1) be available across all three platforms; (2) be a mainstream commercial title; (3) offer familiar interaction design for its genre; and (4) if possible, be a canonical design for one or more of the platforms. The first criterion was the most important, but it was not always possible to meet it (see Section 3.6).

Each experiment involved 14 to 21 participants in a within-subjects design where each participant played the same game on the different platforms (see Table 1), repeating the same playthrough (of a level or mission) in randomised order. We ran a pre-questionnaire to establish player background, including their preferred platforms of those offered by the experiment; and a post-test questionnaire to rate their experience of the gameplay during

the study relative to each platform. The post-questionnaire also asked participants which platform they preferred for the game played.

To do this, we measured three variables: ease of controls, ease of task completion, and satisfaction. Participants were asked to rate their experience on each of these out of 10 using whole numbers. We provided ratings criteria as follows: 0-2 Very bad; 2-4 Bad; 4-6 Fair; 6-8 Good; 8-10 Very good. The three variables were chosen to represent, respectively, the platform, game mechanics, and pleasurability. Thus, we aimed to research the relationship of affective factors in gaming to design issues at both the level of content and implementation. This is the same relationship as proposed in Figure 1 (above). Although the variables are not explicitly associated with any given gamer experience framework, they are informed by them. They are intended to act as a generic reflection which is simple enough for participants to quickly understand and rate, whilst integrating the three in such a way as to help elucidate gamer experience in terms of design. If correlated, this would suggest that satisfaction ratings are linked to platforms through controls and content.

Experiment	Games	Genre	Platforms
1	*Crash Bandicoot*	Platformer	Tablet, Console
2	*Angry Birds Star Wars*	Puzzle	Tablet, Console, PC
3	*Sonic and All-Stars Racing Transformed*	Racer	Tablet, Console, PC
4	*Left 4 Dead 2*	FPS	Console, PC
	Dead Trigger 2	FPS	Tablet

Table 1 Games and platforms used across four experiments

We explained the intended meaning of the variables to gamers to avoid possible differences of interpretation. We told them that (1) Ease of controls means (depending on platform) that keyboard controls, offboard or onboard console controls, or (for touchscreen) virtual controls (including buttons) are easy to use; (2) Ease of task completion means the ability to perform key actions, for example moving an avatar, or changing or firing a weapon; and (3) Satisfaction means feelings of pleasure, achievement, and involvement that come from playing the game.

3.2 Pilot Study: Exploring Issues

Prior to the raft of four experiments, we conducted a short exploratory user study with two games, *Gravity Rush* and *Crash Bandicoot*, the purpose of which was to explore effects of different types of controls on gamer experience. The study was run with five participants, a mixed group of males and females aged 20-25, all students.

Gravity Rush is an action-adventure role play game (RPG). The player controls Kat, an amnesiac with the power to manipulate how gravity affects her. She uses her powers to help the people of Hekseville against an enemy called Nevi. The game was designed for PS Vita, a portable console offering three different types of control: touch, accelerometer, and physical buttons. Each participant was asked to play the same mission three times, each time using one of the three different types of control (order randomized).

Figure 2 Playing *Gravity Rush*F using touch controls

Crash Bandicoot is a platform game; the player controls an avatar who jumps from platform to platform. Crash is an anthropomorphised bandicoot who, at each level of the game, must be guided by the player from the beginning to the end, travelling into the screen and negotiating approaching platforms while avoiding hazards, especially attacks by his enemy Dr Neo Cortex. *Crash Bandicoot*, as well as being playable on PS Vita, additionally runs on a tablet, using touch controls. On a tablet, *Crash Bandicoot* allows gamers to reposition controls as they wish, within constraints: the d-pad (used to control direction of avatar movement) and buttons can be dragged around the screen and their sizes slightly changed. Participants were asked to play through the same level of *Crash Bandicoot* twice: on the tablet, and on the PS Vita, using its physical button controls, order randomized; the order of presentation of the two games was also randomised.

The different 'conditions' (given that the pilot was not formally run as an experiment) are shown in Table 2.

Game	**Console**			**Touchscreen**
	Accelerometer	Touch	Physical Buttons	
Gravity Rush	✓	✓	✓	
Crash Bandicoot			✓	✓

Table 2 Pilot Study comparisons

Playing *Gravity Rush* on PS Vita, participants consistently considered accelerometers and touch controls harder to use than physical button controls, and said that it would take time to learn how to use these 'new types' of controls. However, while participants also preferred physical buttons to virtual ones for *Crash Bandicoot*, they told us that the customisability of the virtual button array helped. Figure 3 shows, to the right, how two participants, IH and ADM (names have been changed to non-corresponding initials throughout) independently repositioned controls in *Crash Bandicoot*, compared to the default (shown to the left). ADM said that this was more comfortable, as 'fingers don't obscure the screen as much'. The other three participants stuck with the default layout.

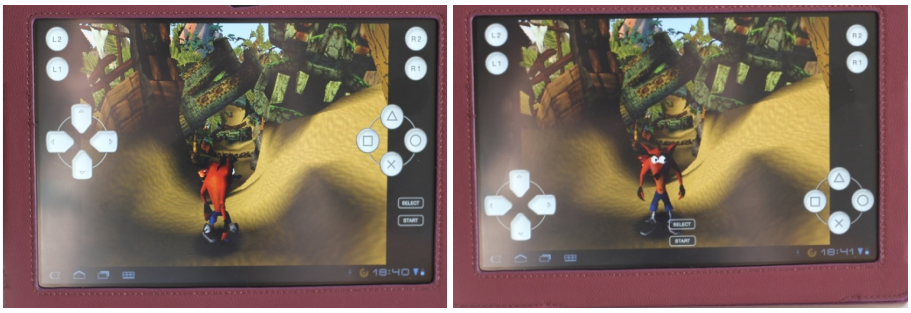

Figure 3 *Crash Bandicoot:* default control layout (left) and user-defined layout (right)

A further finding was that when playing *Crash Bandicoot* on touchscreen, participants interacted with it as they would a portable console: lifted, fingers to the back of the device (see Figure 4). The five participants all said they were familiar with portable console gaming, and their experience of the touchscreen during this study appears to have been influenced by this prior experience. IH, for example, said 'it feels more natural to hold the tablet like this'. However, these results appear not to have been solely due to this prior experience, but also to the touchscreen design being based on a console template, thus evoking console game interaction style. While Figure 2 shows a pinching motion being used for *Gravity Rush's* touchscreen version (best supported by using it flat, as shown), *Crash Bandicoot's* touchscreen design emulates a console, except that all controls are virtual buttons. Therefore, it seems unsurprising that participants held it in a similar way, and that this felt 'natural', since this way of holding the device is conventional for that alternative. Thus, what the pilot study suggests is that the perceived inferiority of some aspects of touchscreen games seen in the literature, particularly regarding controls, may be due to the attempt to recreate a gamer experience developed for an alternative platform.

3.3 *Crash Bandicoot:* 'I prefer buttons'

A major aim of this research was to identify links between game implementation for platform, and gamer experience. If design of touchscreen games emulates interaction on other platforms, and the interaction on those platforms is both evoked and preferred by gamers, this would mean, first, that game platforms cannot be treated as equivalent; and, second, that it may be difficult to consider the gamer experience of touchscreens without considering the influence of other platforms.

Thus, we redesigned the pilot study as an experiment, focussing on *Crash Bandicoot* only, to see whether there were statistically significant differences in participant ratings according to platform. The experiment was a within-subjects design with three conditions: (1) tablet free (participants were free to hold the tablet as they wished); (2) tablet flat (participants had to keep the tablet flat on the table); and (3) console. The participants played the game on the same devices as for the pilot (PS Vita, Sony S), with randomised order of presentation. The three dependent variables were as described earlier: ease of controls, ease of task completion, and satisfaction. As well as asking participants to rate these post-experiment, we ran a pre-test questionnaire on participants' gaming background. This arrangement supported an analysis for correlation between pre- and post- platform preference.

There were 14 participants, 12 males and 2 females, aged 18-30, of various backgrounds (BSc students or graduates). None had taken part in the pilot study.

The experimental hypothesis was that the console would be significantly more highly rated than tablet flat on all three variables. There were two corollary hypotheses: (1) that this

would be because control familiarity and perceived suitability of controls are directly associated with the pleasurability of the game; and (2) due to this, given the choice, players would prefer to hold the tablet like a console.

