Restorative Play: Videogames Improve Player Wellbeing After a Need-Frustrating Event

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ABSTRACT
People often use videogames to restore wellbeing after negative experiences in day-to-day life. Although some research suggests that play can restore wellbeing, few studies have investigated the means by which restoration occurs. We employed self-determination theory (SDT) to understand how and to what degree play improves wellbeing after a need-frustrating event, and how players understand experiences of competence in play.

Sixty-five participants worked at a competence manipulation task prior to playing a competence-satisfying videogame. Competence, affect, and vitality improved during play, and in-game experiences of need frustration were observed to effectively predict post-play negative affect. Post-experiment interviews indicate that videogames are seen to support competence relative to perceived skill, extending our knowledge of how design can support competence and restoration. We demonstrate that play can restore wellbeing, present need frustration as a means to explain negative experiences with interactive systems, and discuss effects of design on competence.

Author Keywords
Video games; wellbeing; self-determination theory; need satisfaction; player experience; restoration

CCS Concepts
•Applied computing → Computer games; •Human-centered computing → Empirical studies in HCI;

INTRODUCTION
Research on the positive outcomes of videogame play has flourished in HCI. Studies have demonstrated the varied wellbeing benefits of playing with friends [101] or in isolation [102]; moreover, these benefits emerge in relatively short periods of engagement [67]. Players themselves see videogame play as a means to experience catharsis [63], reduce stress [13], or cope

during difficult life experiences [40]. However, despite the popular use of videogame play for wellbeing restoration [21, 73], few studies have quantified the effectiveness of restorative play after negative events, or investigated the means by which restoration occurs.

Studies of player experience (PX) in HCI often employ self-determination theory (SDT) [83] as a foundation of the research [94]. In particular, many studies assess in-game experiences of need satisfaction – competence, autonomy, and relatedness – as a means to investigate the wellbeing outcomes of play. However, recent research into unpleasant experiences in sport [77], education [31], and the workplace [35] indicates that negative influences on wellbeing are more effectively explained by need frustration – feeling incompetent, pressured, and socially rejected. Although need frustration may produce new insights into the ways that videogames can improve wellbeing after negative events, experimental studies of this nature are yet to emerge.

The present work describes an experimental study of restorative play based in SDT, measuring need satisfaction and frustration in parallel to more fully understand whether and how play can restore wellbeing after a negative event. In this study, we manipulated competence satisfaction and frustration with a false-feedback task prior to thirty minutes of play with Mark of the Ninja [55], which supports player competence across a range of skill levels. We also conducted post-experiment interviews to understand how players themselves understand competence-supportive game design.

Our results show that Mark of the Ninja was highly effective at restoring competence and wellbeing for participants whose needs were frustrated prior to play; moreover, experiences of need satisfaction and frustration during play were observed to distinctly predict positive and negative post-play wellbeing outcomes. Finally, our post-experiment interview results show that self-described “skill” influenced the ways that individual game elements and player behaviours were seen to support or satisfy competence, respectively.

Our research contributes to HCI literature in three key ways. First, we provide new evidence that videogame play can effectively restore player wellbeing after a negative event. More specifically, we show that participants whose needs were frustrated prior to play experienced greater improvement in competence satisfaction, positive and negative affect, and vitality.
relative to those whose needs were satisfied prior to play. Second, we demonstrate that assessing need satisfaction and frustration in parallel can produce a more complete explanation of the restorative play experience, highlighting the value of need frustration in studies of interactive systems. Third, we extend current perspectives on the ways that competence support, satisfaction, and frustration emerge in and through play. In particular, our thematic analysis shows that players identify competence support in design elements according to their own literacy of videogame conventions and performances, producing varied scenes of potential satisfaction and frustration. Finally, we highlight the broader implications of our findings for the ways that HCI scholars and designers conceptualise competence with respect to interactive systems.

RELATED WORK

Videos and Wellbeing

Videogame play has been shown to benefit player wellbeing in a number of ways. Wellbeing refers to the psychological states that indicate positive functioning (e.g., affect, vitality) [87]. Wellbeing results from acting in reflectively valued and growth-oriented ways – in other words, from living well [81]. Experimental and longitudinal studies indicate that play can improve player wellbeing, with respect to affect [8, 80, 86], vitality [74, 80, 86], and self-esteem [1, 86]. Regular play has also been shown to reduce symptoms of depression [79] and anxiety [34]. Online games may also lower stress [90], and create opportunities for friendship development [62, 102], particularly when played cooperatively.

There is also a growing literature on the use of videogames for coping with unpleasant experiences. Coping strategies are particularly relevant in the context of research suggesting an inverse relationship between minor everyday hassles and wellbeing [48, 26]. Videogames are a popular coping strategy [13, 40], particularly when dealing with work-related issues [21, 73], and players themselves value the experiences of catharsis and escapism that games readily provide [44, 56, 63]. Indeed, some experimental studies have evaluated the effectiveness of play for restoring wellbeing following negative events. For example, videogame play has been shown to increase happiness [76] after viewing a sad film clip, and reduce stress [14] after working at a task while under pressure.

These studies represent some evidence that play can restore wellbeing after a negative event; however, they are less informative regarding how restoration occurs. We therefore turn to SDT, which has been successfully used in prior HCI games research to predict wellbeing outcomes (e.g., [8, 101]).

Self-Determination Theory

Self-determination theory is a macro theory of human motivation, growth, and wellbeing [83]. SDT begins from the position that the human organism is inherently active – the self seeks out interesting and enjoyable (i.e., intrinsically motivating) ways to engage with the environment, and works to coherently assimilate social regulations (i.e., organismic integration). The theory posits three basic psychological needs that energise organismic processes: competence, the feeling of having an effect; autonomy, a sense that actions are self-endorsed and performed willingly; and relatedness, a sense of reciprocal care, value, and belonging in relation to other social figures and collectives [72, 81, 95]. SDT has been successfully applied in domains such as sport [2], learning [71], parenting [24], and work [35] to understand the social-contextual factors that support or thwart human thriving.

SDT has also been applied to PX research, with early studies showing that experiences of need satisfaction during play could predict intrinsic motivation and wellbeing outcomes [69, 86]. With some exceptions (e.g., [93]), more recent work from HCI has used SDT concepts to understand how PX is influenced by particular game elements, such as controller type [8], the degree of challenge [53], in-game rewards (e.g., points) [66], and the presence of social features [49].

A smaller number of studies have applied SDT to investigate how negative events may influence a subsequent session of play. For example, studies involving non-digital games [88] and videogames [75] alike indicate that in-game experiences of need satisfaction remain predictive of beneficial outcomes (e.g., enjoyment, positive affect, performance), even when needs are manipulated prior to play. However, past work has also demonstrated the difficulty of manipulating competence without also influencing autonomy to some degree [75].

The research summarised here demonstrates that need satisfaction measures robustly predict positive outcomes, and can be successfully used to study the ways that particular game elements influence PX. While HCI games research has historically concerned itself with positive experiences (e.g., [91]), more recent work has investigated experiences characterised by negative affects [10], emotional challenge [11, 20, 27], or mixed affect [7, 59]. This turn to complex experiences in HCI games research dovetails with SDT, which has only recently begun to consider need frustration, and its relation to negative experiences [6].

Need Frustration

Need frustration occurs when basic psychological needs are “actively blocked or thwarted” [19]. Whereas diminished need satisfaction emerges in scenes of limited opportunity for growth, need frustration is an oppositional experience; it requires another to impede satisfaction of competence, autonomy, or relatedness. Need satisfaction and frustration are theoretically independent; their co-occurrence within individuals reflects exposure to both positive and negative events [100]. Support for this conceptualisation has been observed in empirical research [3, 6, 38, 58].

Although need frustration has been theorised (by SDT scholars [25] and others [78]) for some time, empirical research in SDT has only recently emerged [6, 89], demonstrating the hypothesised link between need frustration and negative wellbeing outcomes (e.g., depression). Follow-up studies have found further support for this relationship, finding that need frustration predicts lack of motivation [5, 39], burnout [4, 36], and negative affect [37, 38, 58].

