A Study on the Combined Effect of Screen Size and Game Type on Game Immersion

Richard P.M. Neves
SMCSE
City University London
United Kingdom
rpmn72@hotmail.com

Dr Christopher Child
SMCSE
City University London
United Kingdom
C.Child@city.ac.uk

ABSTRACT
As a consequence of devices becoming more portable, we are playing games on smaller screen sizes. Published research has looked at the effect of game type or screen size on immersion, but not together. This paper reports on a study to investigate the combined effect of these dimensions, in particular to determine whether a narrative-based game (believed to be more immersive) would mitigate any effect a small screen size had on game immersion. We tested 20 participants playing either an arcade or third-person shooter game on a smartphone or desktop computer, and measured their experience using the Immersive Experience Questionnaire (Jennett et al., 2008). Analysis of the results suggested that there was a statistically significant difference in immersion scores between the different screen sizes. However, when comparing game type and screen size, our results suggested that there was no statistically significant difference in the immersion scores of participants who played the third-person shooter on the smartphone or desktop computer. This was not expected and may suggest that small screens have the same potential for immersion as larger screens.

CCS Concepts
• **Human-centered computing ~ User studies** • **Human-centered computing~Interaction devices** • *Human-centered computing~Interaction techniques* • **Applied computing ~ Computer games** • *Computing methodologies ~ Cognitive science* • *Computing methodologies ~ Graphics systems and interfaces*

Keywords
Games; immersion; screen size; mobile; desktop

1. INTRODUCTION
The games market is expected to exceed $118 billion in 2019 [17], partly due to the dramatic increase in mobile gaming. Gaming on smartphones is a popular pastime and in research conducted in the US, it is said to be a daily activity by a third of those questioned [13]. Games like *Angry Birds* and *Candy Crush* have become familiar to us all due to their success on smartphones and tablets. However, these are arcade games that you can play for a few minutes and leave, returning to them when you have some time to spare. But how do the more elaborate, plot-driven games fare on the smartphone?

First-person shooters (seeing the world through the character you are playing) and third-person shooters (where you can see the character you are controlling in the game), like the *Call of Duty* and *Grand Theft Auto* series, respectively, have traditionally been produced with the desktop computer and games console (larger screens) in mind. The plot and narrative associated with these games have also been found to play a key role in the gaming experience [6]. But as more of these narrative-based games become available on smartphones (and to a much wider audience), can they be as immersive as they were on the much bigger screen?

In the gaming world, immersion is a term used to describe how the gamer is consumed by the virtual reality they are in and become less aware of the real world outside the game [11]. Immersion is considered to be a good measure of the gaming experience: high levels of immersion – where the gamer has a sense of being in the game is deemed a positive response. *Flow*, an early concept of immersion was well documented in the work of Mihayl Csíkszentmihályi [4] who through his studies on happiness described it as a state in which the individual is so consumed by an activity that all other concerns are temporarily forgotten. We are now aware of several factors that contribute to immersive gaming experiences, from graphics and sound [14] to narrative [18] and even the gamer's own personality and preferences [9, 22].

2. RELATED WORK
The rise in gaming platform variety has led to research on how these differences impact on game immersion.

2.1 Screen Size Impact on Immersion
It is taken for granted that a bigger screen will provide greater immersion [8], but this has not been backed up by all research. While Lombard et al. [15] reported a more immersive experience when showing video clips on large screens compared to small, a similar study by Bracken and Pettey [2] revealed that the *iPod* provided a more immersive experience than a 32" television

screen. Other research by Thompson, Nordin and Cairns [20] and Hou, Nam, Peng and Lee [10] comparing screens sizes when playing games corroborated with Lombard et al., that the larger screens provided the more immersive experience.

2.2 Sound Impact on Immersion

Research by van den Hoogen, Ijsselsteijn and de Kort [21] showed that higher sound levels were highly influential on immersion. More recent research evaluated the immersive potential of sound versus visuals in gaming [19] and concluded that better sound quality enhanced game immersion, whereas image quality did not have a significant impact on immersion.

2.3 Narrative in Immersion

Aside from characters and plot, other narrative devices are commonly used in story-based games, including cut-scenes (a video sequence during which the player has no or only limited control), comic-style storyboards and voiceovers. These approaches can effectively move a story along, but can have a mixed impact on the immersion [12]. Qin, Patrick Rau and Salvendy [18] devised a narrative questionnaire to determine the influence of narrative factors (curiosity, concentration, comprehension, control, challenge, empathy and familiarity) on game immersion. Their research showed that challenge, concentration and control were required for immersion. In addition, gamer curiosity was a common factor influencing player immersion [1].