Figure 4 Tablet Free, and Console conditions

Experience variable	Condition Tablet Free	Tablet Flat	Console
Ease of controls	6.64	3.86	8.43
Ease of task completion	6.57	5	8.71
Satisfaction	6.71	4.85	8.71

Table 3 Mean ratings across experience variables for *Crash Bandicoot* (out of 10)

The results show that for each condition, the mean ratings for all three variables are very similar (see Table 3). The average of all the three mean ratings were: 6.64 for tablet free (mid-'good' band); 4.57 for tablet flat ('fair' band); and 8.62 for console (mid-'very good' band). The console was rated higher than either of the tablet conditions, while tablet free was higher rated than tablet flat. In the tablet free condition, 2 of 14 participants chose to keep the tablet flat (Participants 5 and 10); the other 12 all held it as they would a console.

The experimental hypothesis was supported. Repeated measures ANOVA showed a significant difference in ease of controls $F(2,26) = 20.690$, $p = .000$. Pairwise comparisons revealed that console was significantly more highly rated than tablet flat $p = .000$; and tablet free was significantly more highly rated than tablet flat $p = .002$. There was no significant difference between the ratings for console and tablet free.

There was a significant difference in ease of task completion $F(2,26) = 48.667$, $p = .000$. Console was significantly more highly rated than (a) tablet free $p = .023$; and (b) tablet flat $p. = .001$. There was no significant difference between the ratings for tablet free and tablet flat.

There was a significant difference in satisfaction $F(2,26) = 48.381$, $p = .000$. Console was significantly more highly rated than tablet flat $p = .001$. Tablet free was significantly more highly rated than tablet flat $p = .015$. There was no significant difference between the ratings for console and tablet free.

These results show that on all three variables console was significantly more highly rated than tablet flat. However, in contrast, console was significantly more highly rated than tablet free for one variable only: ease of task completion. There was no significant difference between the ratings for console and tablet held as preferred on ease of controls, or satisfaction. Tablet free was rated significantly higher than tablet flat on two

variables: ease of controls, and satisfaction. However, whether the tablet was held as preferred or flat made no significant difference to ease of task completion. These results suggest that being able to hold a touchscreen as preferred does not necessarily offer as positive a gamer experience for this game than using a console. Equally, in general, using the tablet flat does worsen the experience compared to using it as preferred. To summarise: being able to hold the tablet does not make it a console.

An important issue revealed by the pilot was the possible influence of prior experience on the response to the touchscreen version of the game. To investigate this, we compared data from the pre- and post-questionnaires, shown in Table 4. The 'pre-test' columns in show that for all but one participant (10, DF), amount of play and preference are associated: where one platform is played more than the alternative, it is preferred (although for UT, DG and RW this is based on little or no experience of the latter). It is not clear whether the platform is preferred because it is played more, or is played more because it is preferred. However, where the pre- and post-preferences are the same (as for 9 of the 14 participants, 1-4, 6, 7, 9, and 12, 64%) we can hypothesize that the response to the alternative platform may be influenced by player background. This would imply that where there is a switch, as for participants 5 (NY), 8 (GMN), 10 (DF), 13 (RW) and 14 (TY) (5 participants, 36%), this is because the alternative offers an experience that is compelling enough to override prior experience and preference. However, this is not necessarily the case: it may be because the originally preferred platform is felt to be poor in terms of the game, or the switch is for some other reason. DG preferred touchscreen both before and after the experiment, saying it was because 'I am used to it', and this suggests that familiarity is important. In contrast, the two participants who switched from a touchscreen preference prior to the experiment to console afterwards did so for reasons of design rather than familiarity, saying this was because the game 'worked better for console'. RW felt that, for the touchscreen version of the game, 'using fingers was tricky without physical buttons'. NY, who kept the tablet flat in the tablet free condition, said 'You can't make accurate jumps'. DF, who switched from no preference to console (and was the only other participant to keep the tablet flat in the tablet free condition), said that the touchscreen version 'did not feel natural'. However, while the switches to console were due to preferred design, the switches to touchscreen were not: those who switched from console to touchscreen, GMN and NY, both said, in contrast, that this was because they 'liked a challenge'. Thus, a complex picture emerges of why people prefer or dispreferr platforms, to do with design, familiarity, or challenge. Once again, the responses include the term 'natural'. An implication is that when a conventional interaction has been learned, it is experienced as natural, to the extent that an alternative which is implemented differently is not; and that this a source of lower satisfaction.

	Pre-test			Post-test	
Participant number / initials	Console experience (average hours per week)	Touchscreen experience (average hours per week)	Preference	Preference	Switch?
1 JA	4-6	1-2	Console	Console	
2 DC	3-5	1-2	Console	Console	
3 MJ	2-4	0	Console	Console	
4 ME	10+	3-5	Console	Console	
5 NY	3-5	1-2	Console	Touchscreen (Tablet Flat)	Y
6 UT	10+	0	Console	Console	

7 HH	4-6	3-5	Console	Console	
8 GMN	10+	3-5	Console	Touchscreen (Tablet Free)	Y
9 DG	0	1-2	Touchscreen	Touchscreen (Tablet Free)	
10 DF	2-4	1-2	None	Console	Y
11 SB	3-5	1-2	Console	Console	
12 KT	3-5	1-2	Console	Console	
13 RW	0	1-2	Touchscreen	Console	Y
14 TY	2-4	3-5	Touchscreen	Console	Y

Table 4 Pre-and post-questionnaire data for the *Crash Bandicoot* experiment

These findings show how the implementation of games for particular platforms impacts gamers' ability to interact with it effectively: usability can be negatively affected and this directly influences the affective response. The implication of the findings is that if design in terms of platform implementation is felt to be preferable, gamers can and do switch platform preferences for particular games. Equally, a continued preference for a given platform may be due to design rather than a general platform loyalty. The 8 participants who preferred console both before and after the experiment made comments about touchscreens all of which focus on platform implementation aspects of *Crash Bandicoot* for this platform. The lack of physical feedback from the controls was an issue for players: JA said, 'there was no feedback from buttons and it was hard to coordinate movements'; while SB told us, 'no feedback from controls makes it hard to play'. DC said that 'onscreen controls do not feel as responsive as traditional methods'. HH felt that 'controls are not sensitive enough'. Some participants explicitly expressed a wish for physical buttons, regardless of their performance on a tablet interface: 'I just like buttons' (MJ). Other issues were also raised. KT said that 'the character failed to respond as expected'.

These findings suggest that the design of *Crash Bandicoot* generally works best for console, playing to prior preference in that the touchscreen emulation of console interaction does not fully recreate the original; although it can come close. The fact that patterns of significant differences are not uniform shows that console preference is not due to an uncritical loyalty to this platform. Indeed, the absence of significant differences on ease of controls and satisfaction between console and tablet when the tablet is held (tablet free) suggests that emulations can be accepted by gamers. This is surprising given negative comments including lack of haptic feedback, a seeming over-dependence on one gesture, tapping, and the fact that some of the distinctive affordances of touchscreen such as swiping, scrolling and pinching have not been realized. While the results imply that platforms do differ such that game design must always consider the particular affordances of platforms, they also show that gamers will take to other platforms given that the game offers a positive gamer experience.

3.4 *Angry Birds:* Touchscreens rule?

The *Crash Bandicoot* experiment established a console influence on ratings of the touchscreen version. The larger issues is whether touchscreens can provide a highly rated gamer experience 'in themselves'. Since influence on touchscreen ratings could come from a wider range of platforms than consoles, we decided (1) to increase the number of platforms compared with, to include PC; and (2) to expand the number of genres examined to see if there is also an influence of genre. Thus, we aimed to explore how different games have been implemented for touchscreen with a focus on what works best,

and why. The first of these was a puzzle game which can be used on various platforms: PC, Consoles and Touchscreens: *Angry Birds Star Wars*.

Angry Birds, one of the most popular game series, originated on smartphones and was taken over to consoles and PC. The game genre is a puzzle. The gamer controls a simple slingshot that shoots birds (acting as projectiles) to destroy various building-like structures, the complexity of which increases as the game progresses through levels. There is also virtual camera control to scroll the scene, and zoom in and out. Figure 5 shows screenshots from the PC version of *Angry Birds Star Wars*. This intermediate level was one of those we asked participants to play.

