Flow Encourages Task Focus, but Frustration Drives Task Switching

How Reward and Effort Combine to Influence Player Engagement in a Simple Video Game

Nicholas David Bowman
Texas Tech University
nick.bowman@ttu.edu

Justin Robert Keene
Texas Tech University
Justin.R.Keene@ttu.edu

Christina Jimenez Najera
Texas Tech University
Christina.J.Najera@ttu.edu

ABSTRACT

The current study explores the relationship between perceived cognitive and physical demands of a simple video game, and the balance of reward and effort that results in flow states during gameplay. Cognitive demands and both exertion-based and controller-based physical demands were perceived as lowest in situations where reward was high and effort was low (boredom), moderate when reward and effort were balanced (flow), and highest when the reward was low and effort was high (frustration). Surprisingly, player response times to a secondary task showed the greatest improvement when playing the frustrating video game condition. We interpret this latter finding as evidence of an observed task-switching effect: players initially tried to master the game's over-challenging primary task before giving up and, instead, diverted attention toward a secondary in-game task that required less effort and thus, gave greater attentional rewards to the player. The implications of this cognitive offloading are discussed.

KEYWORDS

flow theory, video games, reward, effort, interactivity-as-demand

ACM Reference Format:

Nicholas David Bowman, Justin Robert Keene, and Christina Jimenez Najera. 2021. Flow Encourages Task Focus, but Frustration Drives Task Switching: How Reward and Effort Combine to Influence Player Engagement in a Simple Video Game. In *CHI Conference on Human Factors in Computing Systems (CHI '21)*, May 08–13, 2021, Yokohama, Japan. ACM, New York, NY, USA, 8 pages. <https://doi.org/10.1145/3411764.3445678>

1 INTRODUCTION

From their earliest prototypes in the 1940s to a global entertainment industry today, video games have fascinated and frustrated players for nearly eight decades. Video games provide users with varying degrees of control over the form and content of on-screen actions [46]. This control is a core source of the appeal of gaming [20] and can facilitate the experience of flow—a state in which game challenges are balanced with player skills and as result, the player becomes fully immersed in the activity [12]. Yet, video games can be demanding on several dimensions, as they require the players'

near-constant attention to cognitive, emotional, physical, and social elements of gameplay [4]. The current study examines the relationship between perceived player demands and reward and effort critical to flow states.

1.1 Flow and Video Games

Flow, according to its original theorizing, is an enjoyable, absorbing, and engaging experience [12]. The experience of flow is often characterized by the (1) merging of action and awareness, (2) a distortion of time, and (3) a balancing of intrinsic reward and self-motivated behavior during a specific action [12, 34]. Tasks likely to facilitate flow states are those that are intrinsically, rather than extrinsically, motivated [41], and as such, represent experience in which effort expenditure is enjoyable [26].

Given their interactive nature, flow is particularly relevant for understanding video game enjoyment [10, 43]. For example, both intrinsic reward and attention were highest when the difficulty of the game matched the skill level of the player, but lower when game difficulty was too low (boring) or too high (frustrating) for the player [27]. This pattern has been replicated as a measure of whether a flow state has been initiated through a series of both behavioral and neural measures [23, 24], and self-report findings support claims that flow manifests as a “Goldilocks-type” state between boredom and frustration [10, 12, 43].

1.2 Reward, Effort, and a Sync Theory of Flow

Recent work has conceptualized flow by investigating the dynamic restructuring of neural activity in a synchronous manner [51]—that is, to focus on flow as a cognitive and behavioral process. This perspective was formalized as the synchronization theory of flow [52], which expands the flow construct to include a set of neurophysiological assumptions and predictions. The synchronization theory of flow proposes that the experience of flow is driven, at least in part, by energetically efficient patterns of discrete brain connectivity between cognitive control and reward networks [23, 51].

In addition to the measurement of neural activity during flow experiences, the *sync theory of flow* also gives us a series of behavioral measurement predictions. One such measure, from the limited capacity model for motivated mediated message processing [15, 17, 29], is the secondary task reaction time (STRT), which assesses the amount of resources available for processing during a given mediated task [30]. Individuals who are more absorbed in a focal task (such as a video game, during a flow state) have fewer resources available for allocation and thus, tend to react slower to extraneous (re: secondary) stimuli. For example, increasing either the cognitive load (introducing novel game instructions) or

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).
CHI '21, May 08–13, 2021, Yokohama, Japan
© 2021 Copyright held by the owner/author(s).
ACM ISBN 978-1-4503-8096-6/21/05.
<https://doi.org/10.1145/3411764.3445678>

perceptual load (cluttering the on-screen environment with additional shapes and colors) resulted in slower STRT responses to a secondary visual task [16]. Given that flow states are characterized in part by a loss of awareness, validating behavioral measures of flow helps assess states *in situ* rather than relying on recollection measures that might conflate flow with other outcomes [4].

1.2.1 Balancing Resource Demands in Video Games. One of the primary sources of a video game’s appeal is its interactivity [21]. At the same time, their interactive nature is also a source of variable and multimodal demand of the player’s limited attentional resources. These limits have consequences for how players engage with game efforts and rewards, and these consequences depend on the type of demand being experienced at a given time.

