Cognitive Workload, Game Experience, and Intrinsic Motivation

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Abstract

When it comes to game design, two features that have been linked to the success of a game are playability and the subjective game experience. This is perhaps not surprising, as the main purpose of a game is to entertain. What cognitive factors that may underlie these features has, however, not been explored. This study examines the relationship between both workload and cognitive workload and player experience. The results suggest that an increase in workload, including cognitive workload, positively affect the player experience of the game as well as the player’s intrinsic motivation.
Acknowledgements

First and foremost, I would like to express my sincere gratitude to Ove Jansson for taking on the role as my second supervisor. Thank you for your encouragement, patience, and guidance throughout this process.

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1 Introduction

When designing games, there are two features one ought to have in mind, as they affect the success of the game design. These are:

1. Playability (i.e. the game is working as intended and as expected by the user).
2. The subjective game experience (i.e. the game is fun, immersive etc.).

Since the main purpose of a game is to entertain, the relationship between these two features and the success of a game design should not be surprising. Less clear, however, is the relationship between these two features and experienced workload, such as cognitive workload. A game perceived as demanding might be challenging and fun, but it could also be perceived as boring and exhausting. It is possible that the amount of cognitive load perceived by the user could have an effect of multiple variables. A game perceived as too cognitive demanding could lower the will to play, in turn lowering the possible effects of playing the game. If the game has a focus on educational properties, then the learning might diminish. Alike, a game designed for physical or psychological rehabilitation might show less of a positive effect.

As of yet, the studies on workload and game experience seem to be focused on the effect of cognitive load on learning, but not on the game experience itself. The aim of this study is to, in an exploratory way, investigate the association between workload, cognitive workload, and a series of other variables related to game experience. As workload is quite ambiguous, this study focuses on self-perceived cognitive load estimated using a measuring tool developed by Nasa. Two versions of a movement-based game are used to explore perceived workload and its impact on game experience. The participants’ subjective game experience, perceived workload, as well as their intrinsic motivation is measured, compared, and correlated against each other with the aim to understand how cognitive load might affect the different measurements. Finding an effect might show an importance of assessing cognitive workload when designing games.

The two game versions used can be described as a reactive version and a strategic version. What separates the versions is that the strategic version contains obstacles that the player needs to avoid in order to succeed. The purpose of using different game mechanics was to increase the chance of a variability in cognitive workload which can be of use when analysing its effect on game experience and intrinsic motivation.
1.1 Research Question

Does a strategic game mechanic increase the experienced workload in comparison to reactive a game mechanic, and if it does: does the experienced workload change the game experience and performance movement based interaction? Is there a stand-alone effect of the experienced cognitive workload on game experience as well?

1.2 Limitations

Since no similar studies were found, a priori power analysis could not be made to estimate the number of participants needed for a good chance of detecting an effect. A post priori test instead showed a power of 0.5, which is below the usually desired power value of 0.8. To increase the power, thus decreasing the risk of a type II error (i.e. false negatives), a larger sample size should be used. Due to time constraints, increasing the sample size was not possible in this study why the conclusions made should be seen not as a statistical truth, but rather as a statistical guideline.

Another limitation in this study relates to the use of Nasa-TLX. Nasa-TLX in its original form is complex and time demanding, why an easier version called Nasa raw TLX was used for this study. The measurement is both frequently used and highly correlated to the Nasa-TLX, but, unlike in Nasa-TLX, the different components of the questionnaire are not weighed with regard to their importance.
2 Background Theory

2.1 Exertion Games

An exertion game is a digital game in which the outcome is mainly determined by physical effort (Mueller et al., 2011). The potential of embracing physical activities in games has attracted large game enterprises, leading to the development of Nintendo Wii, Sony’s PlayStation Move and Microsoft’s Xbox Kinect. There are a number of positive health effects linked to exertions games which makes researching in this field important. For instance, a study conducted by Gerling et al. (2012) showed a positive effect on mood in older adults playing an exertion game. In a review article, Biddiss and Irwin (2010) conclude that active video games enable light to moderate physical activity. Comparing exertion games to non-exertion games, Bloom et al. (2008) found that those playing exertion games had a lower food intake and a greater caloric burn. Promising results are also shown for exertion games in rehabilitation. An example is a study by LeGear et al. (2016) in which participants with the chronic obstructive pulmonary disease (COPD) who played Nintendo Wii got a similar exercise as participants in a traditional pulmonary rehabilitation program.

2.1.1 Tree Bug Game

This study uses a computer game called The Tree Bug Game. The game is controlled solely through body movement, and the player sees his or her movements as white traces on the screen. The purpose of the game is to defend a tree localized at the bottom of the screen (see figure 1), from being attacked by insects. The insects are moving along roads towards the tree to eat it, and to save the tree the player must squash the insects. The game is modifiable and various amount of game mechanics can be applied to the games foundation.