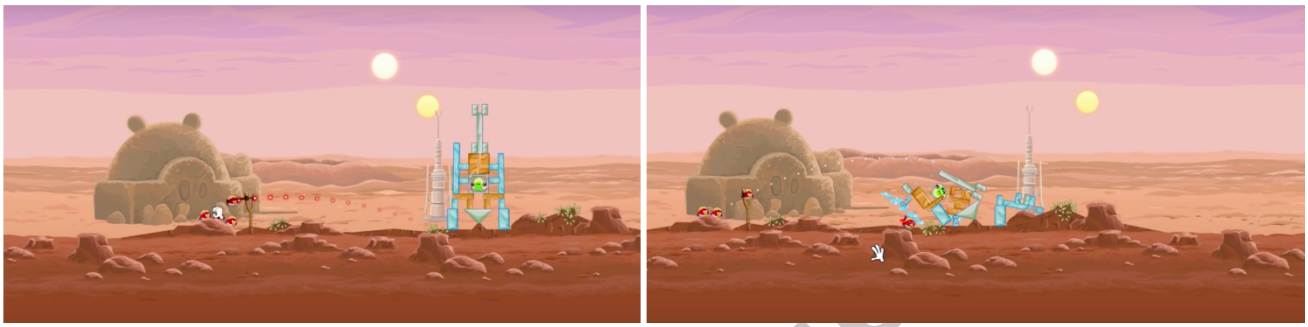

Figure 5 *Angry Birds Star Wars:* gameplay

The experiment was designed similarly to the first (with *Crash Bandicoot*); however, it drops one of the tablet conditions (tablet is held as preferred), and adds a PC condition. There were 18 participants, mostly BSc Students. The experiment was run in the same room with the equipment including Sony Tablet S (touchscreen), Xbox 360, and PC. It is important to note that unlike the PS Vita console used in the *Crash Bandicoot* experiment, Xbox 360 is not a portable console. It has an offboard controller with a joystick: however, mappings between controls and game events are similar to portable consoles. The participants were again asked to rate the game post-experiment on the three variables, and to provide pre- and post-preferences.

The mean ratings for *Angry Birds Star Wars* across the three experience variables are shown in Table 5.

	Condition		
Experience variable	**Touchscreen**	**PC**	**Console**
Ease of controls	8.05	8.47	6.21
Ease of task completion	7.68	7.68	6.1
Satisfaction	7.58	8.63	6.63

Table 5 Mean ratings across experience variables for *Angry Birds Star Wars*

The ratings show that of the three platforms, PC was highest rated. Touchscreen is also highly rated, with console less well rated. The averages of the means for each platform are: 7.8 for touchscreen (high-'good' band); 8.3 for PC (low 'very good' band); and 6.3 for console (low 'good' band).

Repeated measures ANOVA showed a significant difference in ease of controls $F(2,36) = 6.805$, $p = .003$. Pairwise comparisons revealed that PC was rated significantly higher than console $p = .010$. There was no significant difference in ratings between PC and touchscreen, or between console and touchscreen.

There was a significant difference in ease of task completion $F(2,36) = 33.333$, $p = .001$. Pairwise comparisons revealed that PC was rated significantly higher than console $p = .001$. There was no significant difference in ratings between PC and touchscreen, or between console and touchscreen.

There was no significant difference between the three platforms on ratings for satisfaction: *Angry Birds Star Wars* was enjoyed on all three platforms.

To explore the issue of influence on platform preference, we again made an analysis of preferences pre- and post-experiment. Prior to the experiment, 13 of the 19 participants preferred PC to the other two platforms. 4 preferred console, and 2 preferred touchscreen. Post-experiment, 12 participants preferred PC; 2 preferred console and 5 preferred touchscreen. There were two PC preference switches: one to console, and one to touchscreen. The three console preference switches were 2 to touchscreen and 1 to PC. Overall, 74% stuck with their preferred platform: 92% with PC (92%); 50% with console and 100% with touchscreen.

PC was rated significantly higher than console on ease of controls and ease of task completion. There was a range of comments concerning ease of use of PC controls, They are 'easier to use' (GG); PC has 'easy controls' (TR); PC has the 'easiest controls' (JF); 'PC had better controls than the other platforms' (TM). HS said 'I'm a PC gamer and I'm used to the controls'. On console, players said 'it is easier to work with' (MS); and 'consoles are fun to play' (B). However, the most marked switch was away from console, and there were also several negative comments. Both B and JF said that the console controls were overloaded, with 'too many buttons'. JF added that the console was 'less natural to play'. Play was described by SR as 'frustrating'. Two players' comments are explicitly about intuitiveness: TM said 'camera control is unintuitive' (sic), and MC, a console player who rarely used other platforms, said that 'movements are not intuitive', despite indicating in the pre-questionnaire that console controls are easier because he was 'more used to it'. This suggests, again reflecting the findings for *Crash Bandicoot* and *Angry Birds Star Wars*, that gamers may not stay 'loyal' to a platform if the gamer experience is not sufficiently positive for a particular game.

ASH and JN said they both preferred touchscreen post-experiment because it was 'easy to control'. TM stated that he would normally prefer PC, as he was primarily a PC player, but for this type of game he preferred touchscreen 'because it's more comfortable'. AH suggested that he preferred different games on different platforms, but *Angry Birds Star Wars* was 'best on touchscreen'.

The figures show that for this game, pre-experiment preferences largely remained solid post-experiment; however, this appears to be for different reasons than the *Crash Bandicoot* experiment. For the latter, the touchscreen version of the game evoked console experience as in such a way as to reinforce prior preference for console. In contrast, for *Angry Birds Star Wars* it appears that sticking is due to design being strong across both platforms.

Angry Birds Star Wars on touchscreen was enjoyed. Importantly, it is not a port. Originating on touchscreen, it has been remade for other platforms. On touchscreen, controlling the catapult is a swipe and release gesture, with multitouch controls for moving and panning the camera. On PC, the camera is controlled by mouse movements, and the catapult with mouse-down, drag and release, a very common action for any PC user (effectively drag and drop). However, compared to PC and touchscreen, the console requires more controls to perform the same action: both analogues are used: right to

control camera and left to control the catapult, but releasing the catapult further buttons need to be pressed. This explains the significant difference in ease of controls between PC and console.

At this point it is important to consider the relationship of game mechanics to controls. Game mechanics has been described as (1) elements of the game, such as players, roles, objectives, outcomes; and (2) rules, including turn-taking, capture, destroy, and so on [50]. For the *Crash Bandicoot* game, game mechanics were identical across platforms in that elements and rules are unchanged for the different versions. However, the implementation of the destroy objective in *Angry Birds Star Wars* for console changes how this is achieved: it requires more actions compared with touchscreen or PC. Thus game mechanics can be altered by control implementation for a platform in a way that affects gamer experience. If such a change incurs work, it may be rejected, and the implication of this is that implementation for a platform must avoid overheads where these overheads are not experienced as an enjoyable interaction. As some players told us, the results may feel 'unintuitive'.

Angry Birds Star Wars works well on more than one platform. Its implementation for touchscreen was compelling enough to present a strong gamer experience regardless of prior player preference. Thus, players can go with the platform they are used to, or take to a new one. Reflecting the results for *Crash Bandicoot*, these findings suggest that gamer experience is not strongly influenced by prior platform preference and players are not necessarily wedded to particular platforms. Gamers can and do engage with other platforms – given that the game allows them to do so.

3.5 Racing games: 'Where's the challenge?'

Our first experiment with *Crash Bandicoot*, a console platformer ported to touchscreen, shows how virtual recreations of console controls may evoke prior experience of physical controls, which may be felt to be superior, sometimes leading to a preference for the original platform when rated pre- and post-experiment: we also saw that if the emulated platform is evoked (by holding) this improves ratings, reinforcing the point. In contrast *Angry Birds Star Wars* shows that when designed to more clearly capitalise on the distinctive affordances of the platform, gamer experience is rated high, and prior experience on other platforms is shown to be less of a factor. This suggests that game design to engage and realize the distinctive affordances of touchscreens is important.

However, *Angry Birds Star Wars* is a game with simple controls. A key interaction for touchscreen, swipe and release, works for *Angry Birds Star Wars* and is easy to implement; but more complex games may produce implementation challenges that are less straightforward to address. Therefore, our third and fourth experiments concentrate on racers and first-person shooters (FPSs).

The racing game was *Sonic and All-Stars Racing Transformed*. In this game players need to race on a track against others, with various obstacles and power-ups they can pick up and use to their advantage, or to hinder their opponents. Over the course of the race their vehicle automatically transforms between a car, a boat and a plane, depending on terrain (see Figure 6).