Four such demands of video games have been identified [4, 5, 8, 28]. *Cognitive demands* refer to the requirement for players to rationalize the on-screen challenges and puzzles, in terms of learning the systems involved [18] and having the requisite cognitive skills to understand play [19, 20]. *Emotional demands* refer to player’s basic or circumplex affective reactions and can range from more hedonic to more complex and eudaimonic in nature [22, 36]. *Physical demands* refer to both how natural and intuitive a game’s haptic interface is perceived as (naturalness seen as less demanding), as well as the extent to which players exert themselves while playing [31]—these demands are referred to controller demands and exertional demands, respectively. *Social demands* refer to how players engage with other social actors during gameplay, both human and non-human [2, 45]. Notably, although these demands are conceptually distinct from one another, they can and do complement each other. For example, moderate correlations have been reported between recollections of cognitive demand and increased emotional and exertional demands [5, 8, 28]. For the former, emotional demands are often associated with narrative involvement that also requires cognitive engagement to make sense of in-game decisions [9, 42]; for the latter, in-game decision making is usually manifested by one’s physical manipulation of the game controller [39].

Given players’ limited capacities to process mediated information [15, 26], it is plausible that players might explicitly or implicitly shift their attention to some demands over others, especially when there is a perceived or actual conflict among demands. For example, in an experiment that randomly assigned individuals to play a first-person shooter, either alone or while live-streaming, the cognitive and physical demands of the game seemed to override the player’s attention to the social demands of an audience [50]—cognitive and physical demands might have been given attentional primacy if players were experiencing a flow state by which extraneous cues, such as audiences and onlookers, would have been perceived as secondary tasks and thus, irrelevant to focal gameplay. Controller systems that were either unintuitive [31] or overly complex [6, 7] were perceived as frustrating. From a demand perspective, these findings could be explained as situations in which certain control schemes were unfamiliar to players and thus, required a steep learning curve that took away from effort allocation to other demands and resulted in little reward (given that in-game performance usually suffered). For the latter study, the inclusion of multiple controller consoles as part of a flight simulator required an uncommonly high level of physical exertion (moving rapidly

between consoles) that pulled player attention from the primary task of flying and safely landing a fighter jet—a finding common in similar task load research [40].

1.3 Hypotheses

As flow is the product of a dynamic balance of reward and effort, we can also understand boredom as a product of low effort and high reward, and frustration as a product of high effort and low reward. From the demand perspective, we expect those games eliciting flow states—presenting players with a balance of reward and effort—will engage players at moderate levels of cognitive and exertional demand. With respect to controller demand however, we expect that balanced games will leave the player with a perception of comparatively low demand as the controls might feel most intuitive when one is fully absorbed in gameplay (i.e., in a flow state). The distinction between controller and exertional demands is especially relevant given that manipulations of the challenge-skill dynamic of a video game will require players to think faster (cognitive demand) and move more quickly (exertional demand) to meet in-game challenges. However, these same manipulations should *de facto* change how intuitive the game controller is perceived. This is especially relevant for the current study, which used a simplified mouse and keyboard control system (explained in detail, see Section 2.2). Hence, we predict that a balance of reward and effort will result in **(H1)** moderate ratings of cognitive demand, **(H2)** lower ratings of controller demand, and **(H3)** moderate ratings of exertional demand.

2 METHOD

For this study, reward and effort were separately manipulated using a bespoke simple video game such that participants experienced three different gameplay conditions (boredom: high reward/low effort, flow: high reward/high effort; frustration: low reward/high effort). We examined the capacity for those gameplay scenarios to induce flow (using both behavioral and self-report measures) before testing our core predictions associated with cognitive demands and both types of physical demands (controller and exertion demands). Emotional and social demands were controlled by using a game void of engaging narrative content and played in isolation and without a salient on-screen avatar for which to associate with (i.e., an unmarked spaceship).

2.1 Participants

We recruited $N = 123$ participants from a large, public university in the southwestern United States. The average age of our sample was $M = 21.06$ years ($SD = 2.02$), with a near-equal number of males ($n = 60$) and females ($n = 63$). Just over half of the sample, $n = 65$ (52.8%) identified as White or Caucasian, with the next most frequent ethnic groups being Hispanic and Latino, $n = 31$ (25.2%), and Black or African American, $n = 16$ (13%).

Participants had overall moderate levels of self-reported video game skill ($M = 4.07$, $SD = 1.73$ on a single-item, seven-point Likert scale). Participants played video games $M = 5.34$ hours in a typical week ($SD = 3.01$), had been playing games for $M = 12.09$ years ($SD = 4.91$), and had played video games about 10 days in the prior

Figure 1: Screenshot of *Asteroid Impact*, developed by Dr. Richard Huskey (University of California-Davis). The game is freely available via Github: https://github.com/richardhuskey/asteroid_impact.

30-day period, with their most recent gaming session lasting $M = 1:17$ ($SD = 1:15$).

2.2 Stimulus

Participants played *Asteroid Impact* (https://github.com/richardhuskey/asteroid_impact). In the game, participants use a computer mouse to navigate their spaceship to collect gems while avoiding asteroids—both generated randomly on-screen. Each time a gem is collected, a new one appears on screen. The game is designed so that key parameters can be adjusted to adjust the efforts and rewards for gameplay. For the current study, our primary manipulation was asteroid speed. For the high reward and low effort condition (boredom), the asteroids moved slowly throughout the session, making them easy to avoid and thus, allowing for very quick collection of gems. For the low reward and high effort condition (frustration), asteroids moved rapidly throughout the session, making them difficult to avoid and thus, reducing the number of gems one could collect. For the balanced reward and effort condition (flow), asteroids moved at a moderate pace at the start of gameplay, and this pace was automatically and dynamically adjusted based on the participant’s performance: as participants were successful, the asteroids sped up slightly and as they failed, the asteroids slowed slightly. This dynamic balance tracked with player performance so that effort and reward were yoked and moderate.