2.4 Measuring the Immersive Experience

Quantifying the immersive experience has mainly been through the use of questionnaires; however, the use of psychophysiological approaches for recording immersion is slowly being introduced to gameplay studies. Questionnaires have a key benefit over psychophysiological monitoring because they are administered after the gaming session, avoiding any concerns that the measure has interrupted the immersion process. There are several gaming experience questionnaires; however, it is the *Immersive Experience Questionnaire (IEQ)* [11] that has had substantial extensive use and consequently, validity.

In 2008, Jennett et al. created the IEQ using the findings from Brown and Cairns' immersion grounded theory [3], flow studies [5], cognitive absorption [1] and presence [23]. The questionnaire items considered both the cognitive and gameplay aspects of the gamer's experience through 31, 7-point Likert-scale questions, plus a single question measure of immersion (on a scale of 1-10) – in order to ensure the calculated scores are in-line with the overall gamer reported immersion. The higher the calculated IEQ score the more immersive the experience is deemed to be.

Our paper reports on a study designed to measure differences in immersion due to the combined effect of screen size and game type. By looking at both the physical attributes of the gaming environment and the type of game being played, the study addresses a gap in the current body of game immersion research.

The research questions we wanted to answer were:

- Can different game types be equally immersive independent of the device on which they are played?
- Can narrative-based games originally designed for desktop computers and console systems remain immersive when transferred to a smartphone?

To answer these we tested the following hypotheses:

- H_0: When playing a game, immersion is unaffected by the screen size on which the game is played
- H_1: When playing a game, immersion is significantly affected by the screen size on which the game is played

- H_0: When playing a narrative-based game on a smaller screen, immersion is unaffected
- H_1: When playing a narrative-based game on a smaller screen, immersion is significantly affected

3. METHOD

The experimental design was largely informed by methods reported in academic research, Section 2, with our focus on the dimensions of screen size and game type.

3.1 Participants

Twenty participants, mostly postgraduates at City University London, were recruited. As we recognised that the selection of participants created a bias in the reporting of our results we acknowledged the bias and small sample by prefacing all statistical findings with 'suggested'. There was a 50:50 split between males to females with the average participant age of 32, ranging from 25-45 (*SD* 6.64). All but one of the participants had over five years of gaming experience on multiple platforms.

3.2 Games

For this experiment, we wanted participants to play two different style games by using narrative as the differentiator, which research has shown has a positive influence on game immersion [12, 18]. The game types selected were arcade and third-person shooter (3PS).

Arcade game – this had to be a simple game that did not require too much effort, and possibly quite repetitive [11]. *Fruit Ninja* (classic mode) by Halfbrick Studios is a fast-paced game where the player earns points by slicing fruit with a blade by swiping their finger across the screen (smartphone), or by clicking and dragging the mouse (desktop), as the fruit randomly flies across the screen (Figure 1). If players fail to slice three pieces or slice one of the occasional bombs the game ends.

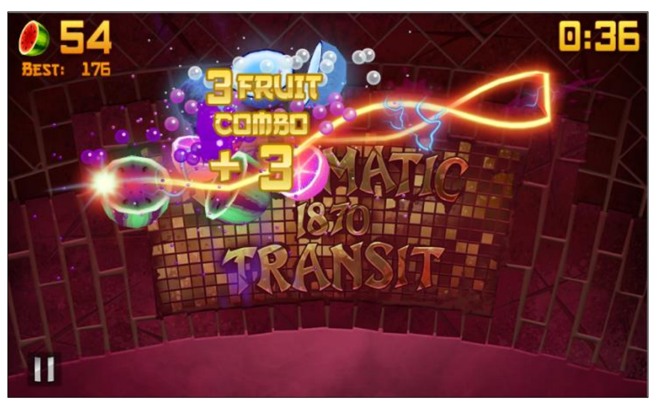

Figure 1. A smartphone screenshot of Half Brick Studio's *Fruit Ninja*

Third-person shooter – this had to have a solid story and plot and feature narrative devices such as voiceover narration and cut-scenes. *Max Payne* by Remedy Entertainment is a story-driven game in which the player takes on the role of the title character and immediately embarks on a story of revenge that involves gunfights and puzzle-solving. In addition, graphic novel panels with voice overs are used to narrate the game (Figure 2).