Figure 6 *Sonic and All-Stars Racing Transformed*: vehicle transformations (car, boat and plane)

The touchscreen version of the racer is not a direct port. It has been adapted to use touch-based controls (see Figure 7): a small analogue stick in the bottom-left corner is used to steer the car. 'Drifting' (shifting back wheels by causing oversteer) is controlled by pressing and holding a button in the bottom-right corner. Available power-ups (adding capacities to the car to give competitive advantage, including weapons such as bombs) are shown as a small icon next to the drifting button, and can be retrieved through tapping. Swipe is used to allow the car to shoot a weapon forward or backward. Compared with other platforms, on touchscreen some tracks are shortened; the car moves automatically, and there is no accelerator.

There were 20 participants, of mixed background and age, predominantly students. As in the preceding experiments, pre- and post-test questionnaires were run. The participants completed one full track on a touchscreen device (Google Nexus 7), PC and Console. Winning was not required.

The mean ratings across the three experience variables for *Sonic and All-Stars Racing Transformed* are shown in Table 6.

The results show that on all three experience variables, console and PC were more highly rated than touchscreens. The averages of the means for each platform are: 4.35 for touchscreen (the lower end of the 'fair' band); 7.93 for PC (high 'good').

Repeated measures ANOVA showed a significant difference in ease of controls $F(2,38) = 56.608$, $p = .000$. Pairwise comparisons revealed that touchscreen was rated significantly lower than (a) PC $p = .000$; and (b) console $p = .000$. Console was rated significantly higher than PC $p = .002$.

Figure 7 *Sonic and All-Stars Racing Transformed* interface on touchscreen

There was a significant difference in ease of task completion $F(2,38) = 76.000$, $p = .000$. Pairwise comparisons revealed that console was rated significantly higher than (a) PC $p = .000$; and (b) touchscreen $p = .000$. There was no significant difference in ratings between PC and touchscreen.

Experience variable	Condition		
	Touchscreen	PC	Console
Ease of controls	3.85	7.1	8.95
Ease of task completion	4.6	8.1	9.5
Satisfaction	4.6	8.6	9.4

Table 6 Mean ratings across experience variables for *Sonic and All-Stars Racing Transformed*

There was a significant difference in satisfaction $F(2,38) = 67.067$, $p = .000$. Pairwise comparisons revealed that touchscreen was rated significantly lower than (a) PC $p = .000$; and (b) console $p = .000$. There was no significant difference in ratings between PC and console.

Thus, the statistical analyses show that console was rated significantly more highly than touchscreen on all three variables. PC is rated significantly more highly than touchscreen on ease of controls and ease of task completion; and console is significantly more highly rated than PC on ease of controls and ease of task completion.

19 / 20 (95%) players preferred PC before the experiment, with 1 preferring touchscreen (and none preferring console). After the experiment, the figures were 15 for console, 5 for PC and none for touchscreen. While 4 of the 19 who preferred PC prior to the experiment expressed the same preference after the experiment, the other 14 switched to console. The single gamer who preferred touchscreen prior to the experiment also switched to console. This means only 20% of these participants preferred the same platform both before and after the experiment.

The console version of the game was widely praised for its controls. It 'felt smooth and more natural' (TE-E), and the controller has 'rumble feedback' (AG). Additionally, although JB mentioned that even though he stuck to PC as he was used to it, he would recommend console for someone new to the game, as it's 'easy to use'.

In contrast, the comments on the PC version were about its familiarity: 4 users explicitly stated that they preferred the PC version because they're familiar with PC controls (mouse and keyboard). OG said 'I've been used to PC since I was little'. RS echoed this: 'I've been playing PC for quite some time'. JB said 'I'm used to keyboard and mouse'.

Different reasons were given for low touchscreen ratings. Many of the negative comments echoed those for *Crash Bandicoot*, concerning the lack of feedback provided by virtual buttons: 'There's no tactile feedback' (JW); 'It doesn't give tactile feedback' (PV); 'I could not tell the position of my thumb on the joystick due to no physical controls' (RB); 'It is hard to control with the touchscreen analogue joystick' (RB2).

However, as with *Angry Birds Star Wars*, there were changes to game mechanics in *Sonic and All-Stars Racing Transformed*. One main area of comment was on simplified design. JH said, 'on the touchscreen version you don't need to accelerate the car'. This was disliked by many players: 'the lack of speed control is horrible' (AO); 'the lack of speed control made the game too easy'(TE-E); 'There was a lack of functions' (JSt). Perhaps because of the removal of acceleration, some participants said they had difficulties in controlling the car: 'Controls are wobbly' (IG); 'It's hard to turn' (TE-E). RS and RB expected the game to have accelerometer control to steer the car, which was not implemented. RS said, 'It was hard to control with the touchscreen analogue stick, I wanted to move the tablet to move the player'. No positive comment was made about the touchscreen gamer experience. The implication of these comments is that game design for

touchscreens needs not only to play to platform affordances, but must also preserve expectations that players bring to games relating to controls and game mechanics. In particular, changes to game mechanics can compromise functionality and challenge. Thus, touchscreen implementations may need to take a conservative approach to game mechanics, unless the alternative produces an experience gamers rate positively.

As tended to happen with *Crash Bandicoot*, when a touchscreen implementation is not sufficiently compelling, gamers refer to other platforms they are familiar with, compare the touchscreen to them, and prefer them. Again, prior experience only exerts influence through preference for implementation of the game: uncritical platform loyalty did not appear to exist among our participants, the majority of whom switched platform preference due to the perceived superiority of console for this game.

3.6 FPSs: losing control

The research reported here involved comparing the same game across different platforms to identify differences in gamer experience, using games of different genres. One of the challenges for this work was that at the time of the research, there was no identical FPS available on all three platforms. Although several have cross-platform franchises, including *Call of Duty: Strike Team* or *Mass Effect: Infiltrator*, these games are often very different to their counterparts. For this reason, the design of the FPS experiment was different to the others: we evaluated *Dead Trigger 2* on touchscreen only (a Google Nexus 7 tablet), as it is not available on other platforms. We compared this with *Left 4 Dead 2* on PC and console (Xbox 360) as it is not available on touchscreen. Because the gameplay and implementation of the two FPSs are not identical, this means we can only statistically compare gamer experience variables between PC and console. However, there are some similarities (see Table 7), making a descriptive comparison of touchscreen and the two other platforms reasonably plausible.

	Left 4 Dead 2	*Dead Trigger 2*
Range weapons	✓	✓
Melee weapons	✓	✓
Team-based (co-op / AI)	✓	
Individual		✓
Zombie kill objective	✓	✓
Other Objectives	✓	✓
Time-gated		✓
Free movement	✓	✓

Table 7 Comparison of two FPSs

Left 4 Dead 2 (see Figure 8) is a survival horror FPS (first-person shooter) game available on PC and Xbox 360. The player controls one character in a party of four (the others are either controlled by AI or by other players if a co-op mode is chosen). The game allows usage of firearms and melee weapons (close-range weapons, including hand-to-hand). The levels mainly consist of progressing through an environment while killing zombies. Sometimes additional objectives may be present. The health bar of the player and companions is shown in the bottom part of the screen. The player can assume the role of any character in the party (chosen at random when starting the game, unless specified).

The player can move with the left analogue stick and aim with the right one in the console version, RT to fire weapon and LT for melee attack. In the PC version standard WASD keyboard buttons are used to navigate, with left and right mouse buttons for shooting and melee respectively. B (console) and R (PC) are used to reload a weapon.

Figure 8 *Left 4 Dead 2*

Dead Trigger 2 (Madfinger Games, 2013) is a zombie apocalypse-themed touchscreen-based FPS, developed for Android and iOS. The levels usually consist of killing zombies, sometimes with additional objectives, such as time-gated missions, and between the missions the player can buy new items and upgrade weapons. *Dead Trigger 2* is a free movement game, unlike many of its predecessors, where the player controls the character's movement as with a PC / console game. The player can use a button to fire a weapon or to switch from shooting to melee (Figure 9). It is also possible to hold the button for more precise aiming. The health bar is represented in the top-left part of the screen, while the top-right corner shows the current weapon and its load. There is a small button on the right used to reload the gun.

Figure 9 Screenshots from *Dead Trigger 2*

The experiment was set up in a similar way as the previous studies, using the same room and same equipment as in the racing game experiment (Google Nexus 7 tablet, Xbox 360 console, university-based PC). It had a total of 21 participants, mostly BSc students. The same pre- and post-test questionnaires were used.