For all conditions, players were given a secondary task—large semi-transparent red circles (sprites) appeared randomly in one of the four corners of the screen. Players were instructed to press their keyboard spacebar to collect these sprites to earn “power-ups” for their spaceship. In practice, collecting sprites had no impact on gameplay, but these instructions ensured some engagement with this secondary task. A screenshot with the primary task (collecting gems) and secondary task (collecting sprites) are shown in Figure 1

2.3 Procedure

After arriving in the laboratory, participants completed basic demographic and gaming experience questions. To protect against

testing effects of the video game (as each participant would play the game three times), they were randomly assigned to one of six order conditions of *Asteroid Impact* that altered the sequence of when the flow, boredom, or frustration setting was used for gameplay—each participant played each setting once. Game sessions were four minutes each, and self-reported enjoyment and demand measures were taken after each session.

2.4 Measures

Effort and reward were assessed with both self-report and behavioral measures. For self-report, enjoyment was indexed using a four-item, seven-point Likert-type scale ($M = 3.45$; $SD = 1.53$) [7]. For the behavioral measure, secondary task reaction times (STRTs) are used as a measure of resource availability. The STRTs record the milliseconds between the presentation of a sprite on screen and the pressing of a designated button, $M = 456.020$ milliseconds ($SD = 198.896$). Slower times indicate more resource allocation to the game’s primary task, and faster times indicate more allocation to the secondary task. Analysis for STRT measures was calculated using harmonic means [53].

Perceived demands of the video game were measured using a 26-item, seven-point, Likert-style scale [8]. The scale was administered three times (once after each play session), although only cognitive demand ($M = 4.40$, $SD = 1.15$, average $\alpha = .872$), controller demand ($M = 3.16$, $SD = 1.40$, average $\alpha = .843$), and exertional demand ($M = 2.27$, $SD = 1.19$, average $\alpha = .900$) were central to our hypotheses.

3 RESULTS

Data analysis files, scripts, and annotated output files are shared online through an Open Science Framework folder (<https://osf.io/8qvad/>). Results are presented in the following subsections and explained in greater detail in our discussion section.

3.1 Induction Check and Initial Analyses

Prior to testing our core hypotheses, we first examined the efficacy of *Asteroid Impact* at inducing flow. Both were tested using univariate analysis of variance: one for self-reported enjoyment measures (expecting lowest scores when playing the frustration condition) and one for STRTs (expecting slowest response times when playing the frustration condition).

For self-reported measure of enjoyment, the overall model was significant, $F(2,364) = 11.58$, $p < .001$, $\eta^2 = .06$. *Post-hoc* inspection found that the frustration condition ($M = 2.17$, $SD = 1.78$) resulted in significantly less self-reported enjoyment than the flow ($M = 3.31$, $SD = 1.56$) or boredom conditions ($M = 3.10$, $SD = 1.63$, respectively; $p < .001$ for both comparisons; Bonferroni corrected). For STRTs, the overall model was significant, $F(2,366) = 3.82$, $p = .029$, $\eta^2 = .020$. *Post-hoc* inspection found that the flow condition resulted in the slowest reaction times ($M = 491$ ms, $SD = 146$), but the differences between the boredom ($M = 459$, $SD = 115$) and the frustration ($M = 465$, $SD = 180$) condition was slightly more complicated. While the flow condition was significantly slower than the boredom condition ($p = .041$), it was not significantly different from the frustration condition ($p = .067$). In addition, the boredom and frustration conditions did not significantly differ ($p = .100$).

Figure 2: Observed pattern of response times compared by experimental condition.

However, given that the effort measure included an over-time component with STRTs presented multiple times within each condition, we also wanted to examine the function of these responses over time. One possibility is that while the mean response times between each condition might not differ as drastically as intended, the measures of variance across the conditions might indicate that the *function* of those response times during a given play session—there were 60 response times probes across each game session—might indicate some behavioral differences across the conditions. To control for the inflated degrees of freedom associated with the numerous within-subjects reaction times, we calculated a multi-level model using the *lme4* package for R [3], nesting these repetitions within flow conditions and within participants with reported statistically significant effects for condition, $F(2, 354.21) = 29.708, p < .001$, and the condition by time interaction, $F(2, 212.44) = 14.798, p < .001$; the main effect of time was not significant; time, $F(1, 223.60) = .397, p = .530$, see Figure 2. Visually inspecting the interaction effect revealed that RTs followed very different patterns across time, depending on game settings. During the boredom condition, reaction times to the secondary task follow a more cubic function in which participants are initially very fast and accelerate even more quickly, then they slow (albeit still reacting faster than in other conditions) before again accelerating (three inflection points in the charted line). The function during the flow condition is more quadratic—reaction times are moderately fast, then slow during gameplay before accelerating towards the end (two inflection points in the charted line). When playing the frustration condition, the function is more negatively linear as participants are initially very slow to respond to the secondary task, but their responses rapidly speed up throughout the game session.

3.2 Hypothesis Tests

The first prediction was that perceived cognitive demand would be lowest when playing the boredom-configured game, moderate when playing the flow-configured game, and highest when playing

Figure 3: Box and whisker plots of observed cognitive demand scores as a function of gameplay condition. Order effects are averaged within game conditions to ease interpretation (see OSF for complete results).