In this study, two different game mechanics were compared. The first mechanic being labelled as reactive and the second as strategic. In the reactive game mechanic, the player only needs to focus on squashing the insects to save the tree. In the strategic mechanic, obstacles in the form of buckets containing water are added to the game. The buckets travel towards the tree in the same way as the insects but, opposite to the insects, the water from the buckets helps the tree to survive. The player must therefore avoid hitting the buckets as he or she tries to squash the insects.
Figure 1: The Tree Bug Game. (a) shows the reactive game mechanic and (b) shows the strategic game mechanic containing obstacles in form of buckets.
2.1.2 Related Work

The Tree Bug Game has been used in a previous study by Berglund et al. (2017) also comparing a strategic mechanic to a reactive one. The hypothesis was that a more reactive game mechanic would generate less movement but more enjoyment. However, no significant difference was found in neither experience, performance or movement. What post-test interviews did suggest was that, for many of the participants, the perceived amount of thinking required by the game mechanics was related to which mechanic they preferred (Berglund et al., 2017).

2.2 Player Experience

The main purpose of video games is to entertain the users (players) and this recreational nature is what separates video games from traditional task-oriented systems (Sánchez et al., 2012). User Experience (UX) is a concept encompassing all sensations experienced by the user when performing a task in an interactive system, also covering pragmatic and hedonic properties of the interaction (Sánchez et al., 2012). When evaluating the usability aspect of UX, the focus is often on the pragmatic aspects of interaction, making UX unsuitable for measuring the experience of video games (Sánchez et al., 2012). Player Experience (PX) is an ambiguous term for user experience in the context of digital games (Nacke and Drachen, 2011). According to Sánchez et al. (2012), the property that characterizes PX is commonly called Playability which describes the quality of a video game regarding its rules, mechanics, goals and design.

2.2.1 GEQ

The Game Experience Questionnaire (GEQ) is a self-report measure of game experience examining the subjective experiences associated with digital gameplay and feelings after playing the game (De Kort et al., 2007). The questionnaire has been translated to Dutch, English, Swedish and Finnish and is being used in several studies within the FUGA-project, a project funded under the EU FP6 NEST "Measuring the Impossible" initiative (Ijsselsteijn et al., 2008). The GEQ has a modular structure and is composed of a core questionnaire, a social presence module and a post-game module (Ijsselsteijn et al., 2013).

This study uses an in-game version of the GEQ which has an identical component structure as the core questionnaire and has been developed
to measure game experience at multiple intervals within a game session (Ijsselsteijn et al., 2013). The in-game version consists of 14 items belonging to seven components so that there are two items for each component. The components are: Immersion, Flow*, Competence, Positive and Negative Affect, Tension, and Challenge. The items are rated on 5-point Likert-scales ranging from 1 (not at all) to 5 (extremely) and consists of statements such as "I felt skilful" or "I found it tiresome". Each of the components are calculated as a mean of the two belonging items from the questionnaire (e.g. to get the score of immersion, one takes the mean of item 1 and 4).

*Flow is described as the feelings of enjoyment appearing when a balance between skill and challenge is attained while performing an intrinsically rewarding activity (Brockmyer et al., 2009). The term also includes a feeling of being in control, experiencing time distortions, and having a specific goal and immediate feedback increase the likelihood of flow (Brockmyer et al., 2009).

## 2.3 Intrinsic Motivation

Many theories have been based on motivation as a unitary concept, focusing on the amount of motivation people have. The self-determination theory (SDT), however, distinguish between different kinds of motivation; autonomous motivation and controlled motivation (Deci and Ryan, 2008). Autonomous motivation includes both intrinsic motivation and a form of extrinsic motivation where people have identified with the value of an activity (Deci and Ryan, 2008). Autonomous motivation tends to benefit greater psychological health and long-term persistence in behaviours compared to controlled motivation (Deci and Ryan, 2008).

### 2.3.1 IMI

The Intrinsic Motivation Inventory (IMI) is a multidimensional measure developed by Ryan (1982) to assess subjects’ motivation for a certain activity. The measure is flexible and has been used in several different settings, such as in sports, school, and in laboratories (McAuley et al., 1989; Markland and Hardy, 1997; Williams et al., 1998; Plant and Ryan, 1985). The measure used in this study is based on a version of the IMI employed by McAuley et al. (1989). It consists of 18 items scored on a Likert type rating scale. Each item belongs to one of four underlying dimensions: interest-enjoyment,
perceived competence, effort, and pressure-tension. The subjects’ levels of motivation is determined as a function of these dimensions.

2.4 Workload and Cognitive Workload

In a simplistic way, workload can be defined as a demand placed upon humans (De Waard, 1996). However, according to De Waard, this definition puts too much emphasis on external demands. Instead, workload is better described in terms of experienced load (De Waard, 1996). With experienced load, workload is human centred, rather than task specific (Rouse et al., 1993).

When the term workload was first coined, the physical aspect was the focal point of research in workload (Miller, 2001). Since then, machines have taken over most physically demanding labour and studies in the area are more focused on other types of workload including psychomotor, perceptual, or communication workload (Miller, 2001).

The Cognitive Load Theory was developed by Sweller in 1988. Cognitive load can be described as a multidimensional construct that represents the load that is imposed on an individual’s cognitive system while performing a certain task (Paas and Van Merriënboer, 1994). Another definition of cognitive load (also known as cognitive or mental workload) is given by Gopher and Donchin: “Mental workload is a hypothetical construct that describes the extent to which the cognitive resources required to perform a task have been actively engaged by the operator”.