Figure 2. A smartphone screenshot of *Max Payne*, with the controller on the left and key actions: interact, jump, bullet time and shoot on the screen as buttons on the right

It was important that the games were available on both the smartphone and desktop, with no changes to the gameplay. Although *Fruit Ninja* was originally created for tablets and smartphones, it could be played on a PC, through the android emulator *BlueStacks App Player for Windows* (beta-1) by BlueStacks.

3.3 Devices

In this experiment we used the *Nexus 4* by LG. This is a touchscreen smartphone running version 4.3 (*Jelly Bean*) of the Android operating system. The screen size was 4.7" diagonally. Our comparator gaming device was a Sony *Vaio* VPCF12MOE. This is a large, desktop-style laptop running *Windows 7 Home Premium*. The screen size was 16.4" diagonally, and in addition a standard infrared-corded mouse was connected to the PC.

To ensure any external noises did not affect the gaming experience, participants wore light-weight, ear-cup, full-stereo headphones (*Sony MDR-V150*).

3.4 Conditions

All test sessions took place in isolated rooms at the university. There were four experimental condition groups, each with five participants (Table 1). A counterbalanced approach was employed to ensure alternation between smartphone and desktop for each test session.

Table 1. The four experimental condition groups for the main study, columns represent the order the games were played

Group	Smartphone Game	Desktop Game
A	Arcade	Arcade
B	3PS	3PS
Group	**Desktop Game**	**Smartphone Game**
C	Arcade	Arcade
D	3PS	3PS

3.5 Procedure

The study was conducted over a two-week period and each test lasted up to one hour.

3.5.1 Welcome, Consent and Demographic Questionnaire

Participants were welcomed and thanked for their involvement in the study and were taken into the testing room. They were told that in order to ensure they all received the same information; the facilitator would read the instructions from a prepared script.

Each participant was asked to sign the experiment consent form. The participant was then asked if they had any questions, before being asked to complete a demographics questionnaire.

3.5.2 Experiment

During the experiment participants were left alone in the testing room (to avoid any distraction/unease). The facilitator was sitting outside, available for assistance, should the participant have needed it [20]. Participants were allowed to train on the game before commencing the main game playing period [11]. While all participants instantly understood *Fruit Ninja*, a tutorial was important for participants who had not played *Max Payne* or 3PSs before. Participants assigned to play the arcade game (Groups A and C) trained and played the game for shorter periods of time – to minimise boredom.

Each testing session was broken down into the following stages:

- Training: 5 minutes on 3PS game; 1 minute on arcade game – facilitator present
- Playing: 15 minutes on 3PS game; 8 minutes on arcade game – facilitator absent
- Evaluation: 5 minutes for completing the IEQ – facilitator absent
- Repeated for the alternative platform

3.5.3 Closing questionnaire

A semi-structured interview using a closing questionnaire on the gaming experience was conducted. In order to accurately document the participant responses the audio was recorded. When the questionnaire was completed, participants were thanked and told that the experiment was over and they were free to leave.

4. RESULTS

The mean IEQ scores for each of the four gaming conditions were calculated, irrespective of the platform order on which the game was played. The arcade game on the smartphone produced a higher IEQ, mean score of 119.40 (SD = 25.03) than when played on the desktop (M = 84.80, SD = 17.56). However, the difference in the means between the platforms when playing the 3PS was less obvious, with the smartphone showing a slightly higher mean IEQ score 100.70 (SD = 19.55), than the desktop (M = 91.30, SD = 31.82).

To test the first hypothesis, H_0: *When playing a game, immersion is unaffected by the screen size on which the game is played*, the IEQs were compared for the two screen sizes each for the arcade and 3PS game in a paired-sample t-test [16].

There was a suggested statistically significant difference in mean IEQ scores between the platforms for the arcade game (Figure 3), with the smartphone scoring higher than the desktop, 34.60 (95% CI, 15.21 to 53.99), $t(9) = 4.036$, $p = .003$, $d = 1.28$. The effect size, d, indicated that this was a large effect. There was no suggested statistically significant difference in mean IEQ scores between the platforms for the 3PS game. However, the smartphone scored higher than the desktop, 9.40 (95% CI, -3.24 to 22.04), $t(9) = 1.683$, $p = .127$.

