HEC MONTRÉAL

Warehouse Management System Gamification Increases Workforce Engagement

By

Mario Passalacqua

Management Sciences
(User Experience in a Business Context)

Thesis submitted in partial fulfilment of the requirements for a Master of Science in Management (M.Sc.)

April 2019

© Mario Passalacqua, 2019

<u>Sommaire</u>

Des recherches récentes ont montré qu'une grande partie des travailleurs dans le monde manquaient d’engagement au travail. Une solution proposée dans le but de pallier cette problématique est la ludification d’interfaces d’employés. En bref, la ludification est un ensemble d’éléments qui incorporent la nature motivante et enrichissante des jeux vidéo en contexte de travail. Ce mémoire évalue l’efficacité de l’intégration de composantes de ludification à une interface de travail pour l’augmentation de l'engagement et la performance des employés. Pour répondre à cette question de recherche, 21 participants ont été recrutés pour participer à une expérience de laboratoire dans laquelle deux éléments de ludification communément utilisés, soit la définition de buts et la rétroaction, ont été intégrés dans un système de gestion d'entrepôt. Pour cette expérience intra-sujet, les participants étaient appelés à effectuer des tâches de prélèvement d’items dans un entrepôt simulé, au cours desquelles l'engagement et la performance étaient mesurés. Les résultats obtenus démontrent qu'une interface gamifiée mène à des niveaux d'engagement neurophysiologique et perçu supérieurs, ainsi qu'à une meilleure performance comparativement à l’interface initiale. D’un point de vue théorique, les résultats permettent d'examiner les mécanismes motivationnels par lesquels la ludification affecte l'engagement et la performance. D’un point de vue pratique, les résultats offrent une solution prometteuse pour les entreprises face au manque d'engagement des employés pour améliorer une multitude de facteurs de performance.

<u>Mots clés :</u> ludification, expérience contrôlée, système de gestion d’entrepôt, engagement des employés, appareil portable, NeuroIS

Summary

Recent research has shown that a large proportion of workers worldwide lack engagement at work. A particularly interesting solution has been the gamification of employee interfaces. In short, gamification attempts to incorporate the motivating and rewarding nature of video games into the workplace. This thesis evaluates whether gamification affects employee engagement and performance. More specifically, this thesis assesses whether the integration of gamification into an employee interface can increase employee engagement and performance. To answer this research question, a 21-subject laboratory experiment was devised, in which goal-setting and feedback, two common gamification elements, were integrated into a wearable warehouse management systems (WMS). In this within-subject experiment, participants went through item picking tasks in a simulated warehouse, while engagement and performance were being measured. In summary, results show that a gamified interface leads to more neurophysiological and perceived engagement, as well as better performance. Theoretically, the results allow for the examination of the motivation pathways by which gamification affects engagement and performance. Practically, the results offer a solution to a lack of employee engagement, thus paving the way for positive company outcomes.

Keywords: Gamification, controlled experiment, warehouse management system (WMS), employee engagement, wearable device, NeuroIS

Table of Contents

Acknowledgement

I would like to begin by thanking my mom and dad for their unwavering support throughout my academic path; without their moral and financial support, none of my academic achievements would have been possible. I am eternally grateful.

I would also like to thank Dr. Pierre-Majorique Léger for the extraordinary opportunities he has offered me, for his guidance, and for his belief in me.

In addition, I would like to thank all involved members of the Tech3lab for their help with various aspects of this thesis, from methodology conception, to equipment debugging, to article correction, and everything in between: Sylvain Sénécal, Élise Labonté-Lemoyne, Shang Lin Chen, Marc Frédette, all members of the research operations team, and all research assistants. Also, I would like to thank Dr. Lennart Nacke (University of Waterloo) for his help and support.

The students at the Tech3lab also deserve a mention, as they help create an environment suitable for learning and progressing, all while having fun. Thank you to Alexandre, Émilie, Laurence, Karl-David, Michael, Félix, Eric, Caroline, Ariane, etc.

Last but certainly not least, I would like to thank my loving girlfriend, who is also endeavouring to draft a perfect thesis. Her support during those long days and nights of drafting have been invaluable.

This work was supported by Mitacs under Grant IT10115; and Natural Sciences and Engineering Research Council of Canada (NSERC) under grant IRCPJ 514835-16.