Figure 4: Box and whisker plots of observed controller demand scores as a function of gameplay condition. Order effects are averaged within game conditions to ease interpretation (see OSF for complete results).

the frustration-configured game. Within-subjects effects were confirmed, Mauchly's $W = .955$, Greenhouse-Geisser $F(1.91, 212.41) = 12.34, p < .001, \eta^2p = .493$, and the effect was linear; $F(1, 111) = 178.53, p < .001, \eta^2p = .617$ (non-significant quadratic effect, $p = .193$). Comparing overall main effects shows the lowest scores for boredom, $M = 3.52$ (95% CI 3.25, 3.80), followed by flow, $M = 4.48$ (4.24, 4.73), and then frustrated players, $M = 5.20$ (4.95, 5.45). No order effects were observed ($p = .096$). **H1 was confirmed** (see Figure 3 for box-and-whisker plots [33]).

Our second prediction suggested that perceptions of controller demand would be lowest in the flow condition as compared to the other two conditions. Although a significant overall effect was found, Mauchly's $W = .771$, Greenhouse-Geisser $F(1.63, 178.48) = 33.05, p < .001, \eta^2p = .226$, and the effect was linear; $F(1, 113) = 48.93, p < .001, \eta^2p = .302$ (non-significant quadratic effect, $p = .070$). Thus, the effect was not in the expected direction. *Post-hoc* analysis revealed that the lowest demands were observed in the boredom condition, $M = 2.89$ (2.64, 3.14) followed by flow, $M = 3.13$ (2.39, 3.30) and frustration, $M = 3.60$ (3.32, 3.87). No order effects were observed, $p = .066$. Given that the frustration condition led to the highest levels of controller demand perceptions, **H2 was rejected** (Figure 4).

Figure 5: Box and whisker plots of observed exertional demand scores as a function of gameplay condition. Order effects are averaged within game conditions to ease interpretation (see OSF for complete results).

We also predicted that perceptions of exertional demand would be lowest when playing the boredom condition, moderate when playing the flow condition, and highest when playing the frustration condition. Exertional scores did differ significantly from each other, Mauchly's $W = .975$, Greenhouse-Geisser $F(1.95, 218.54) = 25.34$, $p < .001$, $\eta^2p = .184$, and the effect was linear; $F(1,112) = 41.74$, $p < .001$, $\eta^2p = .272$ (non-significant quadratic effect, $p = .094$). *Post-hoc* analysis revealed that demands were lowest in the boredom $M = 1.86$ (1.30, 2.01) and flow conditions $M = 2.11$ (1.87, 2.34), and highest in the frustration condition, $M = 2.67$ (2.38, 2.95). Given the non-significant difference between boredom and flow conditions (see overlapping confidence intervals, Bonferroni-adjusted $p = .080$), **H3 was rejected** (Figure 5). That said, we note that exertional demands were highest for the frustration condition as expected, which is critical for task switching claims in Section 4.

4 DISCUSSION

Our study was concerned with understanding the relationship between attentional flow states and the perceived cognitive and physical demands of gameplay. By manipulating the balance of reward and effort in a simple video game, we demonstrated that (a) high reward and low effort calibrations were associated with the lowest perceptions of cognitive and physical demands, (b) a relative and dynamic balance of reward and effort resulted in moderate levels of perceived demands, and (c) high effort and low reward calibrations were associated with the highest perceived levels of demand. These findings confirmed our predictions about cognitive and exertional demands and added nuance to our understanding of controller demand.

We expected game controls to be viewed as equally unintuitive for both high reward/low effort and low reward/high effort conditions, but found a more linear association whereas effort increased, and reward decreased. One possible explanation for this finding is that for high reward/low effort gameplay, the immediate gratifications players receive through their successful performance is at least partly attributed to having a perceived mastery of the in-game controls themselves. Moreover, *Asteroid Impact* has a simple control scheme and likewise, overall controller demand scores were significantly lower than the scale mid-point of 4.00,

$t(122) = -6.56$, $p < .001$. Broadly, these findings suggest that the sync theory of flow aligns with how players perceive the demands of a gaming experience—demanding experiences are ones that draw on cognitive and physical demands simultaneously, which can be a frustrating experience for players.

That said, a closer inspection of participants' response times when engaging the three different game conditions reveals a compelling attempt to cope with demanding experiences. Players' slower response times to a secondary, in-game task suggested more attention to the game's primary task (manipulating a mouse to avoid asteroids and collect gems), and quicker times suggested more attention to the secondary task (pressing the keyboard space bar to collect fictitious power-ups that ultimately did not improve in-game performance). Under conditions of low effort and high reward (boredom), players oscillated between diverting attentional resources to the primary and secondary task (following a cubic function across the 60 trials that were presented over the course of the four minutes of gameplay), which might suggest that these players—who also perceived the game as comparatively undemanding—simply were not being taxed and as a result, could handle both tasks with ease. For these players, the two tasks were likely not seen as competing for attentional resources but instead, were engaged as complementary tasks towards the broader task of gameplay. For players in the flow condition (where effort and reward were balanced), the game's dynamic difficulty adjustment seems to have worked as programmed—as player reaction times slowed slightly, the game slowed down on-screen action and in turn, reaction times improved (reflected in the expected quadratic function). These players were overall moderate in their reaction times (Figure 2, middle group), suggesting that their attentional resources were mostly focused on the primary game task.