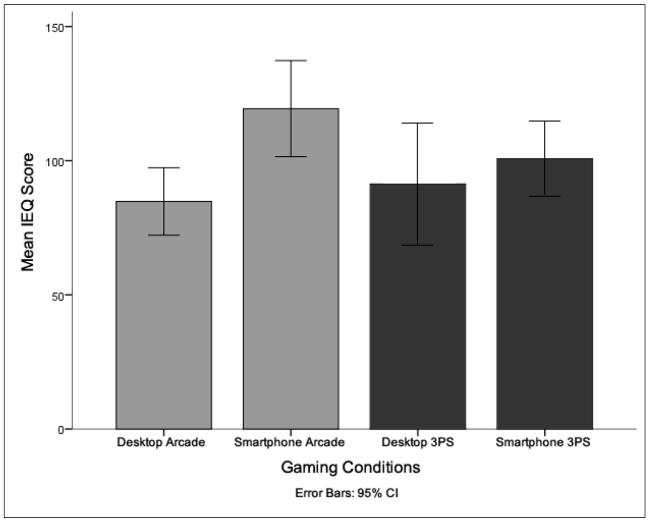

Figure 3. A comparison of the Mean IEQ scores between the platforms for the arcade (left) and 3PS (right) games, with 95% confidence interval error bars

The null hypothesis that immersion is unaffected by the screen size on which the game is played was rejected in favour of the alternative hypothesis for the arcade game. However, in the case of the 3PS game the null hypothesis was supported.

From the scores it appeared as though when the arcade game was played on the smartphone second the IEQ was considerably higher as opposed to when it was played on the smartphone first. There was little difference between the IEQs for the 3PS, irrespective of the platform or order of play. We performed t-tests comparing first and second order of platform play for both game types.

On analysing the arcade game when played on the desktop we found that the assumption of homogeneity of variances was violated, as assessed by Levene's test for equality of variances ($p = .013$). Due to the violation, we instead looked at the modified, unequal variance t-test (Welch t-test). Playing the arcade game on the desktop first did not suggest a statistically significant IEQ score, although the first play scored higher than the second play, 19.20 (95% CI, -4.87 to 43.27), $t(5.52) = 1.994$, $p = .097$.

The assumption of homogeneity of variances was also violated for the 3PS game on the smartphone, $p = .018$. Using the Welch t-test, playing the 3PS game on the smartphone first did not suggest a statistically significant IEQ score, although playing on it second was higher than when played on first, 14.80 (95% CI, -41.51 to 11.91), $t(5.59) = -1.380$, $p = .220$.

Analysing the arcade game on the smartphone showed that there was homogeneity of variances, $p = .250$. Playing the arcade game on the smartphone first did not suggest a statistically significant IEQ score, although playing on it second scored higher than the first play, 16.00 (95% CI, -20.46 to 52.46), $t(8) = 1.012$, $p = .341$.

Similarly, homogeneity of variances was found for the 3PS game on the desktop, $p = .411$. Playing the 3PS game on the desktop first did not suggest a statistically significant IEQ score, although the first play scored higher than the second play, 10.80 (95% CI, -40.253 to 61.85), $t(8) = .488$, $p = .639$.

We concluded that there was no suggested statistical significance between the order of play and the IEQ scores.

To test the second hypothesis, H_0: *When playing a narrative-based game on a smaller screen, immersion is unaffected,* we used the mixed ANOVA to analyse the data [16]. We were comparing between subjects (game type), and within subjects (screen size) against one dependent variable (IEQ score). The results suggested that there was a statistically significant interaction between the game type and platform on IEQ scores, $F(1,18) = 5.863$, $p = .026$, partial $\eta^2 = .246$.

The means and confidence intervals are shown in Table 2. There was also homogeneity of covariances, as assessed by Box's test of equality of covariance matrices ($p = .020$).

Table 2. The estimated marginal means of the IEQ scores for the four gaming conditions

Gaming Conditions	Mean IEQ Score	Standard Error	95% Confidence Interval	
			Lower Bound	Higher Bound
Arcade Desktop (*n*=10)	84.80	8.46	67.04	102.57
Smartphone (*n* =10)	119.40	6.87	104.97	133.83
3PS Desktop (*n*=10)	94.40	8.46	76.64	110.02
Smartphone (*n* =10)	97.60	6.87	83.17	113.22

To compare the groups we performed two separate between-subject ANOVAs (one-way ANOVAs) [16]. There was a suggested statistically significant difference in IEQ scores between the games on the smartphone platform, with the arcade game scoring higher ($M = 119.40$, $SE = 6.867$) than the 3PS $F(1, 18) = 5.040$, $p = .038$, partial $\eta^2 = .219$. There was no suggested statistical significance between the IEQ scores on the desktop, although the 3PS game had a greater IEQ score ($M = 94.40$, $SE = 8.456$) than the arcade game, $F(1,18) = .644$, $p = .433$, partial $\eta^2 = .035$.