List of Tables and Figures

List of tables:

List of figures:

1. <u>Introduction</u>

1.1 Context

Work has always been central to a society's proper functioning and plays an important role in the lives of all. Throughout history, employees, defined as people employed for wages or salary especially at the nonexecutive level, have had various type of relationships with work. From the Middle Ages to the First Industrial Revolution, the work-employee relationship was mainly exploitative of employees, leading to a multitude of revolts (i.e. Peasants' Revolt of 1381, Canut Revolts of 1831). These revolts were meant to improve the work-employee relationship and improve employees' standard of living. In industrialised countries, since the 1960-70's, focus, and thus research, has started to shift towards creating a better work-employee relationship for the employee, allowing them to be engaged, happy and performant at work (Alderfer, 1972; Goffman, 1961; Maslow, 1970; Schuck & Wollard, 2013).

The term employee engagement was first used in the literature by Kahn (1990). In his article, Kahn (1990) explains that meaningfulness, security and availability of resources are necessary to generate employee engagement, defined as an employee harnessing his/her full self at work. Later, Maslach, Schaufeli, and Leiter (2001) published an article exploring why employees experience burnout. They explained how employee engagement is the antipode of employee burnout. From its beginnings in the 1960's, much of the focus on employee engagement has been restricted to the academic sphere. However, a shift occurred when Harter, Schmidt, and Hayes (2002) published a seminal meta-analysis linking employee engagement to employee retention, absenteeism and turnover, as well as company sales, profitability and customer satisfaction. This study generated great interest for employee engagement in the practitioner sphere and thus led to a significant burst in research. Throughout the years, research has shown that a lack of employee engagement is not only harmful to company and employee performance, but also to employee well-being. Indeed, lack of engagement is associated with mental health issues, burnout, physical health issues (Truss, Shantz, Soane, Alfes, & Delbridge, 2013).

Recent research has revealed that 87% of workers are not engaged at work (Harter, Schmidt, Agrawal, Plowman, & Blue, 2016). This is worrisome, considering that employee engagement significantly affects company performance across nine dimensions (Harter et al., 2016). Gamification, defined as the use of video game elements in non-game contexts (Deterding, Khaled, Nacke, & Dixon, 2011), has been successfully implemented in a variety of work domains to combat lack of employee engagement (Seaborn & Fels, 2015). However, few studies have addressed the theoretical underpinnings of gamification's effect on engagement and performance, which are important to understand how long-term engagement and performance can be achieved.

The current thesis aims to examine whether the integration of gamification elements into an employee's work interface leads to more neurophysiological and perceived employee engagement, as well as better performance. It also aims to uncover the motivational mechanisms by which gamification affects engagement and performance. The longstanding link between the concepts of motivation, engagement, and performance is also discussed.

1.2 Research Questions

Two research questions will be answered:

1. Can the integration of gamification into an employee interface significantly increase employee engagement?
2. Can the integration of gamification into an employee interface significantly increase employee performance?

Given the rampant disengagement seen in today's workplace (Manhattan Associates, 2017), these research questions are as relevant as ever. Since employee engagement has been shown to be related to employee mental and physical well-being, as well as employee and company performance (Harter et al., 2016; Truss et al., 2013), answering these research question can prove beneficial in multiple aspects.

A within-subject laboratory experiment was devised to answer these research questions, in which 21 participants partook in item picking tasks in a simulated warehouse. Two common gamification elements, goal-setting and feedback, were integrated into a wearable warehouse management system (WMS), from which participants received picking instructions. A WMS is a technological interface used to efficiently manage the movement and storage of warehouse materials. Two types of goal-setting were integrated: goals set by the participant and goals assigned by the experimenter. The experiment was designed in conjunction with JDA Software, a supply chain management company. Their warehouse management experts aided in setting up a realistic simulated warehouse in our laboratory. They also aided in designing a WMS for the simulated warehouse, and in integrating gamification elements into it. Methodologically speaking, the warehouse management experts allowed our experimental setup and stimuli to be as ecologically valid as possible. Another methodological characteristic of the experiment is its inclusion of both neurophysiological and perceived (self-reported) measures of engagement. Neurophysiological measures allows us to measure engagement without interfering with the task and without participant awareness (Charland et al., 2015), thus limiting biases related to self-reported measure and increasing ecological validity (de Guinea, Titah, & Léger, 2014). Both the input from warehouse management experts and the inclusion of neurophysiological measurement make this experiment unique.

See video in Appendix 1 for an overview of the experimental layout and procedure.

