You Can’t Take It with You? Effects of Handheld Portable Media Consoles on Physiological and Psychological Responses to Video Game and Movie Content

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Abstract

Portable media consoles are becoming extremely popular devices for viewing a number of different types of media content, both for entertainment and for educational purposes. Given the increasingly heavy use of portable consoles as an alternative to traditional television-style monitors, it is important to investigate how physiological and psychological effects of portable consoles may differ from those of television-based consoles, because such differences in physiological and psychological responses may precipitate differences in the delivered content’s effectiveness. Because portable consoles are popular as a delivery system for multiple types of media content, such as movies and video games, it is also important to investigate whether differences between the effects of portable and television-based consoles are consistent across multiple types of media. This article reports a 2×2 (console: portable or television-based x medium: video game or movie) mixed factorial design experiment with physiological arousal and self-reported flow experience as dependent variables, designed to explore whether console type affects media experiences and whether these effects are consistent across different media. Results indicate that portable media consoles evoke lower levels of physiological arousal and flow experience and that this effect is consistent for both video games and movies. These findings suggest that even though portable media consoles are often convenient compared to television-based consoles, the convenience may come at a cost in terms of the user experience.

Introduction

Increasingly, media consumers view their media in a convenient to-go size. By the end of 2008, 26.6 million units of the handheld portable Nintendo DS video game console were sold in the United States, along with 14.2 million units of the handheld portable Sony PlayStation Portable (PSP) video game and media console. Owners of Apple’s millions-selling iPhone and iPod portable media players can use them to download Hollywood films, and the college-bound can use their iPods to study for standardized entrance exams. Universities can use an Apple service to provide lecture videos for students to download on iPhone and iPod units.

The popularity of portable media consoles speaks to their convenience, but is there a trade-off involved in having our media always at hand? Are our fundamental physiological and psychological responses to media different when content is presented using portable media consoles as opposed to stationary, television-based consoles? Much research has focused on the effects of media content, but content is just one influential media attribute. A substantial body of literature examines the effects of formal media features, or “form variables.” Formal features that have been found to influence responses to media include picture motion, image size, color, visual resolution, audio fidelity, and video games’ technological advancement. Considering the influence of form variables, differences between portable and television-based media consoles could profoundly impact the effectiveness of the consoles’ content, but research on the issue is lacking. This study regards portability as a form variable, examining physiological and psychological responses to portable media consoles vis-à-vis television-based consoles. Specifically, we measure effects on two important experience dimensions, physiological arousal and flow experience, because they are associated with an entertaining media experience as well as with enhanced memory and learning. If portable media consoles differ from television-based consoles in their effects on these experience dimensions, then the implications for their effectiveness in entertainment and educational applications are substantial.
In the absence of existing research on effects of portable media consoles, prior studies dealing with physiological and psychological responses to image size7–9 provide some insight. Previous research has typically manipulated image size by comparing effects of a smaller television monitor or image projection with those of a larger version. In these previous studies, larger image sizes have generally been found to elicit higher levels of arousal8,9 and attention,9 as measured by physiological indicators. While portable media consoles’ screens are comparable with television and video monitors in terms of resolution and fidelity, portable consoles’ screens tend to be much smaller. For example, the Apple iPhone, which can be used to play video content, has a diagonal screen size of 3.5 inches, as does the iPod Touch (largest among the Apple iPod models that can play video). Sony’s PSP, which can be used to play video games and other video content, has a diagonal screen size of 4.3 inches. Although the image size research has not involved portable consoles and has not previously been extended to the video game medium, portable consoles’ small screens suggest that their effects on experience might mirror those found with previous image size studies. Therefore, we predict