The players were asked to complete one floor of the building in *Left 4 Dead 2*, which required navigating through the rooms and corridors while killing zombies and finding the stairs to progress to the next floor (where the players were asked to stop). In *Dead Trigger 2* the first mission was also selected for the playthrough as it also required navigating through the house while being attacked by zombies.

The mean gamer experience ratings for the two FPSs are shown as Table 8. These show that PC was more highly rated than console; and console more highly rated than touchscreen. The averages of the means for each platform are: 5.97 for touchscreen (high 'fair' band); 9.18 for PC (middle-high 'very good' band) and 7.74 for console (high 'good' band).

The statistical analysis for this experiment is restricted to two conditions, PC and console. The dependent t-test shows that for *Left 4 Dead 2*, PC is significantly preferred to console on all experience variables.

A paired samples t-test shows that for all three variables, PC is rated significantly higher than console: ease of controls: $t(20) = -4.607$, $p = .000$; ease of task completion: $t(20) = 2.646$, $p = .016$; satisfaction: $t(20) = 2.227$, $p = .038$.

Experience variable	**Condition**		
	Touchscreen (*Dead Trigger 2*)	**PC** (*Left 4 Dead 2*)	**Console** (*Left 4 Dead 2*)
Ease of controls	5.43	9.24	7.33
Ease of task completion	6.19	9.24	7.9
Overall satisfaction	6.29	9.05	8

Table 8 Mean participant ratings for FPS games on different platforms

17 of the 20 participants rated PC most highly after the experiment. Many of the comments centred on controls: 'PC gives better control' (MA); 'PC is best because I'm used to the controls' (RP); 'PC is best because of ease of controls' (PW); 'I'm more comfortable with PC controls' (AW); 'PC gives you more precision' ('PV').

Although touchscreen ratings were significantly lower than PC or Console, and with the caveat that the games are not identical, *Dead Trigger 2* received positive comments. EC said, 'I didn't expect a touchscreen FPS to be so good, even though it's much worse than PC'. ES said, 'It looks very good for a tablet game, I should check it out at home'. Two of the participants, JB and TE-E, were already familiar with *Dead Trigger 2*, being avid FPS players. JB said that it was 'currently the best FPS on the Android market'.

While touchscreen was relatively low rated, unlike the racing game *Sonic and All-Stars Racing Transformed* this was not due to reasons of simplification: in particular, the free movement feature allows gamers to navigate where other touchscreen implementations automate this. Comments on touchscreens again centred on issues with controls: 'It was difficult to aim and shoot' (RP); 'It's tricky using touchscreens' (DW); 'Awkward; felt very unnatural' (AO); 'Virtual buttons are difficult' (JW); 'Very hard to aim the controls, aiming and shooting was difficult, lots of buttons, not as many fingers free' (PV); 'It was very difficult to aim and I often ended up shooting instead of looking around' (TM); 'Hard to control, the aiming movement wasn't smooth, the shoot button was too small' (RB). Again, these comments show that game design in terms of implementation for platform is key for gamer experience.

4. COMPARING THE SAME GAMES ACROSS DIFFERENT PLATFORMS

The four experiments were run to find out how touchscreens compare with other platforms in terms of gamer experience across a range of game genres. Using platform as the independent variable, we measured three gamer experience variables: ease of

controls, ease of task completion, and satisfaction. The results are shown as three 'leaderboards' in Figures 10a, 10b and 10c. Here, the means of the ratings are sorted into very good (>=8), good (>=6, <8), fair (>=4, <6), bad (>=2, <4), and very bad (>=0, <2) bands for each variable. A concise summary of Figures 10a-c appears as Table 9.

The results show that touchscreen was not the most highly rated platform for any genre, being rated 3rd for FPS; 3rd for racer, 3rd for platformer, and 2nd for puzzle. However, despite relatively low scores for this platform, the analyses above show that not all differences between ratings were significant. It is not the case that touchscreens were always significantly lower rated than other platforms (given that a statistical comparison was not possible for FPS). While, for the racer, both PC and console were significantly more highly rated than touchscreen across all three experience variables, this does not apply to platformer or puzzle. For the platformer, console was not significantly more highly rated than the touchscreen (held as preferred) for any variable. For the puzzle, there was no statistically significant difference between touchscreen and PC; or between touchscreen and console.

We carried out two further statistical analyses: first, correlations between the three variables; and second, a linear regression analysis to pinpoint key variable relationships and help indicate causal effects.

There is a significant positive correlation between ease of controls and ease of task completion $r = .783$, N = 222, $p < .01$.

The rank orders are the same, except that ranks 1 and 2 change places, as do ranks 5 and 7, and 9 and 10. There are the same numbers of scores in the very good band; but

	1	2	3	4	5
Very good (>=8)	FPS / PC	Racer / Console	Puzzle / PC	Platformer / Console	Puzzle / Touchscreen
EC	9.24	8.95	8.47	8.43	8.05

	6	7	8	9
Good (>=6, <8)	FPS / Console	Racer / PC	Platformer / Touchscreen	Puzzle / Console
EC	7.33	7.1	6.64	6.21

	10	11
	FPS / Touchscreen	Racer / Touchscreen
Fair (>=4, <6) / **Bad** (>=2, <4)		
EC	5.43	3.85

Figure 10a Gamer experience 'leaderboard' for Ease of Controls

	1	2	3	4	5
Very good (>=8)	Racer / Console	FPS / PC	Puzzle / PC	Platformer / Console	Racer / PC
ETC	9.5	9.24	8.74	8.71	8.1

	6	7	8	9	10
Good (>=6, <8)	FPS / Console	Puzzle / Touchscreen	Platformer / Touchscreen	FPS / Touchscreen	Puzzle / Console
ETC	7.9	7.68	6.57	6.19	6.1

	11
	Racer / Touchscreen
Fair (>=4, <6)	
ETC	4.6

Figure 10b Gamer experience 'leaderboard' for Ease of Task Completion

	1	2	3	4	5	6
Very good (>=8)	Racer / Console	FPS / PC	Platformer / Console	Puzzle / PC	Racer / PC	FPS / Console
S	9.4	9.05	8.71	8.63	8.6	8

	7	8	9	10
Good (>=6, <8)	Puzzle / Touchscreen	Platformer / Touchscreen	Puzzle / Console	FPS / Touchscreen
S	7.58	6.71	6.63	6.3

	11
	Racer / Touchscreen
Fair (>=4, <6)	
S	4.6

Figure 10c Gamer experience 'leaderboard' for Satisfaction

Key EC = Ease of controls; ETC = Ease of task completion; S = Satisfaction

where there are 4 in the good band on ease of controls, there are 5 for ease of task completion. The fair band has the same number of games on both variables – 1 – while on ease of controls only, the bad band has one game. Touchscreen exclusively occupies the lower bands (see Figures 10a and 10b).

EC		ETC		S	
1	FPS / PC	1	Racer / Console	1	Racer / Console
2	Racer / Console	2	FPS / PC	2	FPS / PC
3	Puzzle / PC	3	Puzzle / PC	3	Platformer / Console
4	Platformer / Console	4	Platformer / Console	4	Puzzle / PC
5	Puzzle / Touchscreen	5	Racer / PC	5	Racer / PC
6	FPS / console	6	FPS / console	6	FPS / console
7	Racer / PC	7	Puzzle / Touchscreen	7	Puzzle / Touchscreen
8	Platformer / Touchscreen	8	Platformer / Touchscreen	8	Platformer / Touchscreen
9	Puzzle / Console	9	FPS / Touchscreen	9	Puzzle / Console
10	FPS / Touchscreen	10	Puzzle / Console	10	FPS / Touchscreen
11	Racer / Touchscreen	11	Racer / Touchscreen	11	Racer / Touchscreen

Key:

Very good | Good | Fair | Bad | Very bad

Table 9 Ranked ratings on the three experience variables

There is a significant positive correlation between the variables ease of task completion and satisfaction $r = .805$, N = 222, $p < .01$.

Ranks 3 and 4 change places; as do 9 and 10 (see Figures 10b and 10c). Otherwise, the rank orders are identical. Different numbers of scores appear in different ratings bands: 5 games are rated very good on ease of task completion, and 6 for satisfaction; 5 games are rated good on ease of task completion, and 4 are rated good for satisfaction; 1 game is rated fair on ease of task completion and satisfaction; no game is rated as bad or very bad on either variable. Touchscreen does not appear in the very good band for either variable: this band is exclusively occupied by PC and console. Touchscreen appears exclusively in the lower band.

There is a significant positive correlation between ease of controls and satisfaction $r = .805$, N = 222, $p < .01$.