1.3 Theoretical and Practical Research Contributions

This thesis will explore the underlying effects of gamification through two of the most prominent motivational theories (SDT and goal-setting theory), and one of the leading employee engagement models (JD-R model). This will provide a theory-rich interpretation of the data, which is uncommon in the gamification literature. This will also lead to the proposition of motivational pathways through which gamification affects engagement and performance. In addition, this thesis will shed some light on the longstanding debate about whether self-set goals or assigned goals generate more engagement and better performance. Results from this thesis will provide companies in various domains with a simple way to increase employee engagement and performance, which will then lead to better employee retention, less employee mental health issues, less burnout, better company profitability, etc.

1.4 Article 1

The first article of this thesis was presented at the NeuroIS 2018 conference in Vienna, Austria (Passalacqua et al., 2019a). It was co-authored by Pierre-Majorique Léger, Sylvain Sénécal, Marc Frédette, Lennart E. Nacke, Xinli Lin, Karine Grande, Nicolas Robitaille, Liza Ziemer and Tony Caprioli. The article briefly reviewed the gamification and employee engagement literature to then propose an experiment that would allow to contribute theoretically and practically. At the conference, we were able to obtain useful feedback that allowed us to fine-tune our experiment. After the conference, we ran the experiment and used its data in Article 2. Article 1 is thus a subset of Article 2.

Summary

Engagement, or rather lack thereof has become a major issue because of its negative impact on productivity. Recently, gamification has successfully been implemented into corporate technological interfaces to increase engagement of employees. This paper proposes a theory-driven experiment that examines the impact a gamified interface has on engagement and performance of workers in a warehouse-management task. Specifically, the experiment proposed in this paper compares how the integration of two different types of goal-setting (self-set goals or assigned goals) into a warehouse-employee interface will affect engagement and performance.

1.5 Article 2

This article has been submitted to the European Journal of Information Science in February 2019 as part of special issue calling for theory-driven gamification research (Passalacqua et al., 2019b). It was co-authored by Pierre-Majorique Léger, Marc Frédette, Élise Labonté-Lemoyne, Lennart E. Nacke, Xinli Lin, Caprioli and Sylvain Sénécal. This article builds upon Article 1 by thoroughly reviewing gamification and employee engagement's theoretical foundation, and by interpreting experimental data through theoretical and practical lenses. The experimental data from Article 2 was collected from the experiment proposed in Article 1, which was carefully refined based on feedback received from reviewers and conference attendees.

Summary

According to a recent report spanning 140 countries, a vast majority of workers worldwide lack engagement at work, which leads to lower company performance and success. Companies are looking for a solution; especially supply chain management companies, where hourly workers performing warehouse picking tasks account for more than half of total warehouse expenditure. We present a within-subject experiment in which we investigate the influence of goal-setting and feedback, common gamification elements, to address this problem. A simulated warehouse was set up, where we integrated goal-setting and feedback into a wearable warehouse management system (WMS) interface to examine its effect on user performance, and neurophysiological and self-reported engagement in a warehouse-management task. Results show that a gamified interface leads to better task performance and higher engagement than one without gamification. The article contributes to the understanding of the motivational pathways by which enterprise software gamification affects employee engagement and performance.

1.6 Thesis Structure

This thesis by articles will present Article 1, which briefly introduces gamification and employee engagement, then proposes a laboratory experiment. Article 2 is then presented. This article delves deeper into the theoretical foundation of gamification and employee engagement, describes in detail the experiment proposed in Article 1, and presents and interprets the data from the experiment. To conclude, this thesis will reiterate the key findings by discussing their theoretical and practical relevance. It is important to note that there is some repetition within the introduction and literature review of both articles.

1.7 Contributions

Table 1: Contributions related to article drafting

Step	Contribution
Research question and experiment conception	Develop a research question and experiment to address the partner company's (JDA Software) need – 30% • The remaining 70% belongs to the rest of the research team and partner company's employees (Karine Grande, Nicolas Robitaille, Liza Ziemer, Xinli Lin, Tony Caprioli). Ethics submission – 100%
Literature review	Review the literature to identify past studies related to the current research question – 100% Define and propose constructs and measures to be used in the experiment – 80% • The research team made sure that the proposed measures were valid and feasible, and made sure that the constructs were reliable indicators of the measures.