Perhaps the most intriguing finding involved play under conditions of high effort and low reward (frustrating), which was rated as the most demanding on all measured dimensions, and yet where the greatest linear *improvement* of response times was observed. The finding is surprising as it suggests that players initially devoted their full attention to the primary gameplay task of avoiding the asteroids and picking up the gems, but quickly abandoned this task in favor of the more manageable secondary task of hitting the space bar in response to the visual probes on screen to receive what the players thought was a "power-up." The instant gratification associated with completing the secondary task seems to have served as an unexpected source of reward for these players. This was unexpected to us given that both (a) the game did not provide any obvious performance feedback (such as a player score output) and (b) the "power-ups" had no actual impact on in-game action. In line with the demand approach, when participants played the over-demanding (frustration) condition, they engaged in a complete task switch. Others [16] refer to this as a *cognitive offloading* and suggest that over-taxed participants are likely to shift their attentional resources to secondary tasks, especially when these tasks are extrinsically rewarding (in their study, secondary tasks earned the player additional points that were reflected in real time on screen). That our study observed this similar cognitive offloading without an explicit indicator of secondary task reward suggests that players might *implicitly* shift their engagement with a video game to actively cope with and balance the demands of the experience. Such

findings are especially relevant when discussing autotelic processes, such as video game play, in which engagement with the game is often self-motivating, although we note that in the current study that enjoyment scores were overall middling, and lowest for the frustrating game (a limitation discussed in Section 4.2 below).

4.1 Implications for HCI Research

Research into flow and video games from the perspective of human-computer interaction has often focused on the balance of game challenge and player skill critical to the flow state. For video games to sustain players' flow states, games should be programmed such that they can quickly respond to individual player's skill—recognizing natural variability from one player's experience to the next [10]. Such systems have been demonstrated this *dynamic difficulty adjustment* (DDA) approach with the critical and commercial viability of games such as *flOw* (released in 2006) and *Flower* (released in 2009). A similar logic using player's physiological responses suggested that affective reactions to game content can be indicators of whether players are in flow states [32]. Players do seem to prefer explicit control over game difficulty settings, although overall play evaluations did not differ for players using player-controlled compared to DDA settings ([44], using an adapted version of *flOw*). Integrating DDA settings into gameplay improved several player experience variables relevant to flow states, such as the merging of action and awareness, and the passage of time [1]. However, other perceptions (such as goal clarity and loss of self-consciousness) were hindered DDA systems that were presented constantly—likely a result of the paradox of choice in which having too much control can increase uncertainty and preoccupy individuals with choices not made [11]. Thus, while DDA systems hold promise for gaming experiences, their effects are not fully understood. Within the context of the current study, extant DDA research tends to focus on adjusting primary gameplay tasks and thus, future development of DDA systems should consider if and how these systems account for task switching or cognitive offloading behaviors—particularly relevant given that video gameplay is a known predictor of task-switch performance broadly [20, 35].

Likewise, research into perceived game challenges is prominent in HCI scholarship, including assessments of player preferences for specific types of game challenges [48], and a recent integrated model of challenge originating from recent gameplay interaction scale (CORGIS [13]). Regarding the former [48], research has reliably distinguished between player preferences for physical compared to analytical challenges, which would likely influence perceptions of exertional and cognitive demand from video game play (respectfully)—stronger preferences for either type of challenge could result in the perception that game content was less demanding. In addition, challenge preferences likely drive task-switching behaviors—players driven by cognitive challenges might be less likely to cognitively offload (as they would expect and enjoy mentally taxing gameplay). Regarding the latter [13], there is considerable conceptual and empirical overlap between CORGIS and VGDS. For example, both scales assess cognitive and physical dimensions of gameplay as distinct constructs with demonstrated reliability, and both report a similarly moderate correlation between the constructs. As such and given how similar both approaches understand

cognitive and physical aspects of gameplay, results from the current study would likely replicate using corresponding CORGIS measures. That said, the two approaches differ in the locus of the sources of challenge or demand, with the CORGIS more focused on challenges stemming from on-screen content and VGDS more broadly concerned with demands external to on-screen content (such as physical controller demands and social demands from the presence of others). As the current study used a simple video game with a clear primary task, future research into task focus and task switching in more elaborate games might require an integration of these approaches to understand the dynamics of challenge, demand, and task engagement.

4.2 Future Research Directions

Our research comports with a growing body of literature on the relationship between the demands of interactive media and attentional flow states, and how both are influenced by the balance (or lack thereof) of effort and reward. Broadly, players are expected to shift their engagement with a video game to manage the demands required of the game [4]. In the current study, players managed comparatively intense cognitive and physical demands of a high effort and low reward game by engaging in complete task switching—abandoning the primary gameplay task entirely and instead, shifting focus to a much simpler and easier-to-control task *within the same game that did not help with overall game performance*. More critical is that this switch only occurred when the primary task had a low reward potential (e.g., success unlikely to be achieved) and high effort requirement (e.g., demanding far too much of the player's cognitive and physical resources).