Although cognitive workload is an ambiguous term with no universal definition, the cognitive workload theory has become an established theory applied in a number of fields including ergonomics, human factors, and neurology (Reimer and Mehler, 2011; Gonzalez, 2005; Lim et al., 2010). Given that cognitive load is a multidimensional construct, several methods have been developed to measure it. The measures of workload can be divided into three main categories: physiological, subjective, and performance-based measures (Miller, 2001). The physiological measurement is based on the assumption that increased mental demands lead to increased physical response (Moray, 1979). Physical response is observed in changes in cardiac activity, brain activity, respiratory activity, speech measures, and eye activity (Miller, 2001). While the subjective measurement of workload is based on rankings or scales measuring the amount of perceived workload, the performance measurement relies on examining a person’s performance on a task (Miller, 2001).
One might argue that the physiological measurement could be a better indication on workload, however, all physiological methods requires more equipment which makes the study more complex and time consuming. Another reason not to use physiological measurement is that these measurements are not necessarily linked to a certain phenomenon. An increase in heart rate might be linked to higher levels of stress, but it could also be explained by an increase in physical activity. (Andreassi, 2013)

Hart and Staveland has developed a subjective measure that not only measures cognitive workload, but the broader term workload which includes the categories physical, mental, and temporal in conjunction with performance, effort, and frustration.

2.4.1 Nasa-TLX

The Nasa Task Load Index (Nasa-TLX) is made up of six subscales representing different dimensions of workload: Mental, Physical, and Temporal Demands, Frustration, Effort, and Performance (Hart, 2006). Each scale is twenty-step bipolar with a score ranging from 0 to 100 (Hill et al., 1992).

The Nasa-TLX is described as an excellent multidimensional scale for measuring mental workload (Byers, 1989; Hill et al., 1992). In a comparison, Hill et al. found that the Nasa-TLX was not only an acceptable tool, but it was also sensitive to changes in workload, and well liked. A downside to the Nasa-TLX is the time needed to complete and analyze the test (Miller, 2001).

To counter this negative aspect of Nasa-TLX, a less demanding version has been developed, called the Nasa Raw Task Load Index (Nasa-RTLX) (Miller, 2001). The RTLX uses a new way of scoring that has been found to be almost equivalent to the original TLX, while taking far less time (Byers, 1989). In RTLX, the score is computed by taking the sum of the TLX test and dividing it by six (Miller, 2001). When comparing subjective measurements for a driving situation, PARK found the RTLX to be more sensitive to mental demand and difficulty than the TLX.

3 Method

3.1 Research Design

A within-subjects experimental design was chosen to compare two game mechanic designs. Order effects where controlled for through counter-
balancing, where half of the participants started with the reactive game mechanic, and the other half started with the strategic game mechanic.

3.2 Participant Selection

The participants were students at Linköping University and chosen by means of convenience. Since the questionnaires were in Swedish, the participants were required to be fluent in the Swedish language. The participants’ mean age was 24 years (std.dev = 3, range 21–31).

3.3 Game data

Data from the game was collected automatically and sent to a server. The data for each player consisted of the total amount of movement, number of errors made, and gaming score.

3.4 Questionnaires

In total, six forms were used in this study. These are the forms used listed in the order they were presented in: a demographic form, the Borg RPE-scale, the Nasa Task Load Index, the In-game Game Experience Questionnaire, the Intrinsic Motivation Inventory, and the Big Five Inventory. All questionnaires can be found in Appendix A, but only the game experience questionnaires and Nasa-TLX are used in this report.

3.5 Data Analysis

The data was first explored to make sure that the assumptions for each test were met. In the comparison between the workload of the two game mechanics the data allowed for a parametric within-subjects t-test. For the correlation analysis, assumptions were broken and since the sample size was relative small, Kendall’s Tau was chosen as a correlation coefficient to increase the likelihood of a correct p-value.

3.6 Procedure

The participants, who were recruited by means of convenience and were all students at Linköping University, were first given information about the study, the game, and informed about their rights as participants in a
research study. They were then asked to fill out a demographic questionnaire and an informed consent. The participants were then placed in front of a laptop computer with a 13-inch screen by which they then played the two versions of the game for ten minutes each. After each version, the players were given three questionnaires to fill out; the Game Experience Questionnaire (GEQ), the Intrinsic Motivation Inventory (IMI), and the Nasa Task Load Index (Nasa-TLX).

First, mean value of the participants experienced workload was created from the Nasa-TLX data. In the first step of analysing the data, workload of the two different game mechanics was compared to investigate if there was a difference in experienced workload. Then the GEQ answers were averaged into its different categories (i.e. competence, flow, affect etc.) and two separate meta-values were created, one which consists of the positive GEQ-categories and one which consists of the negative GEQ-categories. A meta-value for the IMI questionnaire was also created. Following the categorisation of the data, a correlation analysis between workload and game experience, as well as workload and intrinsic motivation, were conducted. The correlation analysis was done for the categories in GEQ and IMI as well as their meta-values. After the correlations analysis, a follow up regression analysis was made on the meta GEQ values to explore if workload is a measurement which is able to predict perceived game experience. After that, the variable ”mental demand” (i.e. cognitive workload) from the Nasa-TLX questionnaire was investigated and correlated with the GEQ categories and meta values as well as the IMI variables.

Important to note is that in the analysis of the Nasa-TLX, all questions were treated as equal and used to generate a mean workload value (this method is called Nasa-RTLX). That is, the analysis did not follow the original procedure for Nasa-TLX to assess the weights of each question. Since the questions are treated as equal in the Nasa-RTLX, the tool is less time-consuming than the original Nasa-TLX. Both game mechanics require the use of both physical and mental resources, thus one can argue that it is justifiable to attribute the same weights to all questions.