Experimental stimuli development	Creation and testing of the experimental stimuli used in the experiment – 10% • The bulk of the work (90%) was done by the partner company's employees (Karine Grande, Nicolas Robitaille, Liza Ziemer, Xinli Lin, Tony Caprioli).
Participant management	Recruit and manage participants for study – 100% Manage participant compensation – 100%
Data collection	Test and fix equipment used to collect data – 60% • The remaining 40% belongs to members of the research team Directing the flow of the experiment – 90% • The remaining 10% belongs to members of the research team
Data extraction and transformation	Extraction and post-processing of psychometric and neurophysiological data. Transformation and cleanup of neurophysiological data – 75% • Members of the research team (particularly Élise Labonté-Lemoyne) assisted with the remaining 25%.
Data analysis	Formatting the data so that it can easily be analysed statistically – 100% Statistical analysis – 10% • A member of the research team (Shang Lin Chen) has helped me with the statistical analysis.
Article drafting	Drafting of the two articles included in this thesis – 100%

2. Article 1 : The Impact of Using a Gamified Interface on Engagement in a Warehousing Management Task: A NeuroIS Research Proposal*

Mario Passalacqua[1], Pierre-Majorique Léger[1], Sylvain Sénécal[1], Marc Fredette[1], Lennart E. Nacke[2], Xinli Lin[3], Karine Grande[3], Nicolas Robitaille[3], Liza Ziemer[3], Tony Caprioli[3]

[1] HEC Montréal, Montreal, Canada
{mario.passalacqua, pierre-majorique.leger,sylvain.senecal, marc.fredette}@hec.ca

[2] University of Waterloo, Stratford School of Interaction Design and Business, Waterloo, Canada
lennart.nacke@acm.org

[3] JDA Software, Waukesha, USA and Montreal, Canada
{xinli.lin, karine.grande, nicolas.robitaille, liza.ziemer, tony.caprioli}@jda.com

2.1 Introduction

Over three quarters of warehouse employees are not engaged in their work (Mann & Harter, 2016). This leads to a lack of employee productivity, a high turnover rate, more errors and less profitability; all factors greatly affect organisational efficiency (Mehta & Mehta, 2013). In recent years, gamification of employee interfaces has been employed to combat this issue. Gamification is defined as the use of game design elements in non-game contexts (Deterding, Khaled, et al., 2011). In other words, gamification employs the engaging nature of elements used in video games to create engagement in another context. Some of the common elements used in gamified interfaces are points, levels, goal-setting, feedback, badges and leaderboards. Building upon a framework created by Tondello, Kappen, Mekler, Ganaba, and Nacke (2016), the current study will focus on two of these: goal-setting and feedback. There have been very few attempts at integrating gamification into an employee user interface for technology used within a warehouse setting (Klevers, Sailer, & Günthner, 2016; Small, 2010). Optimization within this setting has mostly focused on the task itself, rather than on the human performing it. Small (2010) adeptly proposes

* Passalacqua M., Léger, P.-M., Sénécal, S., Fredette, M., Nacke, L. E., Lin, X., Grande, K., Robitaille, N., Ziemer, L. & Caprioli, T. (2019) The Impact of Using a Gamified Interface on Engagement in a Warehousing Management Task: A NeuroIS Research Proposal. In: Davis F., Riedl R., vom Brocke J., Léger PM., Randolph A. (eds) Information Systems and Neuroscience. Lecture Notes in Information Systems and Organisation, vol 29. Springer, Cham

that the lack of focus on the human provides a great opportunity to increase employee engagement through gamification.

The objective of this paper is to propose an experiment that can determine how the gamification of a warehouse employee interface affects employee engagement and performance. The experiment will also allow for the examination of the physiological mechanisms by which gamification affects performance. First, employee engagement and gamification literature will be reviewed. Hypotheses will then be presented, followed by the experimental methodology.

2.2 Literature Review

Literature on engagement shows that engagement is a multifaceted concept. It is comprised of behavioural, emotional and cognitive engagement. Behavioural engagement relates to participation and involvement. Emotional engagement comprises positive and negative reactions. Cognitive engagement relates to investment, thoughtfulness and willingness to put in effort towards the task (Fredricks, Blumenfeld, & Paris, 2004). Intuitively, it is easy to understand how an engaged workforce performs better. Empirically, Harter et al. (2016) performed a meta-analysis using 339 research studies and found that employee engagement is related to nine performance outcomes: profitability, productivity, turnover, absenteeism, customer loyalty, safety incidents, shrinkage, patient safety incidents and quality (defects).