Future research should consider more generalizable sources of demand, effort, and rewards in a variety of video games, especially those games in which players have increased autonomy over the on-screen tasks (e.g., open-world “sandbox” games and games with non-linear storytelling schemes) and thus, might have more agency in their own task switching. Task switching could also be an unexpected consequence of (overly) complex game design, in which players might become overwhelmed with the demands of primary gameplay and as a result, divert attention to secondary tasks potentially detrimental to continued player engagement. Such dynamics might explain scenarios in which players consistently engage in side-quests or other secondary tasks in a video game without progressing towards the game's primary goals. One concern expressed by game designers is that of functional fixedness [14] in which players become focused on a single use of an in-game object or approach to a puzzle that they seem unwilling or unable to think creatively about the challenge and thus, get “stuck” in a video game [49]. Knowing when to encourage task balancing or task switching could be key to helping players overcome fixedness. Related to this, future work might also consider a broader set of demands, such as the influence of emotional and social demands on how players expend effort and pursue rewards during gameplay. With respect to effort and reward balances, the current study did not assess player's perceptions of reward. As a result, and absent any explicit rewards (such as game scores or prizes for playing well), we are left to presume implicit engagement with the video game. To this end, future research would benefit from a more nuanced

assessment of (a) whether players were intrinsically motivated or (b) more focal manipulations of extrinsic motivation that would provide compelling comparison data. The latter is critical given that video games can be designed to reward engagement in secondary tasks, such as awarding special badges or “easter eggs” for finding hidden missions (from completing side-quests). Furthermore, reward assessments are likely influenced by player’s challenge preferences [48] in which meeting or exceeding preferred challenges could be seen as more intrinsically rewarding.

5 CONCLUSION

The current study showed that as required effort and resultant reward of a simple video game increase, players perceive the experience as comparatively more cognitively and physically demanding. To cope with this imbalance, players engaged in cognitive offloading—re-allocating their attentional resources away from the game’s overly-tasking primary task and towards a secondary task that while personally rewarding, had no appreciable influence on in-game performance.

ACKNOWLEDGMENTS

We are grateful for the contributions of Robyn Adams, Jonathan Blackwell, Robert Gauthreaux III, Matthew Jenkins, and Claire McAlister of the TTU Cognition and Emotion Lab (<http://ttucl.com/>), as well as the members of the International Communication Association Communication Science & Biology Interest Group (<https://commscience.org/>).