The rank orders are identical (see Figures 12a and 12c), except that ranks 1 and 2 change places, as do ranks 3 and 4, and ranks 5 and 7. There are differing numbers of scores in the very good band: 5 and 6 respectively. The same number appears in the good band (4) and the fair band (1). The bad band has 1 game in the ease of controls band only. The ease of controls variable is the only variable for which touchscreen appears in the very good band. Again, this platform exclusively occupies the lower bands (fair, and bad), with PC and console distributed across the good and very bands.

These results show that the ratings for all three experience variables are significantly correlated: scores for one variable will be reflected by the scores for the other two. However, we also wish to treat the relationship between the variables as causal. Earlier in this paper, we argued that there are different levels in gamer experience: the affective dimension of games, its pleasurability and the satisfaction it gives at the top level; game design, including game story and game mechanics at the second level, and at the third,

game implementation for the platform, where controls are key (see Figure 11, also Figure 1 [earlier]):

Level	Variable
Gamer experience: affective dimension	Satisfaction
Game design (1): content	Ease of task completion
Game design (2): implementation	Ease of controls

Figure 11 Relationships between game design and gamer experience mapped to experience variables

To examine causation, we treated the data as a three-level model (see Figure 12a). We split the model into two sub-models, model 1 and model 2 (see Figure 12b), and carried out linear regression on each. In model 1, the dependent variable is ease of task completion, and the independent variable is ease of controls. In model 2, ease of task completion becomes the independent variable; the dependent variable is satisfaction.

For Model 1, there was a significant relationship between ease of task completion and ease of controls $p < 0.01$. The R^2 value of .614 shows that 61.4% of the variation in ease of task completion can be explained by a model including only ease of controls as the predictor.

For Model 2, there was a significant relationship between satisfaction and ease of task completion $p < 0.01$. The R^2 value of .648 shows that 64.8% of the variation in satisfaction can be explained by a model including only ease of task completion as the predictor.

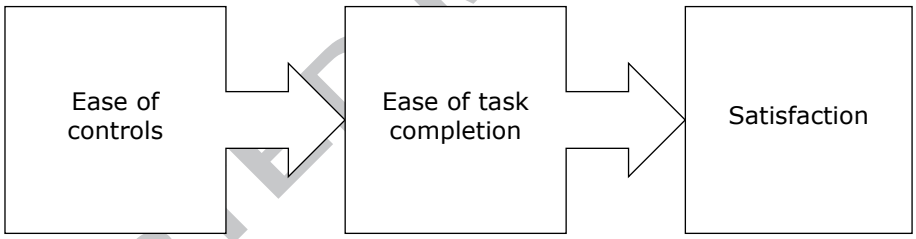

Figure 12a: Three-level model

Model 1	
Independent variable	***Dependent variable***
Ease of controls	Ease of task completion

Model 2	
Independent variable	***Dependent variable***
Ease of task completion	Satisfaction

Figure 12b: Model splits

Our findings help elucidate the dynamics whereby ease of controls influences satisfaction ratings of platforms, and, indirectly, platform preferences. Genre and player background both have an effect, but in different ways. In particular, genre implies differing challenges for game design at the level of controls. Simple puzzle games can be implemented to take

direct advantage of touchscreen affordances. Thus, *Angry Birds Star Wars* scored highly on this platform, since the main action consists of gestures which are central and canonical for touchscreens. However, touchscreen implementations for other genres may play negatively to expectations about how a game 'should' work in terms of functionality and challenge, and / or evoke control mechanisms which are preferred. In order to leverage touchscreen affordances in terms of controls, *Sonic and All-Stars Racing Transformed* altered the content. Thus, it appears that for many genres, despite areas of positive response, touchscreen design needs to focus on controls with an eye on influences on content and player response due to their background and experience of other platforms.

5. COMPARING DIFFERENT GAMES ON THE SAME PLATFORM

The tranche of four experiments reported on in this paper was designed to enable us to identify significant differences in platform ratings for a game of the same genre across three experience variables. The results show that no platform is preferred across all the game genres we examined, suggesting that game genre influences preference; and further, that this is because genres are implemented differently and more or less successfully for a given platform. An issue here is that the analyses do not reveal significant differences between genres on the same platform. since the experimental design was consistent, we can carry out a 'crosswise' *post-hoc* analysis which treats genre, rather than platform, as the independent variable (shown as Figure 13). This could support and add nuance to our discussion on the genre implementation issues we assume lead to touchscreen being rated differently to other platforms. While it is possible to make the analysis for all platforms, for the purposes of this paper we were concerned with touchscreen only – shown as the dark grey bar.

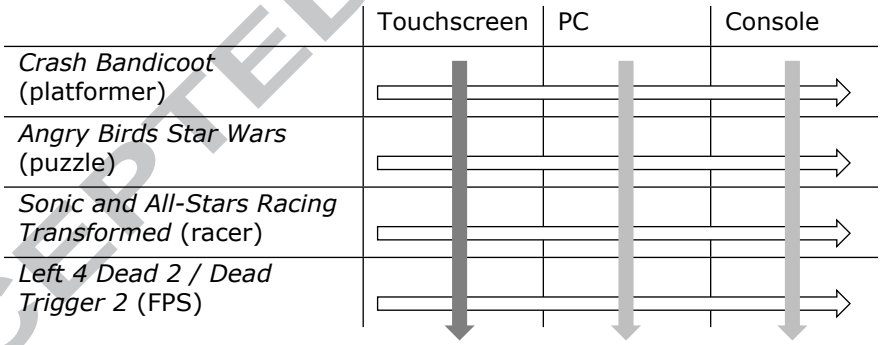

Figure 13 Analysis by platform (white); and by genre (grey)

It should be noted that for the crosswise analysis, since the cohorts in each experiment differed, the design is no longer within subjects, but between subjects. Therefore, the one-way (rather than repeated measures) ANOVA test was applied, with pairwise comparisons using Tukey.

For touchscreen, there were significant differences in ease of controls between the four genres $F(3,73) = 17.367$, $p = .000$. The puzzle (*Angry Birds Star Wars*) was significantly more highly rated than the racer (*Sonic and All-Stars Racing Transformed*), $p = .000$; and the FPS (*Dead Trigger 2*) $p = .000$.The platformer (*Crash Bandicoot*) was significantly more highly rated than the racer, $p = .000$. The FPS was significantly more highly rated than the racer $p = .044$.

For ease of task completion, there were significant differences between the genres, $F(3,73) = 7.760$, $p = .000$. The puzzle was rated significantly more highly than the racer, $p = .000$. The platformer was also significantly more highly rated than the racer, $p = .033$.

For satisfaction, there were significant differences between the genres, $F(3,73) = 7.068$, $p = .000$. The puzzle was significantly higher rated than the racer $p = .000$. The platformer was also significantly higher rated to the racer, $p = .023$.

Thus, on touchscreen, the racer was rated significantly lower on ease of controls than any other game. In contrast, the puzzle was significantly more highly rated than any other game bar the platformer. For the puzzle, *Angry Birds Star Wars*, the participants linked controls to intuitiveness, saying that the game was 'easier to control, more intuitive' (SR) and the 'interface was more comfortable' (TM). The racing game, however, attracted responses expressing a clear desire for tactile feedback from the controls on the touchscreen version. JW said, 'no solid controls = no tactile feedback' 'JW'. There were other negative comments: 'sluggish controls' (JF); 'hard to use accurately' (MO). The FPS, rated higher than the racer only, also attracted some negative comment: it was 'difficult to aim and shoot' (RP), with the controls having 'lots of buttons leaving almost no fingers free' (PV).

On both ease of task completion and satisfaction, the result is the same: both puzzle and platformer are significantly more highly rated than the racer. There are no other significant differences.

These findings reflect those made prior to the *post-hoc* analysis, suggesting that ease of controls is an important differentiator in terms of gamer experience, and adding support to the view that control design to the affordances of touchscreens is crucial. However, significant differences for this variable do not always imply that differences on others are also significant.

6. DISCUSSION AND CONCLUSION

The motivation for this work was the need to understand more about gamer experience of touchscreens, in order to inform design. Thus, there were two main objectives. First, we wished to provide design implications for touchscreen games. Second (and relatedly), we wanted to show that the affective dimensions of gamer experience of touchscreens (and indeed any platform) can be conceptualised as resulting from an interaction between game content and game implementation for platform (shown as Figure 14). Building on existing work, we proposed that gamer experience frameworks could benefit from inclusion of these three levels, with a particular focus on platform issues.