However, SDT research on need frustration in the context of play is largely yet to occur. In one notable exception [3], a cross-sectional survey found that experiences of need frustration in videogame play and day-to-day life were associated
with dysregulated play behaviours. This research is important to the present work, as an indicator that need frustration has practical value for predicting game-related negative outcomes. However, as a cross-sectional study, it cannot demonstrate causality – and indeed, we are not aware of any experimental or longitudinal studies that directly assess need frustration in the context of videogame play. In this paper, we aim to understand the ways that experiences of need frustration, relative to need satisfaction, can influence wellbeing outcomes in the context of restorative play.

METHOD

We conducted an experimental study to investigate the extent to which videogame play can improve wellbeing after a negative event. Participants were randomly assigned to one of two conditions, which influenced the character of the word-finding puzzle used as the experimental manipulation: participants in the control condition worked on relatively easy puzzles and received positive performance feedback, while participants assigned to the experimental condition instead worked on relatively difficult puzzles and received negative performance feedback. Participants in the experimental condition were expected to report greater improvement in competence satisfaction, affect, and vitality during the subsequent play session, relative to those assigned to the control condition.

Participants

A total of 73 participants (56 men, 15 women, and 2 non-binary people, aged between 18 to 46) were recruited for the study between July and October 2017; of these, 19 participants also contributed to the post-experiment interviews. Participants were given the option of receiving a random PC game code for their time, valued at $20. Most participants were undergraduate students from a local institution, recruited via in-class announcements; others were recruited via word of mouth, or directly approached on campus.

Three participants in the control condition were excluded from analysis, as they failed to satisfy pre-determined performance criteria (i.e., finding fewer than six words in either puzzle during the manipulation task). One further participant in the control condition was excluded, as they indicated during the debriefing that their survey responses were heavily influenced by unrelated issues in their personal life, which were brought to mind while responding to vitality scale items (i.e., “I am looking forward to each new day”). In the experimental condition, four participants who correctly guessed the aim of the manipulation task without prompting were excluded.

The final sample therefore consisted of 65 participants (control n=33, experimental n=32). Participants in the control condition were aged from 18 to 46 (M = 23.97, SD = 5.53; 7 women, 25 men, 1 non-binary person). Participants in the experimental condition were aged from 18 to 46 (M = 23.09, SD = 6.38; 7 women, 24 men, 1 non-binary person).

Measures

We measured experiences of need satisfaction and frustration in the word-finding task and Mark of the Ninja with the Balanced Measure of Psychological Needs (BMPN) [89]. Competence satisfaction (CS\textsubscript{BMPN}) and frustration (CF\textsubscript{BMPN}), and autonomy satisfaction (AS\textsubscript{BMPN}) and frustration (AF\textsubscript{BMPN}) subscales were assessed (3 items each). Descriptive statistics for each subscale can be found in Table 1. BMPN items were presented on a 5-point scale between “no agreement” and “much agreement”. Example items from each subscale include “I did well even at the hard things” (CS\textsubscript{BMPN}), “I struggled doing something I should be good at” (CF\textsubscript{BMPN}), “I was free to do things my own way” (AS\textsubscript{BMPN}), and “I had a lot of pressures I could do without” (AF\textsubscript{BMPN}). While competence was the focus of this study, we also measured autonomy because manipulating competence alone has proven difficult in prior research [75].

The Player Experience of Need Satisfaction (PENS) [86] instrument (3 items / subscale) measured in-game experiences of competence satisfaction (CS\textsubscript{PENS}) and autonomy satisfaction (AS\textsubscript{PENS}) after videogame play only, as some items refer to “the game” or “play”. As the word-finding task was not perceived to be particularly game-like or playful, it was introduced to participants only as a “task”, and the PENS manual does not encourage altering subscale items, it was deemed inappropriate for use prior to videogame play. PENS items were measured on a 7-point scale between “Do not agree” and “Strongly agree”. Example scale items include “I felt very capable and effective when playing”, and “I did things in the game because they interested me”, assessing competence and autonomy, respectively. PENS validation studies [17, 45, 46] have generally supported the proposed structure of these subscales when familiarity with the target game cannot be assumed.

Short-term wellbeing was assessed with measures of affect and vitality before and after play. Affect was indexed by the Mood Rating Scale [29], which features a 4-item positive affect subscale and 5-item negative affect subscale; the two measures are conceptually and statistically independent of each other. Items were assessed on a 7-point scale between “Not at all” and “Extremely”; sample items include “joyful” (positive affect) and “frustrated” (negative affect). The Mood Rating Scale has seen successful use in SDT research on videogame play [86].

Vitality was assessed by the 6-item state version of the Subjective Vitality Scale [84], which – on the recommendation of its independent validators [12] – excludes the single reverse-scored item from the original scale. Items were measured on a 7-point scale between “Not at all true” and “Very true”.

| Measure          | pre-play |            |            | post-play |            |            |
|------------------|----------|------------|------------|-----------|------------|------------|
|                  | M        | SD         | ω          | 95% CI    | M          | SD         | ω          | 95% CI    |
| CS\textsubscript{BMPN} | 2.421    | 1.063      | 0.903      | 0.830, 0.941 | 3.354      | 0.743      | 0.787      | 0.677, 0.854 |
| CF\textsubscript{BMPN} | 2.795    | 1.214      | 0.822      | 0.735, 0.885 | 2.764      | 0.807      | 0.605      | 0.325, 0.721 |
| AS\textsubscript{BMPN} | 3.108    | 0.834      | 0.834      | 0.716, 0.857 | 3.723      | 0.740      | 0.618      | 0.479, 0.756 |
| AF\textsubscript{BMPN} | 2.067    | 0.846      | 0.550      | 0.285, 0.727 | 1.974      | 0.703      | 0.625      | 0.416, 0.782 |
| PA                | 3.865    | 1.395      | 0.900      | 0.854, 0.939 | 5.508      | 0.876      | 0.885      | 0.825, 0.925 |
| NA                | 2.658    | 1.280      | 0.837      | 0.669, 0.910 | 2.089      | 0.626      | 0.649      | 0.469, 0.661 |
| Vitality         | 3.936    | 1.206      | 0.893      | 0.829, 0.929 | 4.672      | 1.033      | 0.876      | 0.767, 0.918 |

Table 1. Descriptive statistics. Scale reliability estimates and 95% CIs represent categorical omega (ω) bootstrapped with 1000 replications.
Sample items include “At this moment, I feel alive and vital”, and “At this time, I have energy and spirit”. Finally, we assessed post-play intrinsic motivation with the 7-item Interest/Enjoyment subscale of the Intrinsic Motivation Inventory (IMI) [18, 85], but these results are not reported here.

Mark of the Ninja
The target game, *Mark of the Ninja*, was selected following identification of relevant factors in the PX and SDT literatures, and a more detailed analysis of the game itself. The final aim of this process was to select a videogame that would consistently support competence regardless of player skill, while providing fewer opportunities to satisfy other basic needs. Previous SDT research [82, 86] identified game controls, progression structure, and genre as particularly relevant; in this view, competence is facilitated by “game controls [that] are intuitive and readily mastered”, “tasks [that] provide ongoing optimal challenges and opportunities for positive feedback”, and the platform genre’s “relatively limited choices over actions and environments [and focusing] mainly on progressive challenges within a linear format” [86]. Additional review of PX literature underscored the importance of selecting videogames that represent current design practice, with features (e.g., just-in-time tutorial prompts) that minimise time spent grappling with game rules or mechanics [32, 54, 97].

A list of well-designed platform games was then compiled, in conversation with independent game developers [McLarty, Burdak, Keogh, Van Dyke, Thyer, personal communication]. *Mark of the Ninja* (Figure 1) was selected from this list due to consistently positive reviews from both professional critics [60] and players [99], a diegetic and well-structured tutorial, frequent checkpoints, and an interface providing consistent feedback (e.g., numeric score, enemy sight cones, progress towards optional goals). The game’s mostly linear opening levels, and infrequent presence of non-player characters, were elements identified as offering only moderate support for autonomy and relatedness, respectively.

Procedure
Participants were welcomed and thanked for their attendance upon arrival, then introduced to the manipulation task (adapted from [88]): a simple word-finding puzzle. The task involved forming words of adjacent letters in a 4-by-4 grid over a three-minute period. The puzzles used in each condition can be found in the supplementary materials. Participants worked at two such puzzles, and were given false performance feedback after each one. This manipulation task was expected to produce between-condition differences in both competence satisfaction and frustration. Participants were randomly allocated to the control or experimental condition via random number generator, dependent on order of arrival.