**H1:** Television-based consoles will elicit greater levels of physiological arousal than will portable consoles.

In the image size studies,7,8 larger images also elicited more self-reported excitement,7,8 enjoyment,8 sense of movement,8 and feelings of presence8 (also called telepresence, or the feeling of “being there”)19,20. These responses touch on the concept of the flow experience,15,17,21,22 a merging of actions and awareness, with concentration so intense that there is little attention left to consider anything else.17(p58) Attributes of a flow state include enjoyment, intense concentration, arousal, loss of self-awareness through involvement in an activity, insensitivity to passage of time, and experience of an activity as intrinsically rewarding.15,17,21,22 While studies dealing specifically with image size and flow are lacking, research shows that other media form variables can influence the flow experience.23 Given that larger images have been found to elicit stronger psychological responses relevant to the flow experience,7,8 we predict

**H2:** Television-based consoles will elicit more self-reported flow experience than will portable consoles.

Effects of console type might vary for different types of media played on portable media consoles—for example, video games and movies. Given that this study is novel in exploring form variable effects with video games and movies in concert, we ask

**RQ1:** Will console type’s effects on physiological arousal and flow experience vary for different media, namely video games and movies?

Lastly, we ask whether one of our dependent measures (physiological arousal and flow experience) might mediate the effect of console type on the other measure:

**RQ2:** Will one outcome variable, either physiological arousal or flow experience, mediate the effects of console type on the other outcome variable?

**Method**

**Participants**

Sixty-two undergraduate students (35 male, 27 female) enrolled in communication courses participated in the study for course credit. Participants’ mean reported age was 19.82 years (SD = 1.79), their mean reported hours playing video games per week was 3.60 hours (SD = 5.66), and their mean reported hours watching movies per week was 5.51 (SD = 4.18).

**Design**

This study employed a 2 × 2 (console: portable or television-based × medium: video game or movie) mixed factorial design, with console as a between-participants factor and medium as a within-participants factor. The dependent variables of physiological arousal and self-reported flow experience, as well as other descriptive and control measures, were measured using physiological data collection equipment and questionnaire instruments.

**Stimulus materials**

All participants were assigned to play a video game and view a movie clip, with the order randomly counterbalanced to rule out order effects.

**Consoles.** The console variable was manipulated by randomly assigning participants to use either a PlayStation Portable (PSP) portable handheld console or a PlayStation 2 (PS2) television-based console for both media experiences. Both of these devices are manufactured by Sony Computer Entertainment and are designed to play both video games and movies using optical discs. Despite minor differences between the consoles’ technical specifications, their computing power and presentation quality have been described as very similar24 and essentially equal25,26 and the two consoles possess similar computing hardware characteristics.

**Media.** Participants viewed a clip from the film *Kingdom of Heaven* and played a game from the Prince of Persia series on one of the consoles. For the video game segment, they played either Prince of Persia: Warrior Within (PS2) or Prince of Persia: Revelations (PSP) for 12 minutes, starting at the beginning of the game. Although the games have different titles, the PSP game is a direct copy of the PS2 game adapted for play on the PSP. The PSP version includes some additional game play sequences late in the game’s storyline, but the participants’ 12-minute play sessions were not long enough to reach this added content. Therefore, the only effective difference between console conditions was the console on which the game was played. In the 12-minute Prince of Persia game segment, participants viewed a brief game introduction and then played a fast-paced scenario in which the player-controlled protagonist battles humanoids with swords and other medieval-era weapons aboard a ship. If a game ended because the player’s character was “killed” during the 12-minute session, the participant pressed a button to continue playing at a point in the game near where the previous game ended.

For the movie clip segment, participants watched a clip from the action film *Kingdom of Heaven*, a fictionalized por-
trayal of 12th-century European crusaders’ defense of the city of Jerusalem against Arab leader Saladin. The 12-minute film clip primarily featured siege battle scenes interspersed with occasional scenes depicting both warring sides’ battle preparations. Participants in both the portable and television-based console conditions watched the same clip, with the only difference being the console on which the clip was shown.