SDT distinguishes between two types of motivation: intrinsic, which refers to motivation that comes from within, and extrinsic, which refers to motivation that results from assigned outcomes or reward. Research shows that intrinsic motivation is the main type that is used to explain underlying motivational effects of game design elements (Ryan, Rigby, & Przybylski, 2006). SDT states that satisfying three basic psychological needs will lead to increased intrinsic motivation: (1) competence, described as an employee feeling they can efficiently and competently deal with a challenge; (2) autonomy, defined as the sense of freedom and will when performing a task; (3) relatedness, which is the feeling of connection to others (Deci & Ryan, 1980).

So how exactly does intrinsic motivation from a gamified interface increase employee engagement? This can be explained through the lens of the Job Demands-Resource (JD-R) model (Demerouti, Bakker, Nachreiner, & Schaufeli, 2001; Karasek, 1979). Basically, this model proposes that the intrinsic motivation generated through the satisfaction of SDT's three basic psychological needs by the implementation game design elements results in a greater availability of motivational resources. JD-R states that when employees have enough resources to deal with job demands, engagement is greatly increased (Demerouti et al., 2001). For example, integrating a self-set goal mechanism into an employee interface can increase intrinsic motivation and available resources through the autonomy of the competence aspect of SDT. In other words, allowing employees to set their own goals may give them a certain sense of autonomy. Because motivation cannot be objectively measured, we assume that an engaged participant is a motivated participant, with SDT and the JD-R model providing a conceptual link between these concepts.

Complementary to SDT, goal-setting theory, another well-established theory of human-motivation, provides further insight into how game elements can increase engagement, specifically, the goal-setting game element (Locke & Latham, 2002). This theory states that people are generally motivated to achieve goals. This motivation is because of self-regulation, which is the modification of thought, affect, and behaviour (Kanfer & Ackerman, 1989; Karoly, 1993; Locke & Latham, 2006). In fact, decades of psychological research exist documenting how goal setting increases engagement and performance (Landers, Bauer, & Callan, 2017). However, there is much debate on whether self-set goals or assigned goals produce greater engagement and performance. As is noted in a meta-analysis by Harkins and Lowe (2000), most of the previous studies comparing self-set versus assigned goals did not take into account necessary factors for a valid comparison. Other research into this comparison has shown that goal commitment is higher when goals are self-set (Locke, Latham, & Erez, 1988). Because goal commitment is a strong moderator of the relationship between goals and performance (Locke & Latham, 2002), it can be argued that self-set goals may lead to better performance and possibly more engagement. Based on the reviewed literature, we have developed two hypotheses:

<u>H1:</u> The use of a gamified interface where goals are either self-set or assigned and feedback is received will lead to higher engagement and performance, when compared to no gamification.

<u>H2:</u> The use of a gamified interface where goal-setting is self-set will lead to higher engagement and performance, when compared to assigned goal.

2.3 Methods

Experimental design

This study uses a within-subject design. Twenty subjects aged between 18-25 will participate in this study. They will be taken from our institution's participant pool. The current experiment was approved by our institution's research ethics board.

Building upon recommendations by (Liu, Santhanam, & Webster, 2017) our experiment was designed bearing two types of outcomes in mind: experiential and instrumental. The following experiment will examine the impact of using a gamified interface on an experiential outcome (engagement) and an instrumental outcome (task performance) during a warehousing management task. In this case, a warehouse management task refers to picking specific items from various shelves and placing them into a bin. The implemented elements are goal setting (self-set vs. assigned) and feedback. Goal-setting and feedback have been integrated together because research has consistently shown that the motivational effects of goal-setting are most effective when the participant knows how he/she is progressing towards that goal, via some sort of feedback (Harkins & Lowe, 2000). Three experiment conditions were developed to answer the research questions.

Condition 1: in this condition, participants will go through the picking task (see section 3.2 for details about the task) without any set goal, without any feedback. This serves as a control condition.

Condition 2: in this condition, participants will be able to set their own goals at the beginning of the condition (e.g. The average time to complete the following task is five minutes. Today, I want to beat the average by 45 seconds). When participants are done, they will receive on-screen feedback about their performance (e.g.. "Good job, you have reached your goal").

Condition 3: in this condition, participants will be assigned a goal (average completion time). All 20 participants will be assigned the same goal. They will also receive on-screen feedback about their performance.

We have chosen to always present condition 1 first based on what has been found in the literature. It is clear within the literature that having a task with a goal followed by a task without a goal will lead to lower engagement and performance in the latter task (Locke & Latham, 2006). The order of the conditions 2 and 3 will be counterbalanced to reduce a possible ordering effect.