In the control condition, the scripted introduction to the first puzzle emphasised that participants would likely improve their skills with effort, despite the apparent challenge. After completing the first puzzle, participants were told they had done well, and the second puzzle would be more challenging as a result. After the second puzzle, participants were informed of their score, relative to an average score for the grid, and told the grid contained a total of 74 words. In truth, the first and second grids were comparably difficult (containing approximately 250 words each), and the purported average score was calculated for each participant as half their true score plus one.

In the experimental condition, the first puzzle was introduced as being “difficult”, and participants were explicitly identified as “beginners” who were unlikely to perform well at the task. After the first puzzle, participants were told they had performed poorly, and the second puzzle would be easier as

Figure 1. *Mark of the Ninja* provides a wealth of contextual information to help players succeed in any situation (or quickly try again if they fail).
a result. After the second puzzle, participants were informed of their score, relative to an average score for the grid, and told the grid contained a total of 104 words. In truth, the two grids were comparably difficult (containing approximately 90 words each), and the purported average score was calculated as the participant’s true score plus seven.

All participants completed the first survey directly after the manipulation task. Following this, participants played *Mark of the Ninja*, a 2D action platformer emphasising stealth, from the beginning for thirty minutes; the second survey was completed immediately afterwards. The researcher remained in the room behind a partition while participants completed both surveys and played *Mark of the Ninja*.

Following completion of the second survey, participants were debriefed, and informed of the purpose of the experiment. The debriefing was conducted in stages to differentiate participants who had truly guessed the study’s aims, without assistance, from those who simply claimed similar insight after the fact. The option to participate in the post-experiment interview was then provided when the researcher was free of successive commitments (e.g., conducting another study). Everyone who was asked to participate in the interview agreed to do so. Semi-structured interview questions addressed the experience of playing *Mark of the Ninja* during the experimental session. These questions explored links between individual game elements and experienced enjoyment, affect, and challenge. Subsequent questions referred to play in day-to-day life, but these results are not reported in this paper. Participants took between 60 to 75 minutes to complete the study, depending on interview involvement.

**Preliminary Analyses**

Zero-order correlations between variables of interest can be found in the supplementary materials. Normality assumptions were satisfied for all variables (i.e., all Kolmogorov-Smirnov tests failed to achieve significance; all skewness and kurtosis z-scores < 2.58 [33]). Some variables – CS<sub>BMPN</sub>, CF<sub>BMPN</sub>, AF<sub>BMPN</sub>, and negative affect – did not satisfy Levene’s test of homogeneity of variance; Box-Cox transforms [15] were applied to these variables (λ<sub>s</sub> = 0.3, 0.8, -0.2, and 0.02, respectively) as a result. Transformed variables accordingly produced non-significant results for Levene’s test. All tests were conducted on both transformed and untransformed data, and substantive differences were not observed. For the sake of clarity, all results are reported in terms of untransformed data (see [33]).

Assumptions of linearity, normally distributed and independent errors, multicollinearity, and homoscedasticity were satisfied in each multiple regression analysis. Preliminary work was conducted in R [70, v3.5.0]: Kolmogorov-Smirnov tests were conducted using the “pigrimess” package; categorical omega [50] was calculated with “MBESS”; and “car” was used to conduct Box-Cox transformations, and calculate Levene’s test values. All other analyses were performed in JASP [42, v0.8.5.1].

We analysed interview responses using thematic analysis [16]. All interviews were audio-recorded and transcribed into Scrivener [9, v1.9.7] by the first author. Interview transcripts were then segmented by topic (which only occasionally coincided with new questions in the interview), then reviewed sequentially, adding as many codes as were relevant to each segment. Segments were revisited when prominent new codes were identified. Themes were created by the first author in conversation with the second author.

**Hypotheses and Research Question**

Based on the reviewed literature, we made the following predictions about our quantitative analyses:

H1: Need-frustrated participants, relative to need-satisfied participants, will experience greater improvement in need satisfaction during play.

H2: Need-frustrated participants, relative to need-satisfied participants, will experience greater improvement in wellbeing during play.

H3: Experiences of need satisfaction and frustration during play will distinctly predict positive and negative wellbeing outcomes.

Our post-experiment interviews were guided by the following research question:

RQ1: How do players understand need satisfaction and frustration as they relate to videogame play?

**RESULTS**

In the following, we begin by presenting results that clarify the effects of the manipulation task. Analyses pertaining to H1 and H2 follow the same procedure. First, we assess whether changes in need satisfaction (H1) or short-term wellbeing (H2) during play varied between conditions. When between-condition differences are identified, we then investigate the degree of change in each condition. Next, we present regression analyses that examine whether need satisfaction and frustration respectively predict positive and negative wellbeing outcomes (H3), while controlling for their pre-play values. Finally, we report two themes derived from post-experiment interviews that reflect varying perspectives toward need satisfaction and frustration as they relate to play (RQ1). All analyses were conducted on the full sample, except where results pertaining to individual conditions are explicitly assessed.

**Manipulation Check**

A series of one-tailed independent samples t-tests were conducted to determine the effectiveness of the experimental manipulation (Table 2), which was expected to influence competence satisfaction and frustration.

Between-condition differences were observed for both competence satisfaction (δ = 2.945) and frustration (δ = -1.993), indicating that the experimental manipulation was successful.
We predicted a set of hypotheses, all of which were supported. The extent to which competence satisfaction changed over time interacted with need frustration to predict post-play positive affect, negative affect, and vitality (Figure 2). We conducted multiple regression analyses to test these hypotheses. Table 3 summarizes the regression coefficients for need satisfaction (H3), controlling for pre-play vitality. We found smaller effects also emerged for autonomy satisfaction and frustration, although these results are qualified by 95% CIs whose finite bounds approach zero, as well as the relatively low internal reliability of both measures. Point estimates of effect size for CS<sub>BMPN</sub> and AS<sub>BMPN</sub> manipulations are similar to those found in previous research [75].

**H1: Relative Change in Need Satisfaction During Play**

We predicted that need-frustrated participants, relative to need-satisfied participants, would experience greater improvement in need satisfaction during play (H1). A 2-way between-within ANOVA on CS<sub>BMPN</sub> was conducted to investigate this hypothesis. The observed Condition × Time interaction, $F(1, 63) = 64.09, p < 0.001$, indicates that changes in competence satisfaction during the study varied across conditions (Figure 2). The extent to which competence satisfaction changed over time in each condition was then quantified with dependent $t$-tests. Participants in the experimental condition experienced improvement in competence satisfaction during play, $t(31) = 12.574, p < 0.001, \hat{\delta} = 2.223$ [1.567, 2.868]; in contrast, no discernible change was observed for participants in the control condition, $t(32) = 0.300, p = 0.766, \hat{\delta} = 0.052$ [-0.290, 0.393]. H1 was supported as a result.

An equivalent, exploratory test was conducted for AS<sub>BMPN</sub>, because autonomy was unintentionally manipulated prior to play. However, the Condition × Time interaction was not significant, $F(1, 63) = 2.397, p = 0.127$.

**H2: Relative Change in Wellbeing During Play**

A set of 2-way between-within ANOVAs were conducted on positive affect, negative affect, and vitality (Figure 2) to test H2, which predicted that need-frustrated participants would experience greater improvement in short-term wellbeing during play, relative to need-satisfied participants. Significant Condition × Time interactions were observed in tests of positive affect, $F(1, 63) = 33.63, p < 0.001$, negative affect, $F(1, 63) = 24.75, p < 0.001$, and vitality, $F(1, 63) = 17.05, p < 0.001$, indicating that the magnitude of change in short-term wellbeing during play varied between conditions. These interactions were followed by dependent $t$-tests for each condition to quantify their respective changes in short-term wellbeing.

Participants in the experimental condition experienced improvement in positive affect, $t(31) = 11.650, p < 0.001, \hat{\delta} = 2.059$ [1.437, 2.671], and vitality, $t(31) = 6.273, p < 0.001, \hat{\delta} = 1.109$ [0.661, 1.546], and a decline in negative affect, $t(31) = -5.348, p < 0.001, \hat{\delta} = -0.945$ [-1.358, -0.522]. Participants in the control condition experienced smaller increases in positive affect, $t(32) = 3.811, p < 0.001, \hat{\delta} = 0.663$ [0.281, 1.037]; however, significant changes in vitality, $t(32) = 1.181, p = 0.246, \hat{\delta} = 0.206$ [-0.141, 0.549], or negative affect, $t(32) = 0.772, p = 0.446, \hat{\delta} = 0.134$ [-0.209, 0.476], were not observed. As participants in the experimental condition experienced greater improvement in short-term wellbeing during play, relative to control, H2 was supported.