REFERENCES

- [1] Dennis Ang and Alex Mitchell. 2019. Representation and frequency of player choice in player-oriented dynamic difficulty adjustment systems. CHI PLAY '19: Proceedings of the annual symposium on computer-human interaction in play, October 2019, 589–600. <https://doi.org/10.1145/3311350.3347165>
- [2] Jaime Banks. 2015. Object, me, symbiote, other: A social typology of player-avatar relationships. *First Monday* 20, 2 (2015). DOI: <https://doi.org/10.5210/fm.v20i2.5433>
- [3] Douglas Bates, Martin Maechler, Ben Bolker, Steven Walker, Rune H. B. Christensen, Henrik Singman . . . Pavel N. Krivitsky. 2020. Package ‘lme4’. Retrieved from <https://cran.r-project.org/web/packages/lme4/lme4.pdf>
- [4] Nicholas D. Bowman (Ed.). 2018. Video games: A medium that demands our attention. New York: Routledge.
- [5] Nicholas D. Bowman, Jih-Hsuan Lin, and Chieh Wu. 2021. A Chinese-language validation of the video game demand scale: Measuring the cognitive, emotional, physical, and social demands of video games. Proceedings of the CHI conference on human factors in computing systems (CHI '21). DOI: <https://doi.org/10.1145/3411764.3445348>
- [6] Nicholas D. Bowman and Ron Tamborini. 2012. Task demand and mood repair: The intervention potential of computer games. *New Media & Society* 14, 8 (2012), 1339–1357. DOI: <https://doi.org/10.1177/1461444812450426>
- [7] Nicholas D. Bowman and Ron Tamborini. 2015. “In the mood to game”: Selective exposure and mood management processes in computer game play. *New Media & Society* 17, 3 (2015), 375–393. DOI: <https://doi.org/10.1177/1461444813504274>
- [8] Nicholas D. Bowman, Joseph Wasserman, and Jaime Banks. 2018. Video games: A medium that demands our attention. Development of the video game demand scale. Routledge, New York, NY.
- [9] Rick Busselle and Helena Bilandzic. 2009. Measuring narrative engagement. *Media Psychology* 12, 4 (2009), 321–347. DOI: <https://doi.org/10.1080/15213260903287259>
- [10] Jenova Chen. 2007. Flow in games (and everything else). *Communications of the ACM* 50, 4 (April 2007), 31–34. DOI: <https://doi.org/10.1145/1232743.1232769>
- [11] Alexander Chernev, Ulf Böckenholt, and Joseph Goodman. 2015. Choice overload: A conceptual review and meta-analysis. *Journal of Consumer Psychology* 25, 2 (2015), 333–358. DOI: <https://doi.org/10.1016/j.jcps.2014.08.002>
- [12] Mihaly Csikszentmihalyi. 1990. Flow: The psychology of optimal experience. Harper & Row, New York, NY.
- [13] Alena Denisova, Paul Cairns, Christian Guckelsberger, and David Zendle. 2020. Measuring perceived challenge in digital games: Development & validation of the challenge originating from recent gameplay interaction scale (CORGIS). *International Journal of Human-Computer Studies* 137. DOI: <https://doi.org/10.1016/j.ijhcs.2019.102383>
- [14] Karl Duncker and Lynne S. Lees. 1945. On problem solving. *Psychological Monographs*, 58, 5 (1945). <https://psycnet.apa.org/doi/10.1037/h0093599>
- [15] Jacob T. Fisher and René Weber. 2020. The limited capacity model of motivated mediated message processing (LC4MP). *International encyclopedia of media psychology*. Hoboken, NJ: Wiley Blackwell.
- [16] Jacob T. Fisher, Frederic R. Hopp, and René Weber. 2019. Modality-specific effects of perceptual load in multimedia processing. *Media and Communication* 7, 4 (2019), 149–165. DOI: <https://doi.org/10.17645/mac.v7i4.2388>
- [17] Jacob T. Fisher, Richard Huskey, Justin R. Keene, and René Weber. 2018. The limited capacity model of motivated mediated message processing: Looking to the future. *Annals of the International Communication Association*, (2018), 1–21. DOI: <https://doi.org/10.1080.23808985.2018.1534551>
- [18] James Paul Gee. 2003. What video games have to teach us about learning and literacy. *Computers in Entertainment* 1, 1 (2003), 1–20.
- [19] C. Shawn Green and Daphne Bavelier. 2003. Action video game modifies visual selective attention. *Nature* 423, 6939 (2003), 534–537.
- [20] C. Shawn Green, Michael A. Sugarman, Katherine Medford, Elizabeth Klobusicky, and Daphne Bavelier. 2012. The effect of action video game experience on task-switching. *Computers in Human Behavior* 28, 3 (May 2012), 984–994. DOI: <https://doi.org/10.1016/j.chb.2011.12.020>
- [21] Torben Grodal. 2000. Media entertainment: The psychology of its appeal. Video games and the pleasures of control. Lawrence Erlbaum Associates, Inc., Mahwah, NJ.
- [22] Scott H. Hemenover and Nicholas D. Bowman. 2018. Video games, emotion, and emotion regulation: bridging the gap. *Annals of the International Communication Association* 42, 2 (2018), 125–143. DOI: <https://doi.org/10.1080/23808985.2018.1442239>
- [23] Richard Huskey, Britney Craighead, Michael M. Miller, and Rene Weber, Rene. 2018a. Does intrinsic reward motivate cognitive control? A naturalistic-fMRI study based on the synchronization theory of flow. *Cognitive, Affective, & Behavioral Neuroscience* 18, (2018), 902–924. DOI: <https://doi.org/10.3758/s13415-018-0612-6>
- [24] Richard Huskey, Shelby Wilcox, and Rene Weber. 2018b. Network neuroscience reveals distinct neuromarkers of flow during media use. *Journal of Communication* 68, 5 (2018), 872–895. DOI: <https://doi.org/10.1093/joc/jqy043>
- [25] Michael Inzlicht, Amitai Shenhav, and Christopher Y. Olivola. 2018. The effort paradox: Effort is both cost and valued. *Trends in Cognitive Science* 22, 4 (February 2018), 337–349. DOI: <https://doi.org/10.1016/j.tics.2018.01.007>
- [26] Susan A. Jackson and Robert C. Eklund. 2004. Relationships between quality of experience and participation in diverse performance settings. Proceedings of the 39th Conference of The Australian Psychological Society, September 29 – October 3, 2004, Sydney, NSW, Australia. Basingstoke, U.K.: Taylor and Francis.
- [27] Johannes Keller and Herbert Bless. 2008. Flow and regulatory compatibility: An experimental approach to the flow model of intrinsic motivation. *Personality and Social Psychology Bulletin* 34, 2 (2008), 196–209. DOI: <https://doi.org/10.1177/0146167207310026>
- [28] Kevin Koban and Nicholas D. Bowman. 2020. Further validation and cross-cultural replication of the video game demand scale. *Journal of Media Psychology* (2020). DOI: <https://doi.org/10.1027/1864-1105/a000280>
- [29] Annie Lang. 2009. The SAGE Handbook of Media Processes and Effects. The limited capacity model of motivated mediated message processing. Sage Publications, Inc., Thousand Oaks, CA.
- [30] Annie Lang, Samuel D. Bradley, Byungho Park, Mija Shin, and Yongkuk Chung. 2006. Parsing the resource pie: Using STRTs to measure attention to mediated messages. *Media Psychology* 8, 4 (2006), 369–394. DOI: https://doi.org/10.1207/s1532785xmep0804_3
- [31] Benny Liebold, Nicholas D. Bowman, and Daniel Pietschmann. 2020. Natural in the eyes of the (be)holder: A survey on novelty and learning effects in the enjoyment of naturally mapped video game controllers. *Psychology of Popular Media Culture* 9, 2 (2020), 255–265. DOI: <https://doi.org/10.1037/ppm0000215>
- [32] Changchun Liu, Pramila Agrawal, Nilanjan Sarkar, and Shuo Chen. 2009. Dynamic difficult adjustment in computer games through real-time anxiety-based affective feedback. 2009. *International Journal of Human-Computer Interaction* 25, 6 (2009), 506–529. DOI: <https://doi.org/10.1080/10447310902963944>
- [33] Harvey J. Motulsky. 2014. Common misconceptions about data analysis and statistics. *Naunyn-Schmiedeberg’s Archives of Pharmacology* 387 (December 2014), 1017–1023. DOI: <https://doi.org/10.1007/s00210-014-1037-6>
- [34] Jeanne Nakamura and Mihaly Csikszentmihalyi. 2009. The oxford handbook of positive psychology (2nd. ed.). Flow theory and research. Oxford University Press, Inc., New York, NY.
- [35] Kerwin J. F. Olfers and Guido P. H. Band. 2018. Game-based training of flexibility and attention improves task-switch performance: Near and far transfer of cognitive training in an EEG study. *Psychological Research* 82 (January 2018), 186–202. DOI: <https://doi.org/10.1007/s00426-017-0933-z>