**Stimulus consistency checks**

Two measures were employed to ensure that presentation of the video game and movie clip stimuli was consistent across console types without varying along other dimensions (e.g., presentation quality or content). Because responses to media can be affected by variation in technological advancement\(^{14}\) and degree of violent content,\(^{27}\) checks were included to ensure that participants did not perceive differences between the two console types along these dimensions, thereby ruling out alternate explanations for effects of console type on the dependent variables. Perceptions of general technological advancement were measured after each stimulus segment with a “perceived advancement” index\(^{14}\) asking participants to rate their agreement with six statements about the video game or movie clip they had just experienced: that it “had high-quality graphics,” “had high-quality sound,” “had high-quality play control,” “was technologically advanced,” “was technologically sophisticated,” and “was new” (1, strongly disagree; 7, strongly agree; Cronbach’s α = 0.85 and 0.83 for game and movie clip indexes respectively). A Likert-type item\(^{14}\) measured perceptions of violent content after each stimulus segment by asking participants to rate their agreement with the statement, “The video game I just played (or “movie I just saw”) was violent” (1, strongly disagree; 7, strongly agree).

**Dependent variables**

**Physiological arousal.** Skin conductance level (SCL), recorded in microsiemens (μS), was used as a tonic measure of sympathetic nervous system activity indicating physiological arousal experienced by participants during each stimulus segment.\(^{26,29}\) Data were sampled 200 times per second at a sampling rate of 66.5 Hz with 0.5 volt excitation using a BIOPAC MP35 system during four time periods. The first SCL measurement was a baseline measure taken for a period of 30 seconds before participants played the game or viewed the movie clip. Second, SCL was measured throughout the first 12-minute stimulus segment (either the video game or the movie clip depending on the randomly assigned order). Third, another 30-second baseline SCL measurement was taken, and SCL was measured a fourth time during the second 12-minute stimulus segment. Physiological arousal for each of the two stimulus segments was calculated as the percentage change in mean SCL from the baseline segment to the accompanying stimulus segment (by subtracting the mean SCL for the baseline segment from the SCL for the accompanying stimulus segment, then dividing by the SCL for the baseline segment).

**Flow experience.** To measure participants’ assessment of their flow experience, the questionnaires administered after each stimulus segment included a measure adapted from Novak et al.\(^{22}\) Versions of this measure have been used to assess flow experience with media in several contexts, such as Web use generally,\(^{22,30}\) a specific Web site in a laboratory setting,\(^{29,31}\) online video games,\(^{32}\) an educational video game,\(^{33}\) and a Web-based learning system.\(^{34}\) For this measure, participants read a detailed description of the flow experience, then responded to the question, “To what extent did you experience ‘flow’ while playing this video game?” (or “while watching this movie,”) using a 7-point scale (1, not at all; 7, very much).

**Other measures**

Four other measures were included to collect descriptive information about participants and their relevant media use. The preexposure questionnaire asked participants’ sex, age, estimated hours per week watching movies, and estimated hours per week playing video games. Results for these measures are reported in the “Participants” section. The measures for movie and video game use were also used as potential control measures in analyses.

**Procedure**

Participants were seated in an armchair, completed the preexposure questionnaire, and removed the footwear from their nondominant foot so that two disposable adhesive Ag-AgCl electrodes could be attached to the foot above the abductor hallucis muscle midway between the medial malleolus and the proximal phalanx of the hallux. After a 30-second baseline SCL measurement, participants read an instruction sheet for the first stimulus segment (either video game instructions or information on the movie clip, depending on which stimulus was randomly assigned to be delivered first). The experimenter then started the first stimulus segment on the assigned media console. Depending on their random console type assignment, participants used either the PS2 console attached to a CRT television monitor with a diagonal size of 27 inches, positioned at a comfortable viewing distance 3 to 4 feet from the participant, or the PSP console, which participants held in their hands. SCL was recorded for the duration of the stimulus segment. After 12 minutes, the experimenter stopped the console and SCL measurement and gave participants the postexposure questionnaire for the first stimulus segment.