Due to malfunction in the data server, all game data was lost and had to be excluded from the data analysis.
4 Result

4.1 Workload and Game Mechanics

There was a difference between the perceived workload between the two different game mechanics where the one classified as a strategic mechanic had a higher workload (Mean = 54.85) compared to reactive (Mean = 47.90)

Table 1: Mean, sample size, and standard deviation of the workload between the different game mechanics

<table>
<thead>
<tr>
<th>Strategic</th>
<th>Reactive</th>
</tr>
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<tbody>
<tr>
<td>M</td>
<td>N</td>
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<tr>
<td>54.85</td>
<td>17</td>
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</table>

This difference between the two game modes was also statistically significant $t(17)=2.52, p < .05, r^2 = .52.$

4.2 Game Experience and Reactive Game Mechanic

The following table presents the correlation analysis for both cognitive workload and GEQ as well as workload and GEQ.

Table 2: Correlations between the two workload measures and the GEQ-variables for the reactive game mechanic

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
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<th>4</th>
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<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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<tbody>
<tr>
<td>1. Cognitive workload</td>
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<tr>
<td>2. Workload</td>
<td>.67**</td>
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<td></td>
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<tr>
<td>3. Competence</td>
<td>.51**</td>
<td>.46*</td>
<td>–</td>
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<tr>
<td>4. Immersion</td>
<td>.36</td>
<td>.24</td>
<td>.24</td>
<td>–</td>
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<tr>
<td>5. Flow</td>
<td>.37</td>
<td>.53**</td>
<td>.34</td>
<td>.30</td>
<td>–</td>
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<tr>
<td>6. Tension</td>
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<td>-.01</td>
<td>-.02</td>
<td>.31</td>
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<tr>
<td>7. Challenge</td>
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<td>.53**</td>
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<td>.56**</td>
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<tr>
<td>8. Negative affect</td>
<td>-.35</td>
<td>-.38*</td>
<td>-.42</td>
<td>-.16</td>
<td>-.34</td>
<td>.15</td>
<td>-.26</td>
<td>–</td>
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<tr>
<td>9. Positive affect</td>
<td>.47</td>
<td>.36</td>
<td>.59**</td>
<td>.26</td>
<td>.52**</td>
<td>-.11</td>
<td>.29</td>
<td>-.78**</td>
<td>–</td>
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<tr>
<td>10. Positive meta score of GEQ</td>
<td>.51**</td>
<td>.50**</td>
<td>.60**</td>
<td>.46*</td>
<td>.64**</td>
<td>.05</td>
<td>.54**</td>
<td>-.58**</td>
<td>.77**</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>11. Negative meta score of GEQ</td>
<td>.11</td>
<td>.29</td>
<td>-.03</td>
<td>.23</td>
<td>.23</td>
<td>.53**</td>
<td>.42*</td>
<td>.35</td>
<td>-.25</td>
<td>.02</td>
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</table>

Note: *p < .05, **p < .01.
The correlation analysis between the variables in workload and the categories found in GEQ yielded a significant correlation between:

1. Workload and competence $\tau=.46, p < .05$
2. Workload and game flow $\tau=.53, p < .01$
3. Workload and challenge $\tau=.54, p < .01$
4. Workload and negative affect $\tau= -.38, p < .05$
5. Workload and positive meta score of GEQ $\tau=.50, p < .01$

Following correlations were found between the first variable, mental demands (i.e. cognitive workload), in Nasa-TLX and the categories belonging to GEQ:

1. Cognitive workload and competence $\tau=.51, p < .01$
2. Cognitive workload and challenge $\tau=.49, p < .05$
3. Cognitive workload and positive affect $\tau= .47, p < .05$
4. Cognitive workload and positive meta score of GEQ $\tau=.51, p < .01$

A regression analysis showed that the workload measurement could predict the positive aspects of game experience. Control variables (game experience and perceived movement) were excluded from the model:

Table 3: Regression analysis for the reactive game mechanic

<table>
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<tr>
<th>Step 1</th>
<th>Beta</th>
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<tbody>
<tr>
<td>Constant</td>
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<td>.50</td>
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<tr>
<td>Workload</td>
<td>.03</td>
<td>.01</td>
<td>.66**</td>
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</table>

Note: $R^2=.43$. *p < .01
### 4.3 Game Experience and Strategic Game Mechanic

The following table presents the correlation analysis for both cognitive workload and GEQ as well as workload and GEQ.

Table 4: Correlations between the two workload measures and the GEQ-variables for the strategic game mechanic

<table>
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<th>Measure</th>
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<td>1. Cognitive workload</td>
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<td>2. Workload</td>
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<td>3. Competence</td>
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<td>4. Immersion</td>
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<td>6. Tension</td>
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<td>7. Challenge</td>
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<td>10. Positive meta score of GEQ</td>
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<td>.14</td>
<td>.63**</td>
<td>.23</td>
<td>.54**</td>
<td>-.30</td>
<td>-.12</td>
<td></td>
</tr>
</tbody>
</table>

Note: *p < .05, **p < .01.