Gamer Experience Levels	1 Affective
	2 Design: game content
	3 Design: platform implementation

Figure 14: Proposed gamer experience framework levels

To address the objectives, we developed an experimental methodology which enabled us to compare the same game across different platforms. We chose dependent variables to reflect (1) the affective level (satisfaction); (2) the game content level (ease of task completion); and (3) the platform implementation level (ease of controls). This

comparison was designed to see which platform is preferred for a given game and why. At the same time, the methodology supported a *post-hoc* analysis to look at differences in gamer experience ratings for different genres on the same platform.

Our results show clear relationships between the three variables, both correlational and causal, indicating (reflecting work by Barnett *et al* [29] and Laitinen [30]) that affective responses in gamer experience emerge out of, and are caused by, the two design levels.

While the relationship between the three levels is causal, in that usability issues at the level of controls affect engagement with game content, this in turn giving rise to affective response, there is an important influence of player background which can have an independent influence on each of the two design levels.

As we have seen, players often bring experience of other platforms with them when they interact with touchscreens. This may be compared against the current platform in positive or negative ways. The comparison is often about controls. Player background can exert a negative influence on ratings for touchscreen games when they are perceived as problematic at the level of controls, since this prevents engagement with content. As we saw, many negative comments were made about the lack of haptic feedback, and the difficulty of control.

However, independently of whether controls are usable, players bring expectations about how a game should behave in terms of game mechanics. *Sonic and All-Stars Racing Transformed* removed expected functionality (with no speed control) and again, this was responded to negatively.

This raises the issue of how far it is possible to conceive of particular game mechanics 'suiting' given platforms. While platforms have different affordances, and game mechanics should play to these, our research suggests that game mechanics need careful consideration in light of expectations players bring, particularly the use of affordances which might change them. *Sonic and All-Stars Racing Transformed* is an example of changes to game mechanics allowed by the affordances of the platform being unsuccessful. However, when touchscreen games are free of problems of controls and game mechanics work for them, gamers can and do take to the game and rate it highly. *Angry Birds Star Wars* is a puzzle game requiring camera movements and catapulting; simple game mechanics which can be implemented into native touchscreen affordances. When this happens, influence of player background in terms of prior platform preference reduces: games can be enjoyed on their own terms. This means that there is an important role for usability, to do with game implementation (Level 3 of our proposed framework) centering on controls; and for content (Level 2), centering on game mechanics. Both need to be addressed through design, with an eye to expectations and prior experience which are clearly key.

Angry Birds Star Wars is a 'casual' game with a simple basic action. A key challenge is how to design touchscreen games in new ways which might increase their attractiveness not just for casual games but other genres more traditionally associated with PC and console. For any genre, our findings indicate two design sensitivities and two design hazards that need to be borne in mind when creating games for touchscreens.

The first design sensitivity is: **platforms are not intersubstitutable**. Platforms have native affordances which differ. Racing games are popular on consoles such as PS and Xbox because they feature controllers which enable multiple simultaneous button / joystick interactions to be carried out, allowing fast, complex, precise interactions. Puzzle games can work well on touchscreens because of direct interaction with objects by

swiping and releasing. This means that ports may not work; swipe and release is difficult to implement on console, while haptic feedback does not yet exist for virtual buttons on touchscreens. However, platforms may work for a wide range of games, and an ongoing challenge is how to implement different genres for touchscreen to widen its appeal.

The second design sensitivity is: **a design solution for one touchscreen game may not apply to another**. A simplification of controls to minimal swipes and releases will not work if complexity and explicit user control are expected, as for the racer.

Evocation without emulation is the first design hazard. This relates to the first design sensitivity (platforms are not intersubstitutable). Direct ports may not work, because the emulation is seen as inferior to the original platform which it evokes. This was the issue for the platformer *Crash Bandicoot*; the FPS *Dead Trigger 2*, and the racer. While gamer experience for touchscreen was rated in the fair band apart from the latter, it was much lower than the console equivalent. The example of *Angry Birds Star Wars* shows this is in a different way: platform implementation differs, so that the interactions are quite differently realized on touchscreen and PC, with the result that both are highly rated. This suggests that platform implementations need to be imaginatively and independently considered.

The second design hazard is: **challenges expectations**. This maps to both design sensitivities. As we saw, our participants all had backgrounds in gaming across multiple platforms and genres. While players do not expect platforms to be the same, and value implementations that play to native affordances, there is still an expectation of control ergonomics and seamlessness, functionality of the game in terms of interactions – players expecting to navigate, for example; and of allowing engagement of particular types and levels. *Sonic and All-Stars Racing Transformed* is an example of this: as well as automated speed, participants expected to use accelerometer controls for steering vehicles, which were not implemented.

The design sensitivities and hazards we have discussed suggest that touchscreen game design needs to play strongly to native affordances without simplification of gameplay that challenges expectations.

This begs the question of whether, for touchscreens (or any new platform) a further level needs to be added to those shown in Figure 14: player background. However, this would suggests that touchscreen games must necessarily be seen as a form which is always compared against other platforms and which should do what other platforms do. It would also imply that good games have conventional / canonical forms in terms of content and control. However, as we have seen, when a game plays to platform affordances, there are new possibilities which allow the game to avoid comparison and to be engaged with on its own terms. This suggests that touchscreen games do not need to be seen as reworked derivatives of games as designed for other platforms; but could offer a completely independent experience. If so, the influence of background would be far less important: rather than bring expectations from experience with other platforms, touchscreen games would generate their own.

In turn this suggests new ways to think about what is ‘natural’ and intuitive. On one side this is just what is familiar; on the other, it refers to what works. What works seems to be immediate and is probably prior to what is familiar. It relates to simple, effective controls, clear game mechanics, and interactions with the right functionality. In other words, good design for touchscreens can achieve a compelling immediacy which, while it may depend logically on the content of a game, does not need to depend on the emulation of the familiar.

Future work can be envisaged along different lines. The research looked at six games across four genres: there is undoubtedly scope for looking at a higher number, including multiple exemplars of the same genre. Further work could be done to propose and establish which variables are significant as well as any that appear redundant: for example more fine-grained variables for controls (learnability, feedback) and levels of challenge. The research also suggests the need for practical work in game control design: experimental testbeds for touchscreen control approaches applied to different genres to evaluate with pools of users as part of iterative user-centered design processes.

More broadly, the research presented here points up issues of what is involved in change acceptance and change resistance in games design. Future research could look at novel configurations of controls and changed game mechanics to explore more about how far the space of design needs to respect the familiar and the conventional whilst striving to find new forms which provide compelling, intuitive experiences on their own terms.

REFERENCES

[1] Chou, K. (2013) Mobile Kills the Console But Advances the Gaming Industry. *Wired.com.* http://www.wired.com/opinion/2013/01/how-mobile-kills-the-console-but-advances-the-gaming-industry. Accessed 27 June 2019.

[2] Rogers, T (2013) Let's talk about touching: making great touchscreen controls. *Gamasutra.* http://www.gamasutra.com/view/feature/187126/lets_talk_about_touching_making_.php. Accessed 27 June 2019.

[3] Villamor, C., Willis, D. and Wroblewski, L. (2010) Touch gesture guide. https://www.slideshare.net/narf2916/touch-gestureguide. Accessed 27 June 2019.

[4] Browne, K., Anand, C. (2011). An empirical evaluation of user interfaces for a mobile video game. *Entertainment Computing*. 3 (1), p1-10.

[5] Serviss, B. (2013) Cracking the touchscreen code. *Gamasutra.* http://gamasutra.com/blogs/BenServiss/20130606/193728/Cracking_the_Touchscreen_Code.php. Accessed 27 June 2019.

[6] Gerling, K.M., Klauser, M. and Niesenhaus, J. (2011) Measuring the impact of game controllers on player experience in FPS games. *Proceedings of the 15th international academic mindtrek conference: envisioning future media environments (MindTrek'11)*. ACM, New York, pp 83–86

[7] Lee, A., Song, K., Ryu H.B., Kim J. and Kwon, G. (2015) Fingerstroke time estimates for touchscreen-based mobile gaming interaction. *Human Movement Science* (2015) 44:211-24

[8] Engl, S. and Nacke, L.E. (2013) Contextual influences on mobile player experience – A game user experience model. *Entertainment Computing*, 4, 1:83-91

[9] Weidner (2013) *Gamasutra.* http://www.gamasutra.com/view/feature/187126/lets_talk_about_touching_making_.php#comment189781. Accessed 27 June 2019.