Experimental Setup and Stimuli

A simulated warehouse was set up at the institution's research facilities, the room is 11x17 feet and has five metal bookshelves lined up on a wall. Also, there are four cameras set up around the room, so the participant can be seen at all times. The bookshelves were divided into three columns and four rows. Each compartment having its own unique identifier (e.g. A01001). The picking device used is the Panasonic FZ-N1, a fully rugged device with the Android operating system (version 6.0.1) (see Figure 1). This device is about the same size as an average smartphone. This device will be strapped to the participant's arm.

Figure 1: Panasonic FZ-N1

Experimental Tasks

Participants will have to complete 12 picking tasks in each condition. A single picking task consists of taking a certain quantity of the same item from a compartment (e.g., pick five blue pens from A03002). Not all picks are equal in complexity (e.g. two erasers versus five small white paper clips in small box with about 100 paper clips in various colours). Pick complexity therefore had to be operationalised to assure equal complexity in all conditions. An order picking complexity matrix was created based on research by Chackelson, Errasti, and Tanco (2012). Simply put, pick complexity was determined by the quantity of the picked item, and its number of characteristics that add complexity (e.g. size, colour, brand, type). Because each of the 12 picks had a score, we are able to make sure pick complexity is constant across all conditions.

Measurements

As mentioned above this study will look at engagement and performance as outcome variables. Physiological measures were used to be able to capture the task engagement without interfering in the task itself, therefore maximizing the ecological validity. All physiological data will be synchronised to allow for the best possible quantification of engagement elements, as is recommended by Léger et al. (2014) and Charland et al. (2015). In this case, two of three facets of engagement can be measured physiologically. Emotional engagement can be inferred by measuring emotional valence (positive or negative), as well as emotional arousal (calm/aroused). Electrodermal activity, which is the variance in electrical conductivity in response to sweat secretions, has been shown to be a valid measure of arousal. Electrocardiography, which measures the heart electrical activity is another valid measure of arousal (Cacioppo, Tassinary, & Berntson, 2007). As for emotional valence, it can be with electroencephalography (EEG) (Davidson, 2004). Cognitive engagement is measured using electroencephalography (EEG), which is the measurement of neuron synchronization in the brain. To properly measure cognitive engagement, Pope, Bogart, and Bartolome (1995) created a validated engagement index which measures the power spectral density of three bands (beta/(alpha + theta)) (Chaouachi, Pierre, Jraidi, & Frasson, 2010; Freeman, Mikulka, Scerbo, & Scott, 2004). This index is more complex than the one suggested in the NeuroIS literature (e.g. Müller-Putz, Riedl, & Wriessnegger, 2015). For more information about the physiological tools in this study, refer to the book "Fundamentals of NeuroIS", written by (Riedl & Léger, 2016). Goal commitment and the emotional facet of engagement will be measured with questionnaires. They will be answered on a tablet at the end of each condition, therefore they will not interfere with the task. As mentioned above, the emotional facet of engagement can be inferred by measuring valence and arousal. The Affective Slider (Betella & Verschure, 2016), which composed of a valence slider and an arousal slider, is one of the most reliable ways to measure self-report valence and arousal. The Affective Slider is composed of two sliders. To measure goal-commitment, a five-item questionnaire recommended by Klein, Wesson, Hollenbeck, Wright, and DeShon (2001) was used. As for picking performance, it will be based on two factors: time taken to complete the task compared to the average (calculated during pretests) and task errors (wrong item or quantity).

Procedure

Firstly, the physiological measures will be installed on the participant. Participants then fill out a demographic questionnaire. Participants will then be explained the picking tasks and they will have the opportunity to practice with a training task. Participants then complete the conditions. After each of the 3 conditions, participants will answer the Affective Slider, as well as the goal-commitment questionnaire on a tablet.

2.4 Next Step and Conclusion

We believe that the proposed experiment addresses the need for theory-driven gamification research that allows practitioners to understand the underlying mechanisms behind the integration of game-design elements within a technological interface. Moreover, this study will contribute theoretically and practically to the current body of knowledge. Theoretically, this study will allow for the direct comparison of self-set versus assigned goals, a topic that is still under debate. Practically, this study tests game-elements that can be implemented into a variety of interfaces in diverse contexts, making it of interest to practitioners.