The correlation analysis between the variables in workload and the categories found in GEQ yielded a significant correlation between:

1. Workload and flow $\tau=0.48, p<0.05$
2. Workload and challenge $\tau=0.39, p<0.05$
3. Workload and positive meta score of GEQ $\tau=0.42, p<0.05$

Following correlations were found between the first variable, mental demands (i.e. cognitive workload), in Nasa-TLX and the categories belonging to GEQ:

1. Cognitive workload and flow $\tau=0.51, p<0.01$
2. Cognitive workload and challenge $\tau=0.51, p<0.01$
3. Cognitive workload and positive meta score of GEQ $\tau=0.43, p<0.05$

A regression analysis showed that the workload measurement could predict the positive aspects of game experience. Control variables (game experience and perceived movement) were excluded from the model:
Table 5: Regression analysis for the strategic game mechanic

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>SE B</th>
<th>( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>.07</td>
<td>.56</td>
<td></td>
</tr>
<tr>
<td>Workload</td>
<td>.03</td>
<td>.01</td>
<td>.57*</td>
</tr>
</tbody>
</table>

Note: \( R^2 = .32 \). * \( p < .05 \)

4.4 Intrinsic Motivation and Reactive Game Mechanic

The following table presents the correlation analysis for both cognitive workload and IMI as well as workload and IMI.

Table 6: Correlations between the two workload measures and the IMI-variables for the reactive game mechanic

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cognitive workload</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Workload</td>
<td>(.67^{**})</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Interest-enjoyment</td>
<td>.52</td>
<td>(.55^{**})</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Competence</td>
<td>(.64^{**})</td>
<td>.46*</td>
<td>(.56^{**})</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Effort-importance</td>
<td>(.57^{**})</td>
<td>.47*</td>
<td>(.59^{**})</td>
<td>.39*</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Tension-pressure</td>
<td>-.42*</td>
<td>-.63**</td>
<td>-.47*</td>
<td>-.23</td>
<td>-.49**</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>7. Meta score of IMI</td>
<td>(.59^{**})</td>
<td>.34</td>
<td>(.69^{**})</td>
<td>(.69^{**})</td>
<td>.60**</td>
<td>-.19</td>
<td>–</td>
</tr>
</tbody>
</table>

Note: * \( p < .05 \), ** \( p < .01 \).

The correlation analysis between the variables in workload and the categories found in IMI yielded a significant correlation between:

1. Workload and interest-enjoyment \( \tau = .55, p < .01 \)
2. Workload and perceived competence \( \tau = .46, p < .05 \)
3. Workload and effort-importance \( \tau = .47, p < .05 \)
4. Workload and tension-pressure \( \tau = -.63, p < .01 \)

Following correlations were found between the first variable, mental demands (i.e. cognitive workload), in Nasa-TLX and the categories belonging to IMI:

1. Cognitive workload and interest-enjoyment \( \tau = .52, p < .01 \)
2. Cognitive workload and perceived competence \( \tau = .64, p < .01 \)
3. Cognitive workload and effort-importance $\tau = .57, p < .01$
4. Cognitive workload and tension-pressure $\tau = -.42, p < .05$
5. Cognitive workload and meta score of IMI $\tau = -.59, p < .01$

No statistical significant regression model could be created.

4.5 Intrinsic Motivation and Strategic Game Mechanic

The following table presents the correlation analysis for both cognitive workload and IMI as well as workload and IMI.

Table 7: Correlations between the two workload measures and the IMI-variables for the strategic game mechanic

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cognitive workload</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Workload</td>
<td>.72**</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Interest-enjoyment</td>
<td>.19</td>
<td>-.01</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Competence</td>
<td>.29</td>
<td>.34</td>
<td>.19</td>
<td>–</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Effort-importance</td>
<td>.55**</td>
<td>.39*</td>
<td>.36</td>
<td>.20</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Tension-pressure</td>
<td>-.28</td>
<td>-.45*</td>
<td>.02</td>
<td>.00</td>
<td>-.36</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>7. Meta score of IMI</td>
<td>.33</td>
<td>.22</td>
<td>.57**</td>
<td>.44*</td>
<td>.56**</td>
<td>.02</td>
<td>–</td>
</tr>
</tbody>
</table>

Note: *$p < .05$, **$p < .01$.

The correlation analysis between the variables in workload and the categories found in IMI yielded a significant correlation between:

1. Workload and effort-importance $\tau = .39, p < .05$
2. Workload and tension-pressure $\tau = -.45, p < .01$

Following correlations were found between the first variable, mental demands (i.e. cognitive workload), in Nasa-TLX and the categories belonging to IMI:

1. Workload and effort-importance $\tau = .55, p < .01$

No statistical significant regression model could be created.
5 Discussion

5.1 Result

5.1.1 Workload

The difference found in perceived workload between the two game mechanics showed that the strategic game mechanic was perceived as more demanding. Finding a correlation between workload and a variable belonging to IMI or GEQ for only one of the mechanics may indicate that there is a threshold for how much workload is needed to influence game experience. It could also indicate that the impact of the perceived workload is dependent on the type of game mechanic being used.

For both game mechanics, the correlation analysis between workload and the variables belonging to GEQ showed a positive correlation between workload and: flow, challenge, and the positive meta score of GEQ. The correlation analysis also yielded a positive correlation between workload and competence, as well as a negative correlation between workload and negative affect, for the reactive game mechanic. The fact that the strategic game mechanic did not have a positive correlation between workload and competence may be due to that the higher workload in the strategic game mechanic entails a higher focus, which could make the player more aware of the mistakes made. A way to further explore this theory could be through collecting game data that includes errors made.