In the closing questionnaire, participants were asked which platform they preferred and to explain why.

4.1 Arcade Game

Eight of the 10 participants stated that they preferred the smartphone over the desktop because their interaction with the game required less thought and that swiping the screen was easier than dragging the mouse. Participants also stated the graphics were poorer on the desktop and that the game appeared harder (they died more often). Participants were more positive about the smartphone stating that the graphics, colour and brightness were better on the platform ($n = 2$) and that they preferred the ability to focus on a smaller screen area (n = 2). However, three individual comments were made that holding the smartphone was painful; that the use of fingers to swipe got in the way of what was on the screen and lastly that the smartphone screen was not sensitive enough.

4.2 3PS Game

Seven out of the 10 participants preferred the controls on the desktop and the larger screen size (n = 4). One participant felt the game was faster on the desktop. Participants who did not prefer the desktop thought the game felt more intense (n = 1), the shooting target crosshair was too small (n = 1) and the graphics were poor (n = 1). On the smartphone, three participants preferred the graphics and liked being able to bring the screen closer and sit more comfortably (n = 3). They also cited that the story seemed nicer and the controls were *'cooler'* on the smartphone. However, four participants mentioned that the controls were difficult to use/covered the screen and that performing actions was difficult (n = 2).

5. DISCUSSION

We observed a suggested statistically significant difference between the IEQ scores of the two platforms for the arcade game, with participants scoring the smartphone platform higher than the desktop. Our results were at odds with the more common finding [10, 15, 20]. The difference could be reasoned based on the closing questionnaire where eight of the 10 participants stated that they preferred the smartphone because their interaction required less thought and swiping the screen was easier than dragging the mouse. This is of significance and would have likely had an adverse effect on the immersion scores. Csíkszentmihályi's [4] research identified 'effortless involvement' as a key factor in immersion.

We reported that the IEQ scores were unaffected by the platform when participants played the 3PS game. Based on previous research, one could have postulated a synergistic effect when combined a narrative-based game and large screen size. There does not appear to be any immediately obvious reason for the suggested insignificance, however, through feedback provided in the closing questionnaire, several factors may have contributed to balancing out the experience between the two platforms. For example, while participants enjoyed playing *Max Payne* on the desktop, they also commented that the graphics were 'not sharp' or seemed 'dated', whereas on the smartphone these appeared to be in high-definition. Image quality and the medium's vividness are important in immersion [14]. Also of note is that participants had reported that on the desktop version they felt 'unsafe' and that the game was 'scary', however, when playing on the smartphone they felt that they were more in control and there were more hints making it easier to know what to do.

Another consideration is that while *Max Payne* has some quite complex controls on the desktop, the simplification of the game controls for the smartphone may have potentially improved the immersion. Some participants also said that they preferred the smartphone because it allowed them to get more into the game, by bringing the screen closer or sitting more comfortably. Finally, we cannot ignore the statistics that show more people are playing games on their smartphones [7] – we may have been observing a shift/acceptance that traditional desktop or console game players may be more open to enjoying games on smartphones.

6. CONCLUSION

Our results present an interesting contribution to what we already know about game immersion. In particular, the results are of interest to the game development industry that will benefit from some of the reported insights for making better immersive gaming experiences. It seems we may have reached a point where non-dedicated portable devices, such as smartphones can have the same immersive potential as traditional gaming platforms. Of particular note is the finding that a more complex, narrative-based game has been shown to be equally immersive on two contrasting-sized screens.

Based on the results of this study, we think there are several potential angles for further research. Apart from the need to test the current study with much larger sample sizes, we also think valuable insights could be gleaned by designing studies that compare arcade and 3PS games with different themes (or violent versus non-violent) – as some participants said that it was the character and/or theme that they disliked about *Max Payne*. Another interesting study could look at screen size difference in immersion on a skewed population, for example gamers who have expressed a preference for 3PS games. Finally, an obvious comparison study would be using different game types on like-for-like platforms, i.e. two touch devices (a smartphone and a tablet) or two keyboard and mouse-based computers (a large screen laptop and a notebook). This would rule-out any differences in immersion due to the game controls.

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