3. Article 2: Playing in the Backstore: Interface Gamification Increases Warehousing Workforce Engagement*

Mario Passalacqua[1], Pierre-Majorique Léger[1], Marc Fredette[1], Élise Labonté-Lemoyne[1], Lennart E. Nacke[2], Xinli Lin[3], Tony Caprioli[3], Sylvain Sénécal[1]

[1] HEC Montreal, Montreal, Canada
{mario.passalacqua, pierre-majorique.leger, marc.fredette, elise.labonte.lemoyne, sylvain.senecal}@hec.ca

[2] University of Waterloo, Stratford School of Interaction Design and Business, Waterloo, Canada
lennart.nacke@acm.org

[3] JDA Software, Waukesha, USA
{xinli.lin, tony.caprioli}@jda.com

3.1 Introduction

Only 13% of employees worldwide consider themselves as engaged in their work (Mann & Harter, 2016). This statistic is worrisome considering that a recent meta-analysis of 339 research studies across 230 organizations in 49 industries of 73 countries found that a lack of employee engagement leads to lower company performance across nine dimensions: customer loyalty, profitability, productivity, turnover, safety incidents, shrinkage, absenteeism, patient safety incidents and product quality (Harter et al., 2016). In a warehouse setting specifically, a lack of employee engagement has been linked to a decrease in company profitability, an increase in quality/defect issues, an increase in safety incidence, an increase in turnover, and a decrease in productivity (Manhattan Associates, 2017). As a potential solution to the lack of employee engagement and as a response to recent calls for theory-driven causal experiments on gamification (Nacke & Deterding, 2017; Warmelink, Koivisto, Mayer, Vesa, & Hamari, 2018), we investigate the effects of the gamification of a wearable warehouse management system's (WMS) interface. A WMS is defined as a database-driven application designed to support warehouse efficiency. "A WMS primarily aims to control the movement and storage of materials within a warehouse and process the associated

* Passalacqua M., Léger, P.-M., Fredette, M., Labonté-Lemoyne, E., Nacke, L. E., Lin, X.. Caprioli, T. & Sénécal, S. (2019) Playing in the Backstore: Interface Gamification Increases Warehousing Workforce Engagement, European Journal of Information Systems (submitted).

transactions, including shipping, receiving, put-away and picking" (Ramaa, Subramanya, & Rangaswamy, 2012, p. 14)

There have been few examples of attempting to integrate gamification in a WMS interface (Klevers et al., 2016). However, these studies have not addressed the theoretical foundations and motivational mechanisms of gamification. Therefore, there is a substantial gap in the literature. The warehousing domain has mainly focused on optimizing the warehousing tasks, rather than the human performing them (Small, 2010). This is surprising because, as Small (2010) notes, "the infrastructure required for gamification is already in place: individualised user interfaces, robust data tracking and reporting, and clearly-defined repetitive objectives" (p.29). Also, warehouses rely on many hourly workers performing item picking tasks, tasks which account for 55% of total warehouse costs (Bartholdi & Hackman, 2017). Therefore, increased employee engagement and performance can be especially beneficial in this setting. This lack of emphasis on the human aspect offers a great opportunity to increase employee engagement and performance, and ultimately lead to better company performance.

In this article, we present a within-subject laboratory experiment in which goal-setting and feedback, two of the most common gamification elements, were implemented in a wearable WMS interface to examine their effect on user engagement, as well as performance in an item picking task (Warmelink et al., 2018 Vesa, & Hamari, 2018). Both implicit (neurophysiological) and explicit (self-reported) measures of engagement are used, allowing for a richer understanding of the user's perceived and physiological state (de Guinea et al., 2014). Overall, our results show that a gamified interface results in higher emotional and cognitive engagement, and better performance, when compared to a non-gamified interface. This thesis provides evidence that the integration of gamification in employee interfaces can positively affect employee engagement, at least in the short term. This thesis also contributes to the understanding of the motivational mechanisms underlying gamification, specifically focusing on how the intrinsic motivation generated from gamification elements ultimately results in a greater potential for employee engagement and performance.

3.2 Literature Review and Hypothesis Development

The following sections will review gamification, self-determination theory, job demand-resource model, engagement, and goal-setting theory literature. Hypotheses related to engagement, performance, and gamification will then be derived.