A positive correlation between workload and flow was found for both game mechanics. This could be interpreted as the higher the workload the higher the flow. However, since there was not a perfect correlation (i.e a correlation coefficient of +1), one might assume that for a higher workload than observed in this study, this correlation may not be found. This is given support by the fact that the correlation between workload and flow is higher for the reactive game mechanic than the strategic mechanic (i.e. the correlation became lower when the perceived workload increased). Flow also encompasses being in control and experiencing time distortions. A higher workload may impose a higher focus allowing for a higher sense of control as well as losing track of time. The positive correlation could implicate that in order to promote flow in players, one should strive for a certain amount of workload when designing a game while respecting the balance of difficulty and skill.

Workload and challenge was positively correlated for both game me-
chanics, which would be expected as a game perceived as more challenging should also be perceived as more demanding, thus require a higher amount of workload.

A negative correlation was found between workload and the negative affect for the reactive game mechanic, meaning that, for the reactive game mechanic, the negative affect decreases as the workload increases. This may imply that a game that is not sufficiently demanding could instead invoke negative affect in the player, such as being bored. If this were to be applied to game design, creating a game that is sufficiently demanding could reduce negative affect for the players.

For both game mechanics, a positive correlation was found between workload and the positive meta score of GEQ. This shows that the averaged positive game experience correlates with workload, supporting the theory that the player must experience some workload for a positive game experience.

A regression analysis was done of the positive meta score of GEQ for both game mechanics. This showed that the workload variable, in both cases, was able to explain over 30% of the variance. It also shows that the positive game experience, in both game modes, increases with an increase in participant workload.

The correlation analysis of workload and the variables belonging to IMI yielded a positive correlation between workload and effort-importance, and tension pressure for both game mechanics. For the reactive game mechanic, a positive correlation was also found between workload and interest-enjoyment, and workload and perceived competence. These correlations seem to be in line with the correlations found between workload and the variables belonging to GEQ that are discussed above. This strengthens the theory that workload has a positive effect on game experience.

### 5.1.2 Cognitive Workload

The correlation analysis between cognitive workload and the variables belonging to GEQ showed a positive correlation between cognitive workload and challenge as well as between cognitive workload and the positive meta score of GEQ for both game mechanics. For the reactive game mechanic, positive correlations were also found between cognitive workload and competence and between cognitive workload and positive affect. A positive correlation between cognitive workload and flow was instead found for the strategic game mechanic. For the strategic game mode, the variables corre-
lating to cognitive workload are the same as the variables found correlating to workload.

The correlations between cognitive workload and the variables belonging to IMI are also very similar to the correlations between workload and the variables belonging to IMI. For the reactive game mode, cognitive workload and workload correlates positively with the same four variables belonging to IMI. The difference found for the reactive game mode, disregarding slightly different values for the correlation coefficient, is that cognitive workload also correlates positively with the meta score of IMI. For the strategic game mode, both workload and cognitive workload correlated positively with the effort-importance variable of IMI. A positive correlation was also found between workload and the tension-pressure variable but not between cognitive workload and tension-pressure.

Overall, the correlations found for cognitive workload corresponds well with the correlations found for workload. This implies that there is a strong connection between cognitive workload and workload. Thus, the same reasoning as shown above can also be applied to the cognitive dimension of workload. It should, however, be noted that analysing a single variable of the Nasa-TLX has not been validated and thus no firm conclusion should be drawn from this analysis.

5.2 Method

There are some aspects of the method applied in this study that need to be brought forward as they may have had an impact on the conclusions that can be drawn from the result. Firstly, the number of participants was quite low. A post hoc power calculation showed a statistical power of 0.5 for the t-test. A power this small shows that is difficult to find statistical significance for all variables and thus smaller effects may have been missed.

The game experience questionnaire was translated into Swedish for this study and validated by three students at Linköping University with Swedish as their native language. Since the students validating the translating were not bilingual, and the translated measurement was not pre-tested before being used in this study, there is a risk that the translated version of the measurement is not fully coherent with the original version.

In this study, the perceived workload was analysed using Nasa-RTLX and not the originally developed Nasa-TLX. The RTLX is highly correlated to the TLX, but there is a possibility that treating all variables of the measurement as equal could yield a result that differs from the TLX. As
stated in the background section, PARK found the RTLX to be more sensitive to mental demand and difficulty than the TLX in a driving situation. A similar difference between the measurements might also be found for gaming. If such a difference exists, it is yet to be found which version is more suitable for analysing workload in gaming. The use of a 13-inch computer screen may have implications regarding the player experience. For instance, a screen this small could induce a higher workload and a lower player experience compared to a larger screen.

Lastly, since the participants were chosen by means of convenience there is a chance that the results cannot by generalised to a larger population. For example, the age within the sample ranges from 21 to 31. It is not certain that the same results would be found for participants that are either younger or older.