For the second stimulus segment, the entire procedure was repeated with the same console, but using the medium not used in the first segment (video game or movie clip), including another 30-second baseline SCL measurement, instruction sheet, 12-minute stimulus segment with SCL measured for the segment’s duration, and postexposure questionnaire. The electrodes were then removed and participants were debriefed, thanked, and dismissed.

**Results**

**Stimulus consistency checks**

Perceived advancement consistency. To rule out any possible confounding effects of perceived differences in technological advancement between consoles, a repeated-measures analysis of variance (ANOVA) was run with
console type as a between-participants factor, medium as a within-participants factor (the same factors were used in all subsequent ANOVA analyses reported here), and the perceived advancement index as a dependent variable. The main effect of console type was not significant, \( F(1, 60) = 0.009, p = 0.925, \eta^2_p < 0.001 \), nor was the main effect of medium, \( F(1, 60) = 0.001, p = 0.997, \eta^2_p < 0.001 \), nor the two-way interaction, \( F(1, 60) = 0.901, p = 0.346, \eta^2_p = 0.015 \). Including the number of hours spent per week playing video games and watching movies as covariates in an analysis of covariance (ANCOVA) produced no differences in significance for this or any other ANOVA test in the study, so the control measures and ANCOVA tests are not discussed further.

Perceived violent content consistency. To also rule out any possible confounding effects of perceived differences in violent content between consoles, a repeated-measures ANOVA was run with perceived violent content as a dependent variable. The main effect of console type was not significant, \( F(1, 60) = 0.138, p = 0.712, \eta^2_p = 0.002 \), nor was the main effect of medium, \( F(1, 60) = 0.455, p = 0.503, \eta^2_p = 0.008 \), nor the two-way interaction, \( F(1, 60) < 0.001, p = 0.992, \eta^2_p < 0.001 \).

In sum, results for the consistency check items indicate that there were no significant effects of console type on perceptions of technological advancement or the extent to which their content was violent, nor were there main effects of medium or a console-by-medium interaction effect on these perceptual dimensions. These findings rule out the possibility that differences in perceived advancement or intensity of violent content could serve as alternate explanations for any effects of console type observed in hypothesis tests.

Physiological arousal

Examination of SCL waveforms indicated three instances where data were flawed due to experimenter error or inconsistent equipment performance (i.e., a baseline measure was not recorded correctly or a skin conductance waveform indicated no consistent signal). With 248 total SCL baseline and stimulus measurements taken during the study (four with each of 62 participants), the rate of faulty SCL data was only 1.21%. For these cases, the sample mean was imputed to replace the flawed SCL percentage change measure for the relevant stimulus segment, with the SCL percentage change measure for the other segment left unaffected.

The distribution of the SCL percentage change measure was also susceptible to positive skewing because skin conductance level can increase by much more than 100% but cannot decrease by more than 100% from baseline because its minimum is zero. To normalize the distribution of the data, scores of at least two standard deviations (SD = 1.259 for video game, 1.470 for movie clip) above the mean SCL change (\( M = 0.233 \) for video game, \(-0.050 \) for movie clip) were replaced with the segment’s mean SCL change score. The SCL percentage change scores of three stimulus segments were more than two standard deviations above the sample mean (above 2.75, or 275% for the game, and above 2.89, or 289% for the movie clip) and were thusly replaced. After these procedures were completed, the skewness of the SCL data was not abnormal (<1.00 for both video game and movie clip SCL change measures).

To test whether console type affected participants’ physiological arousal, a repeated-measures ANOVA was run with the SCL percentage change measure as a dependent variable. (See Table 1 for a summary of results.) The main effect of console type was significant, \( F(1, 60) = 5.119, p = 0.027, \eta^2_p = 0.079 \), with a significantly more positive skin conductance change in the television-based console condition (\( M = 0.005, SE = 0.060 \)) than in the portable console condition (\( M = 0.174, SE = 0.052 \)). These results support H1. There was also a significant main effect of medium, \( F(1, 60) = 10.693, p = 0.002, \eta^2_p = 0.151 \), with a significantly more positive change in the video game condition (\( M = 0.059, SE = 0.057 \)) than in the movie clip condition (\( M = 0.228, SE = 0.061 \)). The two-way interaction between console type and medium was not significant, \( F(1, 60) = 1.807, p = 0.184, \eta^2_p = 0.029 \). This null interaction effect finding addresses RQ1 by indicating consistent effects of console type on physiological arousal across media.