**H3: Need Satisfaction and Frustration as Predictors**

Our third hypothesis (H3) concerned whether experiences of need satisfaction and frustration during play respectively predict positive and negative post-play wellbeing outcomes. Regression models were fitted to post-play measures of positive affect (Table 3), negative affect (Table 4), and vitality (Table 5).
to test this hypothesis. We account for the influence of each pre-play wellbeing variable in Model 1, prior to assessing the predictive value of need satisfaction or frustration in Model 2 [23]. As a result, changes in explained variance (i.e., $\Delta R^2$) associated with Model 2 more clearly reflect the extent to which basic needs influence short-term wellbeing outcomes. PENS measures of need satisfaction were used in these models because they more directly assess the player experience.

The addition of need satisfaction or frustration measures in Model 2 led to significant improvement in explained variance for positive affect, $\Delta R^2 = 0.396$, $p < 0.001$, negative affect, $\Delta R^2 = 0.138$, $p = 0.009$, and vitality, $\Delta R^2 = 0.099$, $p = 0.018$. These results are consistent with empirical work in other domains [6, 19] and theoretical literature [81], providing further evidence that need satisfaction and frustration respectively predict positive and negative wellbeing outcomes.

To provide further evidence for need frustration as a predictor of negative wellbeing outcomes, we constructed an additional model of post-play negative affect, with pre-play negative affect, and in-game need satisfaction and frustration as predictors. Neither competence nor autonomy satisfaction were observed to significantly predict post-play negative affect in the presence of need frustration measures ($ps \geq 0.345$), supporting H3 (see supplementary materials for the full table).

**RQ1: Player Perspectives on Need Satisfaction and Frustration in Play**

We conducted interviews to produce more developed insights into participant experiences with *Mark of the Ninja* during the experimental play session. Two themes pertaining to competence satisfaction and frustration – habituation of virtual activity, and aligning with design intent – were constructed from the interview transcripts.

**Theme 1: Habitualisation of virtual activity**

This theme refers to *habitualisation*, a process through which game rules, mechanics, control inputs, and (to some extent) the intended player experience become normalised and incorporated into innate bodily knowledge during play [52]. It is through this augmentation of player and videogame – the “merging of actual and virtual bodies and worlds” [51, p. 4] in play – that players advance the tacit knowledge they need to progress the game state. P19 summarised this experience in *Mark of the Ninja* in terms of “learning all those things in a very short space of time, and trying to keep them all – you know, present in your mind.” These experiences were often described by participants who self-identified as not being a “gamer” (P17, P19), had trouble adjusting to the button mapping (P4, P5, P10, P13, P15, P18), or lacked genre experience (P1, P4, P11, P18). Participants discussed having to direct attention towards more foundational aspects of play (e.g., controls, P10, P17, P19; tactics, P18), which corresponded with feelings of intense concentration or focus (P15, P18, P19). However, some of these disadvantages were mitigated by *Mark of the Ninja’s* tutorial and user interface:

P17: I think having like the base commands on the screen, that was useful, because – for a game that I haven’t played before, it made it a lot easier, trying to work out what was going on. So having those base commands was awesome, [...] also, when the game would sort of pop up, like “grappling hook would be useful here”, like that helped!

Game elements were more often considered novel or “cool” (P1, P5, P17) as a result of participants’ inexperience and learning-focused approach to the game. As P1 noted, “...because this is a new game, it’s interesting to see how it plays out, a bit curious about the continuation, whether there will be like new tricks, right”. Participants described trying new tactics in response to failure, and occasionally seemed confused as to why their actions (e.g., stealth kills) failed (P6, P17, P19).

P6: Oh, the sword attack? It took me a couple of goes to realise that there wasn’t a specific button for the sword, like it only appeared at specific points, when you were still undetectable to the guard [...] it makes sense now that I look back at it, it’s just at that time, I kept pushing it [the X button]. [...] I ended up doing the martial [arts] kick [...] and it didn’t make sense as to why I wasn’t just stabbing him.

However, participants appreciated qualities of the game design that encouraged perseverance in the event of failure:

P5: Going into a room that has three guards, taking out a light, hiding, and then doing all of that, and kind of focusing on it – getting found and going “oh fuck”, going down a vent and coming up somewhere else, having another crack at it, makes you feel more competent, because you achieve something.

P17: So I think the fact that... it – if I, like, got killed by a guard or whatever, it just took me back like a couple of... steps back, and it wasn’t a big deal. I think that helped make it more enjoyable too. It wasn’t frustrating, it was just like “oh ok, like I mucked that up, but I’ll keep going”.

For these players, the immediately salient aspects of playing *Mark of the Ninja* relate to the self-contained (and easily forgotten) experiences of practice, adaptation, and novelty associated with “learning how to play”.

**Theme 2: Aligning with design intent**

This theme reflects participants’ attempts to play in accord with the (perceived) design intent, which is incentivised (explicitly, with points, and implicitly, with greater challenge), and assumed to be the most enjoyable way to experience the game. More specifically, this theme highlights ways that the literacies associated with videogame play – the “...fundamental conduit through which the videogame reveals its experiences to the competent player” [52, p. 78] – can influence PX. Participants’ understanding of the design intent was informed by literacies developed through prior engagement with *Mark of the Ninja* (P2, P5) or other games with comparable mechanics (P7, P8, P14). P2 shows how videogame literacy allows players to resistuate challenge and fun in alignment with game themes and intended performances:

P2: It was my perception of that character and fulfilling that role is where I got the challenge, because it was the tutorial and everything was very easy, but it was..
the opportunities that were presented to me, so there was some degree of autonomy in play, where it’s like – I could avoid this whole situation just by walking past or because I’m this person that’s like losing their mind and a hired killer, that’s what they’re trained to do their whole life, I can put myself out on a limb and risk myself and the mission by trying to kill everyone [laughs]. And that was fun because it’s all like time-based mechanics where I’m trying to line everything up, and execute and everything at the right time. That’s where the fun was.

These players recognised that the physical vulnerability of the archetypal ninja was offset by the potential for smooth or fluid movement (i.e., relative to other characters; P2, P7, P8), and the capacity to avoid detection. Recognising and enacting these possibilities is contingent on player literacy.

Researcher: Ok. What about the stealth makes it enjoyable, then, beyond like, being easy to do?

P14: I think it has this feeling that you are a ninja, and you’re... hiding and planning your attack. It’s just how it makes you feel.

P13: – going back to the whole ninja thing, like yeah you do a lot of killing, but also, there’s an approach to it where you – say you have the ability to infiltrate a place but not leave any traces whatsoever, like no-one would ever know that you were there, but even though you’ve gone in, you’ve taken a bunch of things, like, you’ve done stuff but like no-one would ever find out until like – let’s say you killed someone important, they won’t find out until the next morning, stuff like that.

In this theme, successful play was identified as maintaining the character of the ninja – as archetype and player character – and simply being detected could be considered failure (P2, P7, P12, P13, P14).

P2: I was joyful, but with intermittent moments of frustration, if I like fumbled something or didn’t understand an instruction and later figured it out [...] I didn’t feel like I was looking up to the character anymore, and I felt just as bad as everyone else [in the game world].

P13: So let’s say if you get spotted, you can just run up and smack the dude a few times. But yeah, it’s definitely frustrating, not in the sense that “oh like, oh, I lost the game”, but more of like, “damn it, I like, I failed at my own code of trying to be like this perfect ninja”.

For these participants, much of Mark of the Ninja is familiar; habituation is merely an adjustment to the already-learned fundamentals – controller use, tactics, timing – taught in other videogames. Progress is less inherently rewarding as a result – it seems almost inevitable – instead, these players are more invested in living up to the high-risk, high-reward fantasy associated with the ninja.

DISCUSSION

H1: Relative Change in Need Satisfaction During Play

In this study, we investigated the extent to which videogame play could restore wellbeing after a need-frustrating event, whether assessing need frustration could help explain improvement in wellbeing during play, and how players themselves understand experiences of competence in play. We found, as predicted, that participants in the experimental condition – whose need for competence was frustrated in the manipulation task – experienced greater improvement in competence during play, relative to control (H1). Whereas participants in the experimental condition experienced significant competence restoration, competence satisfaction remained stable during play for participants in the control condition, indicating that participants across conditions identified similar opportunities to satisfy competence in Mark of the Ninja.