A study with a larger sample size would more reliably identify statistical significance and correct effect sizes. By including game data, the relationship between workload and player experience could be further explored. It would be interesting to examine if there is a connection between workload and player movement as this could have implications for the design of movement based games.
6 Conclusion

Due to the small sample size in this study, no firm conclusions should be drawn from the results. However, the results indicate that an increase in workload, including cognitive workload, positively affect the player experience of the game as well as the player’s intrinsic motivation. Further studies are needed to be able to determine what components of a game increases workload.
References


McAuley, E., Duncan, T., and Tammen, V. V. (1989). Psychometric properties of the intrinsic motivation inventory in a competitive sport setting: A


Appendix A

Demografiformulär
Nedan besvarar du några snabba frågor angående din demografiska placering. All information som du anger är endast för studiens syfte och din anonymitet försäkras.

Hur gammal är du?
____________________

Kön
☐ Man
☐ Kvinna
☐ Annat

Vad studerar du?
____________________

Hur många år har du studerat på universitet/högskola?
____________________

Vad är din högsta avslutade utbildning?

☐ Gymnasial utbildning
☐ Högskoleexamen
☐ Kandidatexamen
☐ Magisterexamen
☐ Masterexamen
☐ Annat
☐ Föredrar att inte svara
Appendix A

Hur många timmar per dag lägger du på att spela spel?
*Denna fråga berör både webbläsarspel, datorspel och mobilspel.*

Spelar du rörelsebaserade spel?
*Som exempelvis Kinect, *inte* rörelsebaserade spel med handkontroller (Wii U)*

☐ Ja
☐ Nej

Vilken typ av spel föredrar du?
*Välj ett eller flera alternativ.*

☐ Role Playing Games (RPG)
☐ First Person Shooter (FPS)
☐ Real Time Strategy (RTS)
☐ Puzzle Games
☐ Adventure Action Games

Vilka plattformar föredrar du?
*Välj ett eller flera alternativ.*

☐ Mobiltelefon
☐ Surfplatta
☐ Dator
☐ Konsol (på TV)

Jag bekräftar härmed att jag har tagit det av mina rättigheter som försöksdeltagare i en vetenskaplig studie, och att jag är medveten om att den data som frambringas av studien kan komma att användas i vetenskapliga skrifter och andra framtida studier.

__________________________  __________________________
Datum                     Underskrift
**Appendix A**

**Borgs RPE-skala®**
- en skattning av den egenupplevda fysiska ansträngningsgraden

<table>
<thead>
<tr>
<th>Nummer</th>
<th>Beskrivning</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Ingen ansträngning alls</td>
</tr>
<tr>
<td>7</td>
<td>Extremt lätt</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Mycket lätt</td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Lätt</td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Något ansträngande</td>
</tr>
<tr>
<td>14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Ansträngande</td>
</tr>
<tr>
<td>16</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Mycket ansträngande</td>
</tr>
<tr>
<td>18</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Extremt ansträngande</td>
</tr>
<tr>
<td>20</td>
<td>Maximal ansträngning</td>
</tr>
</tbody>
</table>

**Instruktioner**

Den här skalan, den så kallade Borgskalan, går från 6 "Ingen ansträngning alls" till 20 "Maximal ansträngning". Vi vill att du under arbetet uppskattar din känsla av ansträngning. Du ska då försöka skatta den allmänna ansträngningen i hela kroppen, det vill säga lägga ihop ansträngningen du känner i musklerna i ben och armar med den du känner i bröstet i form av andfåddhet.

Appendix A

**NASA Task Load Index**


1. **Mentala krav**
   Hur stor mental och perceptuell kapacitet krävdes (t.ex. tänkande, beslutsfattande, beräkning, högkomst, tittande, letande/sökande, etc.)? Var uppgiften lätt eller krävande, enkel eller komplex, hur lätt var det att rätta till eventuella fel?

<table>
<thead>
<tr>
<th>Mycket låg</th>
<th>Mycket hög</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. **Fysiska krav**
   Hur stor fysisk aktivitet krävdes (t.ex. tryckande, dragande, svängande, kontrollerande, aktivering etc.)? Var uppgiften lätt eller krävande, långsam eller snabb, lugn eller hetsig, avslappnad eller stressig?

<table>
<thead>
<tr>
<th>Mycket låg</th>
<th>Mycket hög</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. **Tidskrav**
   Hur stor tidspress kände du på grund av hastigheten som uppgifterna och de kritiska situationerna dök upp i? Var tempot långsamt och utan brådska eller högt och hektiskt?

<table>
<thead>
<tr>
<th>Mycket låg</th>
<th>Mycket hög</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. **Ansträngning**
   Hur hårt behövde du arbeta (mentalt och fysiskt) för att uppnå din prestation?

<table>
<thead>
<tr>
<th>Mycket låg</th>
<th>Mycket hög</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. **Prestation**
   Hur framgängsrik tror du att du var i att uppnå de mål som experimentledaren (eller du själv) satt upp? Hur nöjd är du med din prestation?

<table>
<thead>
<tr>
<th>Mycket låg</th>
<th>Mycket hög</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. **Frustration**
   Hur osäker, modfälld, irriterad, stressad och förargad gentemot säker, vid gott mod, tillfredsställd, avslappnad och självbeläten kände du dig under uppgiften?