[10] Hou, Z., Zhang, Y., Yang, Y. (2012) Enhancing Touch Screen Games Through a Cable-driven Force Feedback Device. *Virtual Reality and Visualization (ICVRV), 2012 International Conference*, 14-15 Sept. 2012 Qinhuangdao, pp 56 – 61

[11] Lee, J., Dietz, P., Leigh, D., Yerazunis, W. and Hudson S. (2004) Haptic pen: a tactile feedback stylus for touch screens. *UIST '04 Proceedings of the 17th annual ACM symposium on User interface software and technology* pp291-294

[12] Dempsey, S.J., Szablewski, M. and Atkinson, D. (2015) Tactile sensing in human–computer interfaces: The inclusion of pressure sensitivity as a third dimension of user input. *Sensors and Actuators A: Physical* 232 (2015) 229-250

[13] Statt, N (2015) Playing games on the PC is making a comeback *Cnet.com* http://www.cnet.com/uk/news/playing-games-on-the-pc-is-making-a-comeback/. Accessed 27 June 2019.

[14] Zaman, L., Natapov, D. and Teather, R.J. (2010) Touchscreens vs. Traditional Controllers in Handheld Gaming. *Futureplay '10 Proceedings of the International Academic Conference on the Future of Game Design and Technology*. Pages 183-190

[15] MOGA (2018) http://www.mogaanywhere.com. Accessed 27 June 2019.

[16] Rogers, S. (2012) *Swipe This! The Guide to Great Touchscreen Game Design*. UK: John Wiley and Sons Ltd.

[17] Stuart, K. (2011) Touchscreens, smartphones and the haptic future of games. *The Guardian.* https://www.theguardian.com/technology/gamesblog/2011/jun/02/future-of-touchscreen-gaming. Accessed 27 June 2019.

[18] Cummings, A.H. (2007) The Evolution of Game Controllers and Control Schemes and their Effect on their games. In *Proceedings of the 17th Annual University of Southampton Multimedia Systems Conference (MC07)*, Southampton, UK.

[19] Wigdor, D. and Wixon, D. (2011) *Brave NUI World: Designing Natural User Interfaces for Touch and Gesture*. Elsevier

[20] Valli, A. (2008) The design of natural interaction. *Multimedia Tools and Applications* (2008) 38:295-305

[21] Norman, D. (2010) Natural Interaction Is Not Natural. *Interactions* 17 (3): 6-10.

[22] Bachl, S., Tomitsch, M, Wimmer, C, Grechenig, T (2010) Challenges for designing user experience of multi-touch interfaces. In *Proceedings of Engineering Patterns for Multi-Touch Interfaces workshop (MUTI'10)*. ACM.

[23] Poels, K., de Kort, Y. and Ijsselsteijn, W. (2012) Identification and Categorization of Digital Game Experiences: A Qualitative Study Integrating Theoretical Insights and Player Perspectives. *Westminster Papers in Communication and Culture*. 9 (1): 107–129.

[24] Calvillo-Gámez, E.H., Cairns, P. and Cox, A.L. (2010) Assessing the Core Elements of the Gaming Experience. In R. Bernhaupt (Ed.) *Evaluating User Experience in Games*. (pp. 47-71). Springer

[25] Drachen, A. and Nacke, L. (2011) Towards a Framework of Player Experience Research. *Proceedings of the 2011 Foundations of Digital Games Conference, EPEX 11 Workshop*.

[26] McCarthy, J. and Wright, P (2004) *Technology As Experience*. MIT

[27] Rogers, R., Sharp, H. and Preece, J. (2015) *Interaction Design (4TH Ed)*. Wiley

[28] Hekkert, P. (2006) Design aesthetics: Principles of pleasure in design. *Psychology Science*, 48, 2:157-172

[29] Barnett, L., Harvey, C. and Gatzidis, C. (2018) First Time User Experiences in mobile games. *Entertainment Computing* 27 (2018) 82-88

[30] Laitinen, S (2005) Better Games Through Usability Evaluation and Testing *Gamasutra* http://www.gamasutra.com/view/feature/130745/better_games_through_usability_.php. Accessed 27 June 2019.

[31] ISO 9241-11 (2018) Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts. https://www.iso.org/obp/ui/#iso:std:iso:9241:-11:ed-2:v1:en. Accessed 27 June 2019.

[32] Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience*. Harper & Row.

[33] Sweetser, P. and Wyeth, P. (2005) GameFlow: a model for evaluating player enjoyment in games. *Computers in Entertainment (CIE) - Theoretical and Practical Computer Applications in Entertainment.* 3 (3): 1-24

[34] Cairns, P., Cox, A., and Nordin, A. I. Immersion in digital games: a review of gaming experience research. In *Handbook of digital games*, M. C. Angelides and H. Agius, Eds. Wiley-Blackwell, 2014, 339–361.

[35] Brown, E. and Cairns, P. (2004) A grounded investigation of immersion in games. *ACM Conf. on Human Factors in Computing Systems, CHI 2004*, ACM Press, 1297-1300

[36] Poels, K., de Kort, Y. and IJsselsteijn, W. (2007) Its always a lot of fun! exploring dimensions of digital game experience using focus group methodology. In *Proc. of FuturePlay 2007*, 83–89.

[37] Desurvire H., Wiberg C. (2009) Game Usability Heuristics (PLAY) for Evaluating and Designing Better Games: The Next Iteration. In: Ozok A.A., Zaphiris P. (eds) *Online Communities and Social Computing. OCSC 2009. Lecture Notes in Computer Science, vol 5621*. Springer, Berlin, Heidelberg.

[38] Järvinen, A., Heliö, S. and Mäyrä, F. (2002) *Communication and Community in Digital Entertainment Services*. Prestudy Research Report, Hypermedia Laboratory, University of Tampere.

[39] Desurvire, H., Caplan, M. and Toth, J. A. (2004) Using Heuristics to Evaluate the Playability of Games. In *CHI '04 extended abstracts on Human factors in computing systems* (Vienna, Austria). ACM, 2004, 1509-1512.

[40] Korhonen, H. and Koivisto, E. M. I. (2006) Playability Heuristics for Mobile Games. In *Proceedings of the 8th conference on Human-computer interaction with mobile devices and services* (Helsinki, Finland). ACM, 9-16.

[41] Nacke, L. (2009) From Playability to a Hierarchical Game Usability Model. *FuturePlay @ GDC Canada*, May 12-13 2009, 11-12.

[42] Lazzaro, N. (2004) Why We Play Games: Four Keys to More Emotion in Player Experiences. *Proceedings of GDC'04 Game Developer Conference.*

[43] Johnson, D. and Gardner, J. (2010) Personality, motivation and video games. *OZCHI'10 Proceedings of the 22nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction*. Pages 276-279

[44] Mandryk, R., Atkins, M. S., and Inkpen, K. A continuous and objective evaluation of emotional experience with interactive play environments. In *CHI '06: Proceedings of the SIGCHI conference on Human Factors in computing systems* (New York, NY, USA, 2006), ACM, pp. 1027–1036.

[45] IJsselsteijn, W.A., de Kort, Y.A.W. and Poels, K. (2013). *The Game Experience Questionnaire*. Eindhoven: Technische Universiteit Eindhoven.

[46] Procci K., Singer A. R., Levy K. R., & Bowers C. (2012). Measuring the flow experience of gamers: An evaluation of the DFS-2. *Computers in Human Behavior*, 28(6), 2306–2312.

[47] Harpsted, E., Zimmermann, T., Nagapan, N., Guajardo, J.J., Cooper, R. and Solberg, T. (2015) What Drives People: Creating Engagement Profiles of Players from Game Log Data. *CHI PLAY '15 Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play*. Pages 369-379

[48] Lankes, M. and Bernhaupt, R. (2011) Using embodied conversational agents in video games to investigate emotional facial expressions. *Entertainment Computing* 2 (2011) 29–37

[49] Martel, E. and Muldner, K. (2017) Controlling VR games: control schemes and the player experience. *Entertainment Computing* 21 (2017) 19–31

[50] Ferdig, E. R. (2009) *Handbook of Research on Effective Electronic Gaming in Education.* IGI Global.

Highlights

- Experimental work on the value of touchscreens for gamer experience
- Proposes a gamer experience framework with 3 levels, deployed as 3 variables
- Compares the same games across three different platforms: touchscreen, console, PC
- Offers a set of design implications for future development of touchscreen games