These results demonstrate that play can effectively reverse the need-frustrating effect of a negative event, complementing prior work on affective improvement [14, 80]. Our results also provide quantitative support for recent HCI games research on coping [40], in which participants described using games to experience competence in response to circumstances that presented few opportunities for its satisfaction. Although further research is needed to understand the ways that videogames can support coping and restoration, play’s competence-satisfying quality seems essential to the restoration process.

H2: Relative Change in Wellbeing During Play

As predicted, and in line with the results for H1, need-frustrated participants were observed to experience greater wellbeing restoration during play, relative to those in the control condition (H2). More specifically, whereas participants in the control condition experienced some improvement in positive affect, participants in the experimental condition experienced substantial increases in positive affect and vitality during play, and a decline in negative affect. Although participants in the experimental condition experienced greater wellbeing restoration during play, it is worth noting that their need-frustrating experience did not ultimately benefit their wellbeing, relative to those in the control condition – post-play affect and vitality were comparable across conditions (Figure 1).

It remains unclear why need-satisfied participants only experienced a significant increase in positive affect during play. The change may have been caused by autonomy satisfaction, which also improved during play across conditions (Table 1), and was shown to predict positive affect (see below). However, further research is needed to draw firm conclusions regarding this finding.

H3: Predictive Value of Need Satisfaction and Frustration

We hypothesised that experiences of need satisfaction and frustration during play would distinctly predict positive and negative post-play wellbeing outcomes, and results were consistent with these expectations. Although the sample size did not allow for meaningful conclusions about individual predictors [23], the proportion of variance explained in models of positive affect, negative affect, and vitality was consistently improved by the addition of need satisfaction or frustration measures. Crucially, need frustration was shown to predict negative affect more effectively than need satisfaction, demonstrating its value for studies of negative wellbeing outcomes.
Following SDT [100], it is likely that the abundance of need-satisfying design elements in *Mark of the Ninja* led to improvement in wellbeing outcomes, and its relative absence of need-frustrating elements helped attenuate negative outcomes. Although we have focused on wellbeing outcomes in this study, SDT research in education [5, 41] indicates that disengagement and amotivation are also fuelled by need frustration. It therefore seems essential for developers and researchers alike to consider the need-frustrating qualities of designs for entertainment, retention, or behaviour change.

While prior research has examined the effects of need frustration in sport [6], education [5, 22], and the workplace [4, 98], the present work is (to our knowledge) the first experimental study to investigate the influence of need frustration on negative wellbeing outcomes in the context of videogame play. Notably, competence explained a significant proportion of variance in all three wellbeing outcomes, highlighting its importance to the restorative play experience.

RQ1: Experiences of Competence in Play

We conducted post-experiment interviews to further investigate the ways that players identify competence support in a game’s design, and understand experiences of need satisfaction and frustration in play. We hoped that conducting these interviews immediately after the study would help participants recall specific details about *Mark of the Ninja*. We found that participants described their in-game experiences in ways that reflected their localised knowledge of videogames, game controllers, and genre conventions.

More specifically, less literate participants tended to focus on the functional experience of learning to operate (in) the game, and the aspects of *Mark of the Ninja*’s design that supported the learning process. For these participants, the on-screen control prompts, clear tutorial, and frequent checkpoints elicited competence support. The competence satisfaction afforded by in-game progress was a result of these scaffolding elements. Accordingly, these players experienced competence frustration when their incomplete understanding of the game design (e.g., conditions for performing stealth kills) obstructed progress on multiple occasions.

Participants with more applicable literacies (e.g., with 2D platformers or stealth games) described attempts to play in ways that reflected what they saw as designer intent – trying to embody the elegance and subtlety of the ninja. These participants found competence support in the fluidity of character movement, and the responsiveness of game input, which facilitated more complicated manoeuvres and helped prevent detection. These players experienced competence satisfaction when their enacted performances aligned with their ideas about how a scene should play out, as informed by the ninja-avatar, the array of possible approaches enabled by the game design, and the limits of their own abilities. Conversely, need frustration occurred when these participants failed to meet these self-imposed standards for play, even when these “failed” performances resulted in further progress in the game.

SDT posits that videogames primarily satisfy competence by responding to player activity with immediate positive feedback, a clear sense of progress, variations in challenge over time, and an intuitive control scheme [82, 86]. These abstractions generalise across players and videogames; they assume, to some extent, a player whose prior habitualisation to games prepares them for other, similar ones; a player with “embodied literacies” [52] through which videogame control schemes can be intuited. These results, however, suggest that a broader view of player experience is produced by acknowledging the range of potential videogame performances [43].

In particular, this study indicates that players identify competence support in game elements that facilitate engagement at their present literacy. Whereas less literate players attend to aspects of design that convey the fundamentals of engagement, players with more closely-aligned literacies identify competence support in game elements through which performances may be altered to reflect design intent. Experiences of competence satisfaction and frustration are situated in players’ ongoing perception of success or failure at interpreting and enacting play as they understand it. These results elaborate the present characterisation of competence in SDT games literature [82], accounting for a greater proportion of the increasingly wide range of videogame players.

Crucially, our study highlights that we cannot assume that literate players and users will necessarily experience high competence satisfaction during interactive system use, or indeed be shielded from experiences of competence frustration. Whereas more literate participants were familiar with the game controls, for example, they nonetheless described in-game scenarios characterised by competence frustration. Our findings align with those of Johnson et al. [46], who conducted their PENS validation study using data from a highly literate sample and derived a single Intuitive Controls and Competence factor.

These results have further implications for the ways that researchers and designers conceptualise competence with regards to interactive systems more generally. Software-based literacies inform user perspectives on what constitutes competent use. The usability of an interactive system – and indeed, the extent to which it facilitates expressive user performances – varies as a function of user literacy. Aspects of software design that support expressiveness for literate users may go unnoticed by novices, or obstruct their use.

Limitations and Future Work

Several issues emerged regarding scale use in this study. BMPN measures of autonomy satisfaction and frustration demonstrated low reliability prior to play (ωs = 0.528 and 0.550, respectively), and similarly weak post-play reliability was observed in our chosen measure of negative affect (ω = 0.480). The BMPN is a general scale, and may not be well-suited to player experience research. The negative affect scale’s poor reliability is harder to explain, given its length (five items), item clarity, and prior use in videogame research [86]. Results involving these measures should be interpreted with some caution. Future PX research on need frustration should consider alternative measures.

These issues reflect a broader need for reliable, externally validated PX scales in HCI games research [28, 57]. High-quality
survey measures remain crucial in the context of a growing interest in psychophysiological measures and game-based metrics, as researchers applying these techniques continue to adopt PX scales for verification [30]. Applying a broader range of assessments (e.g., observational methods) would also benefit PX measurement in the present study, and the broader literature.

Future work in this area could explore the influence of intentional play for restoration, relative to play for enjoyment, on player behaviour and PX. Individuals who play for restoration may, for example, place greater value on the reliability of solitary play [102] to avoid the performance pressure and toxic player behaviour that characterise online play experiences [96]. In this sense, restorative play may involve a narrowing of taste; a preference for more familiar, comfortable, and conveniently need-satisfying experiences. While experiences of need satisfaction undoubtedly contribute to a “well-lived life”, identifying circumstances under which videogame play is reflectively valued remains an open question for SDT-PX research.

The present work compared participants in a need-frustrated (experimental) condition to those in a need-satisfied (control) condition. However, future studies could instead adopt a “neutral” control, comprising participants whose needs are neither satisfied nor frustrated prior to videogame play, with potential to develop further insights into relationships between need satisfaction, need frustration, and restorative play.

Overall, our findings align with anecdotal evidence from players who report playing videogames to feel “better” after a difficult day. This empirical support is valuable for reassuring concerned individuals (e.g., players, parents, or partners) as to the efficacy of restorative play. More broadly, the present work also augments an emerging trend of cross-sectional videogame research that measures need satisfaction and frustration in parallel to investigate positive and negative outcomes of videogame play [68, 92].