Flow experience

To test whether console type affected participants’ self-reported flow experience, a repeated-measures ANOVA was run with the self-reported flow experience measure as a dependent variable. The main effect of console type was significant, \( F(1, 60) = 5.540, p = 0.022, \eta^2_p = 0.085 \), with significantly greater flow experience reported in the television-based console condition (\( M = 4.000, SE = 0.274 \)) than in the portable console condition (\( M = 3.143, SE = 0.240 \)). These results support H2. Significance was not found for the main

| Table 1. Summary of Means and F Values for Consistency Checks and Dependent Variables |
|---------------------------------------------|----------------|---------|--------|----------------|---------|--------|
|                                             | TV-based | Portable | F      | Game   | Movie   | F      |
| Consistency checks                           |          |          |        |        |         |        |
| Perceived advancement                        | 5.219    | 5.239    | 0.009  | 5.231  | 5.227   | 0.001  |
| Perceived violence                           | 5.759    | 5.857    | 0.138  | 5.752  | 5.865   | 0.455  |
| Dependent variables                          |          |          |        |        |         |        |
| Physiological arousal                        | 0.005    | -0.174   | 5.119* | 0.059  | 0.228   | 10.693**|
| Flow experience                              | 4.000    | 3.143    | 5.540* | 3.661  | 3.481   | 0.674  |

*p < 0.05; **p < 0.01.

Note: Reported means are estimated marginal means.
effect of medium, $F(1, 60) = 0.517, p = 0.475, \eta^2_p = 0.009$, nor the two-way interaction between console type and medium, $F(1, 60) = 0.179, p = 0.674, \eta^2_p < 0.003$. Again, this null interaction effect finding addresses RQ1 by indicating consistent effects of console type on self-reported flow experience across media.

**Mediation analyses**

Given that console type was found to have a main effect on both physiological arousal and self-reported flow experience, further analyses explored whether one of these dependent variables might mediate the effects of console type on the other. To compare both possible mediation paths, two competing repeated-measures path models were created following Kline’s recommendations. The first model featured console type, medium, and their interaction term as factors, physiological arousal as a mediating variable, and flow experience as the dependent variable. The second model included the same factors, but with the roles of flow experience and physiological arousal reversed. In response to RQ2, the results of the comparison were inconclusive, as the path from physiological arousal to flow experience ($b = 0.593, p = 0.022$) in the first model was roughly equivalent to the path from flow experience to physiological arousal ($b = 0.602, p = 0.023$) in the second model. Both models exhibited a very good fit with the data, but the fit indicators for the model with physiological arousal as a mediator, $\chi^2(13) = 6.286, p = 0.36$; expected-cross-validation index (ECVI) = 0.595; root-mean-squared error of approximation (RMSEA) = 0.0, $p$ of close fit (pclose) = 0.965; standardized root mean residual (SRMR) = 0.0583, were too similar to the indicators for the model with flow experience as a mediator, $\chi^2(13) = 6.654, p = 0.22$; ECVI = 0.601; RMSEA = 0, pclose = 0.955; SRMR = 0.0525, to permit a definitive conclusion regarding a mediation path.

**Discussion**

The popularity of portable media consoles is justified, as portable media players provide flexibility and convenience regarding the locations and settings in which they can be used. The present study’s findings, however, indicate that this convenience comes at a cost to the user’s media experience. Portable media consoles may be handy, but the experience they provide is not the same. In this study, portable media consoles elicited less physiological arousal and self-reported flow experience compared to television-based consoles, and this effect of console type was consistent across two different types of media—a video game and a movie clip. In addition, console type’s effects do not appear to be due to differences in technological quality or intensity of content presentation, as participants did not rate the consoles as significantly different in terms of technological advancement or amount of violence in the presented content.