<table>
<thead>
<tr>
<th>Mycket låg</th>
<th>Mycket hög</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Appendix A

### In-game GEQ

Var god ange hur du kände dig när du spelade spelet för varje påstående nedan enligt följande skala:

<table>
<thead>
<tr>
<th>Inte alls</th>
<th>Lite</th>
<th>Måttligt</th>
<th>Ganska mycket</th>
<th>Extremt mycket</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

1. Jag var intresserad av spelberättelsen  ____
2. Jag kände mig framgångsrik  ____
3. Jag kände mig uttråkad  ____
4. Jag fann spelet imponerande  ____
5. Jag glömde världen omkring mig  ____
6. Jag kände mig frustrerad  ____
7. Jag upplevde spelet som tröttsamt  ____
8. Jag kände mig irriterad  ____
9. Jag kände mig skicklig  ____
10. Jag kände mig helt uppslukad  ____
11. Jag kände mig nöjd  ____
12. Jag kände mig utmanad  ____
13. Jag var tvungen att anstränga mig  ____
14. Jag kände mig bra  ____
## Appendix A

Ringa in det alternativ som du personligen bäst håller med om.

Med andra ord, hur upplevde du spelet?

<table>
<thead>
<tr>
<th>Inte alls</th>
<th>Mycket</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Jag tyckte om spelet väldigt mycket</td>
<td>1</td>
</tr>
<tr>
<td>2. Jag tycker att jag är ganska bra på spelet</td>
<td>1</td>
</tr>
<tr>
<td>3. Jag lade ner mycket ansträngning i det här spelet</td>
<td>1</td>
</tr>
<tr>
<td>4. Det var viktigt för mig att göra bra ifrån mig i det här spelet</td>
<td>1</td>
</tr>
<tr>
<td>5. Jag kände mig spänd under spelet</td>
<td>1</td>
</tr>
<tr>
<td>6. Jag försökte mycket hårt när jag spelade spelet</td>
<td>1</td>
</tr>
<tr>
<td>7. Spela spelet var kul</td>
<td>1</td>
</tr>
<tr>
<td>8. Jag skulle beskriva spelet som väldigt intressant</td>
<td>1</td>
</tr>
<tr>
<td>9. Jag är tillfredsställd med min prestation i spelet</td>
<td>1</td>
</tr>
<tr>
<td>10. Jag kände mig pressad när jag spelade spelet</td>
<td>1</td>
</tr>
<tr>
<td>11. Jag var orolig när jag spelade spelet</td>
<td>1</td>
</tr>
<tr>
<td>12. Jag försökte inte så hårt att spela spelet</td>
<td>1</td>
</tr>
<tr>
<td>13. Medan jag spelade tänkte jag på hur mycket jag tyckte om spelet</td>
<td>1</td>
</tr>
<tr>
<td>14. Efter att ha spelat spelet ett tag, kände jag mig ganska duktig</td>
<td>1</td>
</tr>
<tr>
<td>15. Jag var väldigt avslappnad när jag spelade spelet</td>
<td>1</td>
</tr>
<tr>
<td>16. Jag är ganska skicklig på att spela spelet</td>
<td>1</td>
</tr>
<tr>
<td>17. Det här spelet höll inte min uppmärksamhet</td>
<td>1</td>
</tr>
<tr>
<td>18. Jag kunde inte spela spelet så bra</td>
<td>1</td>
</tr>
</tbody>
</table>

1. Stämmer absolut inte
2. Stämmer ganska dåligt
3. Stämmer varken bra eller dåligt
4. Stämmer ganska bra
5. Stämmer absolut

Jag ser mig själv som någon som...

1. Är pratsam
2. Tenderar att hitta fel hos andra
3. Gör ett grundligt jobb
4. Är deprimerad, nere
5. Är originell, kommer med nya idéer
6. Är reserverad
7. Är hjälpsam och osjälvvisk mot andra
8. Kan vara något vårdslös
9. Är avspänd, hanterar stress väl
10. Är nyfiken på många olika saker
11. Är full av energi
12. Startar gräl med andra
13. Är pålitlig i arbetet
14. Kan vara spänd
15. Är sinrikt, en djup tänkare
16. Spreader mycket entusiasm
17. Har en förlåtande läggning
18. Tenderar att vara oorganiserad
19. Ornar mig mycket
20. Har en livlig fantasi
21. Tenderar att vara tydläten
22. Är i allmänhet tillitstiftande
23. Tenderar att vara lat

Kontrollera att du skrivit en siffra framför varje påstående

__24.__ Är känslomässigt stabil, blir inte upprörd så lätt
__25. __Är uppfinningsrik
__26. __Har en självhåvande personlighet
__27. __Kan vara kall och distanserad
__28. __Framhårdar tills uppgiften är slutförd
__29. __Kan vara lynnig
__30. __Värdesätter konstnärliga, estetiska upplevelser
__31. __Är ibland blyg, hämmad
__32. __Är omtänksam och vänlig mot nästan alla
__33. __Gör saker effektivt
__34. __Förblir lugn i spända situationer
__35. __Föredrar rutinarbete
__36. __Är utåtriktad, sällskaplig
__37. __Är ibland ohövlig mot andra
__38. __Gör upp planer och fullföljer dem
__39. __Blir lätt nervös
__40. __Tycker om att reflektera, leka med idéer
__41. __Har få konstnärliga intressen
__42. __Tycker om att samarbeta med andra
__43. __Blir lätt distraherad
__44. __Har en utvecklad smak för konst, musik eller litteratur

Appendix A
Upphovsrätt

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