We highlight that the results presented here may not generalise across players, the videogame medium at large, or even the 2D platform genre. Future studies should examine the differential effects of individual videogames or game elements on need satisfaction and wellbeing derived from play, and investigate to what extent our findings vary across player expertise. While sample homogeneity (i.e., mostly undergraduate students) limited the risk of making Type II errors [47], more varied samples would improve the generalisability of future research. In particular, the predominance of men as participants in videogame research is a known issue [103], and their over-representation in this sample is a limitation of the study. It may also be fruitful to investigate the influence of player preferences for specific subject matter [64, 65] in the restoration process. The present work has, in general, reduced videogames to mere vehicles for entertainment; while individuals may indeed seek positive experiences when playing for restoration, more complex [104] and emotionally challenging [11, 20, 27] material is regardless expressed in and through the medium [61].

The present work has demonstrated that videogame play can be highly effective at restoring player wellbeing after a negative event; moreover, we have shown that improvement in post-play wellbeing is directly attributable to need satisfaction and frustration experienced during play. However, understanding the ways that videogames influence wellbeing merits further consideration of the myriad players, videogames, and social contexts implicated in PX. We therefore remain interested in the varied experiences made possible through videogames – not only for their potential function in restoration, but as valuable artefacts in and for themselves.

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REFERENCES
[1] Paul JC Adachi and Teena Willoughby. 2015. From the Couch to the Sports Field: The Longitudinal Associations Between Sports Video Game Play, Self-Esteem, and Involvement in Sports. Psychology of Popular Media Culture 4, 4, 329–341.
[2] James W. Adie, Joan L. Duda, and Nikos Ntoumanis. 2008. Autonomy Support, Basic Need Satisfaction and the Optimal Functioning of Adult Male and Female Sport Participants: A Test of Basic Needs Theory. Motivation and Emotion 32, 3, 189–199.
[3] Johnie J. Allen and Craig A. Anderson. 2018. Satisfaction and Frustration of Basic Psychological Needs in the Real World and in Video Games Predict Internet Gaming Disorder Scores and Well-Being. Computers in Human Behavior 84, 220–229.
[4] Kimberley J. Bartholomew, Nikos Ntoumanis, Ricardo Cuevas, and Chris Lonsdale. 2014. Job Pressure and Ill-Health in Physical Education Teachers: The Mediating Role of Psychological Need Thwarting. Teaching and Teacher Education 37, 101–107.
[5] Kimberley J. Bartholomew, Nikos Ntoumanis, Athanasios Mouratidis, Ermiioni Kartziti, Ceciie Thøgersen-Ntoumani, and Symeon Vlachopoulos. 2018. Beware of Your Teaching Style: A School-Year Long Investigation of Controlling Teaching and Student Motivational Experiences. Learning and Instruction 53, 50–63.
[6] Kimberley J. Bartholomew, Nikos Ntoumanis, Richard M. Ryan, Jos A. Bosch, and Ceciie Thøgersen-Ntoumani. 2011. Self-Determination Theory and Diminished Functioning: The Role of Interpersonal Control and Psychological Need Thwarting. Personality and Social Psychology Bulletin 37, 11, 1459–1473.
[7] Max V. Birk, Ioanna Iacovides, Daniel Johnson, and Regan L. Mandryk. 2015. The False Dichotomy Between Positive and Negative Affect in Game Play. In Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play. ACM, 799–804.
[8] Max V. Birk and Regan L. Mandryk. 2013. Control Your Game-Self: Effects of Controller Type on Enjoyment, Motivation, and Personality in Game. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM, 685–694.

[9] Keith Blount, Lee Powell, Tihomir Dolapchiev, Ioa Petra’ka, Janik Baumgartner, David Vignoni, and Kenichi Yoshida. 2016. Scrivener for Windows and Linux [Version 1.9.7]. Literature and Latte.

[10] Julia Ayumi Bopp, Elisa D. Mekler, and Klaus Opwis. 2016. Negative Emotion, Positive Experience?: Emotionally Moving Moments in Digital Games. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. ACM, 2996–3006.

[11] Julia Ayumi Bopp, Klaus Opwis, and Elisa D. Mekler. 2018. “An Odd Kind of Pleasure”: Differentiating Emotional Challenge in Digital Games. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. ACM.

[12] Terence J. Bostic, Doris McGartland Rubio, and Mark Hood. 2000. A Validation of the Subjective Vitality Scale Using Structural Equation Modeling. Social Indicators Research 52, 3, 313–324.

[13] Jeroen Bourgonjon, Geert Vandermeersche, Bram De Wever, Ronald Soetaert, and Martin Valcke. 2016. Players’ Perspectives on the Positive Impact of Video Games: A Qualitative Content Analysis of Online Forum Discussions. New Media & Society 18, 8, 1732–1749.

[14] 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, 375–393.

[15] G. E. P. Box and D. R. Cox. 1964. An Analysis of Transformations. Journal of the Royal Statistical Society 26, 2, 211–252.

[16] Virginia Braun and Victoria Clarke. 2006. Using Thematic Analysis in Psychology. Qualitative Research in Psychology 3, 77–101.

[17] Florian Brühlmann and Gian-Marco Schmid. 2015. How to Measure the Game Experience? Analysis of the Factor Structure of Two Questionnaires. In Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems. ACM, 1181–1186.

[18] Center for Self-Determination Theory. n.d. Intrinsic Motivation Inventory (IMI). Accessed 22 August, 2019 from https://selfdeterminationtheory.org/intrinsic-motivation-inventory/.

[19] Beiwen Chen, Maarten Vansteenkiste, Wim Beyers, Liesbet Boone, Edward L. Deci, Jolene Van der Kaap-Deeder, Bart Duriez, Willy Lens, Lennia Matos, Athanasios Mouratidis, Richard M. Ryan, Kennon M. Sheldon, Bart Soenens, Stijn Van Petegem, and Joke Versuyf. 2015. Basic Psychological Need Satisfaction, Need Frustration, and Need Strength Across Four Cultures. Motivation and Emotion 39, 2, 216–236.

[20] Tom Cole, Paul Cairns, and Marco Gillies. 2015. Emotional and Functional Challenge in Core and Avant-garde Games. In Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play. ACM, 121–126.

[21] Emily Collins and Anna L. Cox. 2014. Switch On to Games: Can Digital Games Aid Post-Work Recovery? International Journal of Human-Computer Studies 72, 654–662.

[22] Pedro Cordeiro, Paula Paixão, Willy Lens, Marlies Lacante, and Kennon M. Sheldon. 2016. Factor Structure and Dimensionality of the Balanced Measure of Psychological Needs Among Portuguese High School Students. Relations to Well-Being and Ill-Being. Learning and Individual Differences 47, 51–60.

[23] Richard B. Darlington and Andrew F. Hayes. 2016. Regression Analysis and Linear Models: Concepts, Applications, and Implementation. Guilford Press, New York, USA.

[24] Edward L. Deci, Robert E. Driver, Lucinda Hotchkiss, Robert J. Robbins, and Ilona McDougal Wilson. 1993. The Relation of Mothers’ Controlling Vocalisations to Children’s Intrinsic Motivation. Journal of Experimental Child Psychology 55, 2, 151–162.

[25] Edward L. Deci and Richard M. Ryan. 2000. The “What” and “Why” of Goal Pursuits: Human Needs and Self-Determination of Behavior. Psychological Inquiry 11, 4, 227–268.

[26] Anita DeLongis, James C. Coyne, Gayle Dakof, Susan Folkman, and Richard S. Lazarus. 1982. Relationalship of Daily Hassles, Uplifts, and Major Life Events to Health Status. Health Psychology 1, 2, 119–136.

[27] Alena Denisova, Christian Guckelsberger, and David Zendle. 2017. Challenge in Digital Games: Towards Developing a Measurement Tool. In Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems. ACM, 2511–2519.

[28] Alena Denisova, A. Imran Nordin, and Paul Cairns. 2016. The Convergence of Player Experience Questionnaires. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play. ACM.

[29] Ed Diener and Robert A. Emmons. 1984. The Independence of Positive and Negative Affect. Journal of Personality and Social Psychology 47, 5, 1105–1117.

[30] Anders Drachen. 2015. Behavioral Telemetry in Games User Research. In Game User Experience Evaluation, Regina Bernhaupt (Ed.). Springer International, Switzerland, 135–165.
[31] Stephen R. Earl, Ian M. Taylor, Carla Meijen, and Louis Passfield. 2017. Autonomy and Competence Frustration in Young Adolescent Classrooms: Different Associations with Active and Passive Disengagement. Learning and Instruction 49, 32–40.