- [36] Mary Beth Oliver, Nicholas D. Bowman, Julia K. Woolley, Ryan Rogers, Brett I. Sherrick, and Mun-Young Chung. 2015. Video games as meaningful entertainment experiences. *Psychology of Popular Media and Culture* 5, 4 (2015), 390-405. DOI: <https://doi.org/10.1037/ppm0000066>
- [37] Roger Ratcliff. 1993. Methods for dealing with reaction time outliers. *Psychological Bulletin* 114, 3 (1993), 510-532. DOI: <https://doi.org/10.1037/0033-2909.114.3.510>
- [38] Ryan Rogers, Nicholas D. Bowman, and Mary Beth Oliver. 2015. It's not the model that doesn't fit, it's the controller! The role of cognitive skills in understanding the links between natural mapping, performance, and enjoyment of console video games. *Computers in Human Behavior* 49, (2015), 588-596. DOI: <https://doi.org/10.1016/j.chb.03.027>
- [39] Daniel Roth, Jean-Luc Lugin, Sebastian von Mammen, and Marc E. Latoschik. 2017. *Controllers & their inputs: Masters of puppets. Avatar, assembled: The social and technical anatomy of digital bodies*. New York, NY: Peter Lang Publishers.
- [40] Justin Rueb, Michael Vidulich, and John Hassoun. 1992. Establishing workload acceptability: An evaluation of a proposed Kc-135 cockpit redesign. *Proceedings of the Human Factors and Ergonomics Society* 36, 1 (May 1992), 17-21. DOI: <https://doi.org/10.1177/154193129203600106>
- [41] Richard M. Ryan and Edward L. Deci. 2000. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology* 25, 1 (January 2000), 54-67. DOI: <https://doi.org/10.1006/ceps.1999.1020>
- [42] Michael A. Shapiro, Jorge Peña-Herborn, and Jeffrey T. Hancock. 2006. *Realism, Imagination, and Narrative Video Games. Playing video games: Motives, responses, and consequences*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers.
- [43] John L. Sherry. 2004. Flow and media enjoyment. *Communication Theory* 14, 4 (2004), 328-347. DOI: <https://doi.org/10.1111/j.1468-2885.2004.tb00318.x>
- [44] Jan D. Smeddinck, Regan L. Mandryk, Max V. Birk, Kathrin M. Gerling, Dietrich Barsilowski, and Rainer Malaka. 2016. How to present game difficulty choices?: Exploring the impact of player experience. CHI '16: Proceedings of the 2016 CHI conference on human factors in computing systems. 5595-5607. DOI: <https://doi.org/10.1145/2858036.2858574>
- [45] Constance A. Steinkuehler and Dmitri Williams. 2006. Where everybody knows your (screen) name: Online game as "third places." *Journal of Computer-Mediated Communication* 11, 4 (2006), 885-909. DOI: <https://doi.org/10.1111/j.1083-6101.2006.00300.x>
- [46] Jonathan Steuer. 1992. Defining virtual reality: Dimensions determining telepresence. *Journal of Communication* 42, 4 (1992), 73-93. DOI: <http://doi.org/10.1111/j.1460-2466.1992.tb00812.x>
- [47] Ron Tamborini, Nicholas D. Bowman, Allison Eden, Matthew Grizzard, and Ashley Organ. 2010. Defining media enjoyment as the satisfaction of intrinsic needs. *Journal of Communication* 60, 4 (2010), 758-777. DOI: <https://doi.org/10.1111/j.1460-2466.2010.01513.x>
- [48] Jukka Vahlo and Veli-Matti Karhulahti. 2020. Challenge types in gaming validation of video game challenge inventory. *International Journal of Human-Computer Studies* 143. DOI <https://doi.org/10.1016/j.ijhcs.2020.102473>
- [49] Suriel Vazquez. 2017. Why you get stuck in games, and what you can do about it. *Game Informer*. Retrieved from <https://www.gameinformer.com/b/features/archive/2017/11/22/why-you-get-stuck-in-games-and-what-you-can-do-about-it.aspx>
- [50] Evan R. Watts, Kevin Koban, and Nicholas D Bowman. 2021. Digital gaming audiences: awareness, without closeness. *Entertainment Computing* 26, (2021). DOI: 10.1016/j.entcom.2020.100384
- [51] Rene Weber, John L. Sherry, and Klaus Mathiak. 2008. The neurophysiological perspective in mass communication research. *Biological Dimensions of Communication: Perspectives, Methods, and Research*, (2008), 41-71.
- [52] Rene Weber, Ron Tamborini, Amber Westcott-Baker, and Benjamin Kantor. 2009. Theorizing flow and media enjoyment as cognitive synchronization of attentional and reward networks. *Communication Theory* 19, 4 (2009), 397-422. DOI: <https://doi.org/10.1111/j.1468-2885.2009.01352.x>
- [53] Robert Whelan. 2008. Effective analysis of reaction time data. *The Psychological Record* 58, (2008), 475-482. DOI: <https://doi.org/10.1007/BF03395630>