**Theoretical implications**

This study extends the body of research on form variable effects into the realm of portable media consoles by showing that portable consoles elicit diminished physiological and psychological responses compared to their television-based counterparts. In addition, the finding that the physiological and psychological effects of portable consoles are consistent across two different media—a video game and a movie clip—speaks to the robustness of these effects. Further research should explore what specific dimensions of portable consoles influence their effects and what other physiological (e.g., facial electromyogram as a measure of emotional response, electroencephalogram as a measure of attention), cognitive, and affective responses are affected by portable consoles. Ideally, such responses should be explored in concert as we have done here so that physiological and questionnaire data can complement and inform one another.

Although this study focused on effects of console type, there was also a main effect of medium on physiological arousal, with the video game eliciting more arousal than the movie clip. This effect lends itself to multiple interpretations. It may be that the effect is merely an indicator of the slightly increased physical activity (e.g., moving thumbs) required for video game play compared to movie viewing or the result of some idiosyncratic difference between the specific game and film used here that would not be observed with different stimuli. Alternatively, though, the effect may suggest that the video game medium elicits fundamentally different psychological responses compared to other media such as film and television. Future research focusing on psychophysiological responses to different media can explore the issue further.

This study identified portable consoles’ effects on both physiological arousal and self-reported flow experience, but we did not find clear evidence for a mediating relationship in console type’s effects on these experience dimensions. A mediation relationship may exist despite the inconclusive results, or both effects may have been instantiated concurrently because both dependent variables were convergent indicators of the same experiential phenomenon. Further research can continue to examine whether there are causal mediated relationships in consoles’ physiological and psychological effects or whether they occur concurrently.

**Practical implications**

This study’s findings also inform portable media consoles’ application. In many instances, the convenience they provide may outweigh the reduction in physiological and psychological response that we have observed. However, there are scenarios where our findings suggest caution in choosing console types. Physiological arousal and flow experience are two components associated with an entertaining media experience as enhanced memory and learning. If portable media consoles diminish these media experience dimensions, then these effects should be taken into consideration in their use. For example, a video game or film distributor providing advance copies of a product to critics might be wise to use a version made for a television-based console lest the product provide a less exciting and engaging experience. Similarly, a student may enjoy the convenience of a portable media console when studying for an examination or watching a lecture, but other formats might be more effective for learning. Portable media consoles are not without advantages, but they may not be ideal in all situations.

**Limitations**

Aside from the typical limitations of experiments, a few limitations particular to this study should be noted. Our study’s 12-minute stimulus segments were enough to generate
observational differences in the dependent measures, but effects might be different with longer media use sessions. Similarly, we explored console effects with two different entertainment media, but others, such as educational media or Web applications, should be studied to see if effects remain consistent. Effects on user experience might also be different when additional equipment is used with portable devices (e.g., earphones instead of the main speakers) or with different portable devices. A final limitation is that while the effects we observed on our flow measure add to an understanding of portable devices' effects on the flow experience, the measure may not have fully assessed all aspects of the flow experience. As with many similar flow experience measures used in previous research,22,30–34 our measure may have tapped aspects of the flow experience related to engagement and involvement, but not other aspects of the concept, such as the balance between participants' skill and challenge.15,21 Future research on effects of portable consoles, as well as on the flow experience more generally, should consider alternative measures to assess effects on the full conceptual spectrum of the flow experience.

Conclusions

By no means should this study be taken to mean that portable media consoles are inferior to other media consoles. Their advantages are many, and they add great flexibility to media use options. What is worth extracting from our findings, though, is that when media users grab a portable media console to take that video game or movie out the door with them, they may also be leaving behind a little bit of the media experience they desire.

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Disclosure Statement

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References

2. Graham J. Now showing at an iPod near you: Apple to rent movies through iTunes store. USA Today, Jan. 16, 2008, 2B.