[32] Malte Elson and Thorsten Quandt. 2016. Digital Games in Laboratory Experiments: Controlling a Complex Stimulus Through Modding. Psychology of Popular Media Culture 5, 1, 52–65.

[33] Andy Field, Jeremy Miles, and Zoë Field. 2012. Using R. Sage, London, England, 166–204.

[34] Nicolas Gillet, Jacques Forest, Charles Benabou, and Kathleen Benten. 2015a. The Effects of Organizational Factors, Psychological Need Satisfaction and Thwarting, and Affective Commitment on Workers’ Well-Being and Turnover Intentions. Le Travail Humain 78, 2, 119–140.

[35] Nicolas Gillet, Evelyne Fouquereau, Tiphaine Huyghebaert, and Philippe Colombat. 2015b. The Effects of Job Demands and Organizational Resources through Psychological Need Satisfaction and Thwarting. The Spanish Journal of Psychology 18.

[36] Nicolas Gillet, Marc-André K. Lafrenière, Robert J. Vallerand, Isabelle Huart, and Evelyne Fouquereau. 2014. The Effects of Autonomous and Controlled Regulation of Performance-Approach Goals on Well-Being: A Process Model. British Journal of Social Psychology 53, 1, 154–174.

[37] Katie E. Gunnell, Peter R. E. Crocker, Philip M. Wilson, Diane E. Mack, and Bruno D. Zumbo. 2013. Psychological Need Satisfaction and Thwarting: A Test of Basic Psychological Needs Theory in Physical Activity Contexts. Psychology of Sport and Exercise 14, 5, 599–607.

[38] Leen Haerens, Nathalie Aelterman, Maarten Vansteenkiste, Bart Soensens, and Stijn Van Petegem. 2015. Do Perceived Autonomy-Supportive and Controlling Teaching Relate to Physical Education Students’ Motivational Experiences Through Unique Pathways? Distinguishing Between the Bright and Dark Side of Motivation. Psychology of Sport and Exercise 16, 3, 26–36.

[39] Ioanna Iacovides and Elisa D. Mekler. 2019. The Role of Gaming During Difficult Life Experiences. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. ACM.

[40] Hyungshim Jang, Eun Joo Kim, and Johnmarshall Reeve. 2016. Why Students Become More Engaged or More Disengaged During the Semester: A Self-Determination Theory Dual-Process Model. Learning and Instruction 43, 27–38.

[41] JASP Team. 2017. JASP [Version 0.8.5.1]. University of Amsterdam, Netherlands. https://jasp-stats.org/.

[42] Darshana Jayemanne. 2017. Performativity in Art, Literature, and Videogames. Springer International, Cham, Switzerland.

[43] Charlene Jennett. 2010. Is Game Immersion Just Another Form of Selective Attention? An Empirical Investigation of Real World Dissociation in Computer Game Immersion. Thesis.

[44] Daniel Johnson and John Gardner. 2010. Personality, Motivation and Video Games. In Proceedings of the 22nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction. ACM, 276–279.

[45] Daniel Johnson, M. John Gardner, and Ryan Perry. 2018. Validation of Two Game Experience Scales: The Player Experience of Need Satisfaction (PENS) and Game Experience Questionnaire (GEQ). International Journal of Human-Computer Studies 118, 38–46.

[46] Will Kalkhoff, Reef Youngreen, Leda Nath, and Michael J. Lovaglia. 2014. Human Participants in Laboratory Experiments in the Social Sciences. In Laboratory Experiments in the Social Sciences, Murray Webster and Jane Sell (Eds.). Elsevier, 103–126.

[47] Allen D. Kanner, James C. Coyne, Catherine Schaefer, and Richard S. Lazarus. 1981. Comparison of Two Modes of Stress Measurement: Daily Hassles and Uplifts Versus Major Life Events. Journal of Behavioral Medicine 4, 1, 1–39.

[48] Maximus D. Kaos, Ryan E. Rhodes, Perttu Hämäläinen, and T. C. Graham. 2019. Social Play in an Exergame: How the Need to Belong Predicts Adherence. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. ACM.

[49] Ken Kelley and Sunthud Pornprasertmanit. 2016. Confidence Intervals for Population Reliability Coefficients: Evaluation of Methods, Recommendations, and Software for Composite Measures. Psychological Methods 21, 1, 69–92.

[50] Brendan Keogh. 2018a. A Play of Bodies: How We Perceive Videogames. MIT, Cambridge, USA.

[51] Brendan Keogh. 2018b. With Thumbs in Mind. In A Play of Bodies: How We Perceive Videogames. MIT, Cambridge, USA, 75–108.

[52] Madison Klarkowski, Daniel Johnson, Peta Wyeth, Mitchell McEwan, Cody Phillips, and Simon Smith. 2016. Operationalising and Evaluating Sub-Optimal and Optimal Play Experiences through Challenge-Skill Manipulation. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. ACM, 5583–5594.
[54] Madison Klarkowski, Daniel Johnson, Peta Wyeth, Simon Smith, and Cody Phillips. 2015. Operationalising and Measuring Flow in Video Games. In Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction. ACM, 114–118.

[55] Klei Entertainment. 2012. Mark of the Ninja. Videogame [PC]. Microsoft Studios, Washington, USA.

[56] Andrew Kuo, Richard J. Lutz, and Jacob L. Hiler. 2016. Brave New World of Warcraft: A Conceptual Framework for Active Escapism. Journal of Consumer Marketing 33, 7, 498–506.

[57] Effie L.-C. Law, Florian Brühlmann, and Elisa D. Mekler. 2018. Systematic Review and Validation of the Game Experience Questionnaire (GEQ) – Implications for Citation and Reporting Practice. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play. ACM, 257–270.

[58] Ylenio Longo, Alexander Gunz, Guy J. Curtis, and Tom Farsides. 2016. Measuring Need Satisfaction and Frustration in Educational and Work Contexts: The Need Satisfaction and Frustration Scale (NSFS). Journal of Happiness Studies 17, 1, 295–317.

[59] Elisa D. Mekler, Stefan Rank, Sharon T. Steinemann, Max V. Birn, and Ioanna Iacovides. 2016. Designing for Emotional Complexity in Games: The Interplay of Positive and Negative Affect. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts. ACM, 367–371.

[60] Metacritic. 2013. Mark of the Ninja Critic Reviews for PC. https://www.metacritic.com/game/pc/mark-of-the-ninja/critic-reviews (Accessed 21 December, 2018).

[61] Alexander Muscat and Jonathan Duckworth. 2018. WORLD4: Designing Ambiguity for First-Person Exploration Games. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play. ACM, 341–351.

[62] Bonnie Nardi and Justin Harris. 2006. Strangers and Friends: Collaborative Play in World of Warcraft. In Proceedings of the 2006 Conference on Computer Supported Cooperative Work. ACM, 149–158.

[63] Christopher A. Oswald, Chris Prorock, and Shane M. Murphy. 2014. The Perceived Meaning of the Video Game Experience: An Exploratory Study. Psychology of Popular Media Culture 3, 2, 110–126.

[64] Cale J. Passmore and Regan L. Mandryk. 2018. An About Face: Diverse Representation in Games. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play. ACM, 365–380.

[65] Nicole Peever, Daniel Johnson, and John Gardner. 2012. Personality & Video Game Genre Preferences. In Proceedings of The 8th Australasian Conference on Interactive Entertainment. ACM.

[66] Cody Phillips, Daniel Johnson, Madison Klarkowski, Melanie Jade White, and Leanne Hides. 2018. The Impact of Rewards and Trait Reward Responsiveness on Player Motivation. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play. ACM, 393–404.

[67] Andrew K. Przybylski and Netta Weinstein. 2017. A Large-Scale Test of the Goldilocks Hypothesis: Quantifying the Relations Between Digital-Screen Use and the Mental Well-Being of Adolescents. Psychological Science 28, 2, 204–215.

[68] Andrew K. Przybylski and Netta Weinstein. 2019. Investigating the Motivational and Psychosocial Dynamics of Dysregulated Gaming: Evidence From a Preregistered Cohort Study. Clinical Psychological Science 7, 6, 1257–1265.

[69] Andrew K. Przybylski, Netta Weinstein, Richard M. Ryan, and C. Scott Rigby. 2009. Having to Versus Wanting to Play: Background and Consequences of Harmonious Versus Obsessive Engagement in Video Games. CyberPsychology & Behavior 12, 5, 485–492.

[70] R Core Team. 2018. R: A Language and Environment for Statistical Computing [Version 3.5.0]. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org.

[71] Rémi Radel, Philippe Sarrazin, Pascal Legrain, and Lucie Gobancé. 2009. Subliminal Priming of Motivational Orientation in Educational Settings: Effect on Academic Performance Moderated by Mindfulness. Journal of Research in Personality 43, 4, 695–698.

[72] Johnmarshall Reeve, Glen Nix, and Diane Hamm. 2003. Testing Models of the Experience of Self-Determination in Intrinsic Motivation and the Conundrum of Choice. Journal of Educational Psychology 95, 2, 375–392.

[73] Leonard Reinecke. 2009. Games and Recovery: The Use of Video and Computer Games to Recuperate from Stress and Strain. Journal of Media Psychology 21, 3, 126–142.

[74] Leonard Reinecke, Jennifer Klatt, and Nicole C Kramar. 2011. Entertaining Media Use and the Satisfaction of Recovery Needs: Recovery Outcomes Associated With the Use of Interactive and Noninteractive Entertaining Media. Media Psychology 14, 2, 192–215.

[75] Leonard Reinecke, Ron Tamborini, Matthew Grizzard, Robert Lewis, Allison Eden, and Nicholas David Bowman. 2012. Characterizing Mood Management as Need Satisfaction: The Effects of Intrinsic Needs on Selective Exposure and Mood Repair. Journal of Communication 62, 3, 437–453.
[76] Diana Rieger, Lena Frischlich, Tim Wulf, Gary Bente, and Julia Kneer. 2015. Eating Ghosts: The Underlying Mechanisms of Mood Repair Via Interactive and Noninteractive Media. Psychology of Popular Media Culture 4, 2, 138–154.

[77] Meredith Rocchi, Luc Pelletier, and Philippe Desmarais. 2017. The Validity of the Interpersonal Behaviors Questionnaire (IBQ) in Sport. Measurement in Physical Education and Exercise Science 21, 1.

[78] Saul Rosenzweig. 1944. An Outline of Frustration Theory. In Personality and the Behavior Disorders, J. McV. Hunt (Ed.). Ronald Press, New York, USA, 379–388. https://archive.org/details/personalityandth031639mbp

[79] Carmen V. Russoniello, Matthew Fish, and Kevin O’Brien. 2013. The Efficacy of Casual Videogame Play in Reducing Clinical Depression: A Randomized Controlled Study. Games for Health Journal 2, 6, 341–346.

[80] Carmen V. Russoniello, Kevin O’Brien, and Jennifer M. Parks. 2009. The Effectiveness of Casual Video Games in Improving Mood and Decreasing Stress. Journal of CyberTherapy and Rehabilitation 2, 1, 53–66.

[81] Richard M. Ryan and Edward L. Deci. 2017a. Basic Psychological Needs Theory: Satisfaction and Frustration of Autonomy, Competence, and Relatedness in Relation to Psychological Wellness and Full Functioning. In Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness. Guilford, New York, NY, 239–271.

[82] Richard M. Ryan and Edward L. Deci. 2017b. Motivation and Need Satisfaction in Video Games and Virtual Environments. In Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness. Guilford, New York, NY, 508–531.

[83] Richard M. Ryan and Edward L. Deci. 2017c. Self-Determination Theory: An Introduction and Overview. In Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness. Guilford, New York, NY, 3–25.

[84] Richard M. Ryan and Christina Frederick. 1997. On Energy, Personality, and Health: Subjective Vitality as a Dynamic Reflection of Well-Being. Journal of Personality 65, 3, 529–565.

[85] Richard M. Ryan, Valerie Mims, and Richard Koestner. 1983. Relation of Reward Contingency and Interpersonal Context to Intrinsic Motivation: A Review and Test using Cognitive Evaluation Theory. Journal of Personality and Social Psychology 45, 4, 736–750.

[86] Richard M. Ryan, C. Scott Rigby, and Andrew Przybylski. 2006. The Motivational Pull of Video Games: A Self-Determination Theory Approach. Motivation and Emotion 30, 4, 344–360.

[87] Kennon M. Sheldon. 2018. Understanding The Good Life: Eudaimonic Living Involves Well-Doing, Not Well-Being. In The Social Psychology of Living Well, Joseph P. Forgas and Roy F. Baumeister (Eds.). 116–136.

[88] Kennon M. Sheldon and Vincent Filak. 2008. Manipulating Autonomy, Competence, and Relatedness Support in a Game-Learning Context: New Evidence that All Three Needs Matter. British Journal of Social Psychology 47, 2, 267–283.

[89] Kennon M. Sheldon and Jonathan C. Hilpert. 2012. The Balanced Measure of Psychological Needs (BMPN) Scale: An Alternative Domain General Measure of Need Satisfaction. Motivation and Emotion 36, 4, 439–451.

[90] Jeffrey G. Snodgrass, Michael G. Lacy, H. J. Francois Dengah, and Jesse Fagan. 2011. Enhancing One Life Rather than Living Two: Playing MMOs with Offline Friends. Computers in Human Behavior 27, 3, 1211–1222.

[91] Penelope Sweetser and Peta Wyeth. 2005. GameFlow: A Model for Evaluating Player Enjoyment in Games. Computers in Entertainment 3, 3.

[92] István Tóth-Király, Beáta Bóthe, Anett Neszta Márki, Adrien Rigó, and Gábor Orosz. 2019. Two Sides of the Same Coin: The Differentiating Role of Need Satisfaction and Frustration in Passion for Screen-Based Activities. European Journal of Social Psychology 49, 6, 1190–1205.

[93] Selen Türkay and Sonam Adinolf. 2018. Understanding Online Collectible Card Game Players’ Motivations: A Survey Study with Two Games. In Proceedings of the 30th Australian Conference on Computer-Human Interaction. ACM, 501–505.

[94] April Tyack and Elisa D. Mekler. 2020. Self-Determination Theory in HCI Games Research: Current Uses and Open Questions. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. ACM.

[95] April Tyack and Peta Wyeth. 2017. Exploring Relatedness in Single-Player Video Game Play. In Proceedings of the 29th Australian Conference on Computer-Human Interaction. ACM, 422–427.

[96] April Tyack, Peta Wyeth, and Daniel Johnson. 2016. The Appeal of MOBA Games: What Makes People Start, Stay, and Stop. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play. ACM, 313–325.

[97] April Tyack, Peta Wyeth, and Madison Klarkowski. 2018. Video Game Selection Procedures For Experimental Research. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. ACM.
[98] Wenceslao Unanue, Konrad Rempel, Marcos E. Gómez, and Anja Van den Broeck. 2017. When and Why Does Materialism Relate to Employees’ Attitudes and Well-being: The Mediational Role of Need Satisfaction and Need Frustration. *Frontiers in Psychology* 8.

[99] Valve Corporation. Mark of the Ninja on Steam. store.steampowered.com/app/214560/Mark_of_the_Ninja (Accessed 21 December, 2018).

[100] Anja Van den Broeck, D. Lance Ferris, Chu-Hsiang Chang, and Christopher C. Rosen. 2016. A Review of Self-Determination Theory’s Basic Psychological Needs at Work. *Journal of Management* 42, 5, 1195–1229.

[101] Kellie Vella, Daniel Johnson, and Leanne Hides. 2015. Playing Alone, Playing With Others: Differences in Player Experience and Indicators of Wellbeing. In *Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play*. 3–12.

[102] Kellie Vella, Madison Klarkowski, Daniel Johnson, Leanne Hides, and Peta Wyeth. 2016. The Social Context of Video Game Play: Challenges and Strategies. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems*. ACM, 761–772.

[103] Kellie Vella, Madison Klarkowski, Selen Türkay, and Daniel Johnson. 2019. Making Friends in Online Games: Gender Differences and Designing for Greater Social Connectedness. *Behaviour & Information Technology*.

[104] Douglas Wilson and Miguel Sicart. 2010. Now it’s Personal: On Abusive Game Design. In *Proceedings of the International Academic Conference on the Future of Game Design and Technology*. ACM, 40–47.