Gamification

Immersion, contentment, and satisfaction; these three signs of intrinsically motivated behaviour have been shown to arise when people play video games or serious games (Huotari & Hamari, 2016; Ryan et al., 2006). In other words, video games or serious games are known to engage people. Gamification, defined as the use of video game elements in a non-gaming context, is trying to latch on to this engaging and motivating nature of games (Deterding, Dixon, Khaled, & Nacke, 2011 & Dixon, 2011). As is brought forward in a gamification review by Koivisto and Hamari (2017), gamification has gained much traction since its conceptual beginnings in 2010. It has been applied in many domains such as intra-organizational communication and activities (Moradian, Nasir, Lyons, Leung, & Sim, 2014), public engagement (Palacin-Silva et al., 2018), fitness (Zhao, Arya, Whitehead, Chan, & Etemad, 2017), health (Tabor, Bateman, Scheme, Flatla, & Gerling, 2017), education (Denny, McDonald, Empson, Kelly, & Petersen, 2018), and marketing and advertising (Cechanowicz et al. 2013). Common gamification elements used in these studies are progress/feedback, narrative/story, time pressure, competition, leaderboards, avatars, goals, badges, levels, etc. While some attempts at gamifying systems have failed (e.g., Allen, 2011), many have shown positive effects in terms of performance, enjoyment, satisfaction, and engagement (Koivisto & Hamari, 2017; Warmelink et al., 2018). However, very few of these studies have addressed or applied the theoretical foundations of gamification, which has been flagged as an important problem in the gamification literature (Nacke & Deterding, 2017; Santhanam, Liu, & Shen, 2016; Seaborn & Fels, 2015; Warmelink et al., 2018).

Liu et al. (2017) have developed a framework for the research and design of gamified systems, which can be useful for devising solid experimental paradigms to contribute the theoretical foundations of gamification. In short, for gamified systems to create meaningful engagement, they must be designed by taking into account experiential and instrumental outcomes. Experiential outcomes relate to concepts such as fulfilment, enjoyment, and satisfaction (Tomaselli, Sanchez, & Brown, 2015; Wu & Liu, 2007) , whereas instrumental outcomes relate to helping users complete a task (Li, Hsieh, & Rai, 2013). More traditional information systems have mainly focused on instrumental outcomes. However, the value of experiential outcomes has recently become more apparent (Tomaselli et al., 2015; Wu & Liu, 2007). Liu et al. (2017) therefore stress that both these outcomes must be taken into account in the design of gamified system for success to be achieved.

Self-Determination Theory

Self-determination theory (SDT), a psychological theory of human motivation, has emerged as the leading theory with regards to explaining human motivation and understanding motivational effects of games (Ryan, Rigby & Przybylski 2006; Deci & Ryan 1985). Initially proposed by Deci and Ryan (1980), this theory has been refined by various researchers over the four decades to become a solid theoretical pillar for human motivation. This theory was born from the need to explain seemingly intrinsically motivated animal behaviour that could not be explained using the dominant theory at that time, i.e., Hull's Drive Theory (1943) (Gagné, 2014). Motivational theorists such as White (1959) and de Charms (1968) proposed that intrinsic motivation arose from a feeling of autonomy, from a feeling that one's behaviour and actions come from within and not from external forces. In 1971, Deci proceeded to test this theory by having students complete an inherently enjoyable game (i.e., SOMA puzzle). In one group, students received a monetary reward and in the other, no reward. Deci (1971) found that monetary rewards decreased intrinsic motivation to play the game, when compared to the other group. He suggested that the rewards diminished participants' feeling of autonomy. Later studies confirmed that autonomy is key factor in intrinsic motivation (Deci, 1972; Amabile, DeJong & Lepper, 1976; Lepper & Greene, 1975; Zuckerman et al., 1978). Later and recent research has found that the feeling of mastering one's environment, or in other words, feeling competent, is another key factor in intrinsic motivation (Vallerand & Reid, 1984; Dysvik, Kuvaas & Gagné, 2013). Many other factors were tested, but relatedness, the feeling of being related to others, emerged as the only other key factor (Deci, Eghrari, Patrick & Leone, 1994; Deci & Ryan, 2000; Ryan & Deci, 2000). It is through this process that the three basic psychological needs for intrinsic motivation have come about: (1) competence, described as an employee feeling they can efficiently and competently deal with a challenge; (2) autonomy, defined as the sense of freedom and will when performing a task; (3) relatedness, which is the feeling of connection to others (Deci & Ryan, 1980).

Research has shown that playing video games satisfies these three psychological needs and is intrinsically motivating (Rigby & Ryan, 2011). Games often include various levels or difficulties that can be adapted to a player's skill, which can induce a feeling of competence. Games are played by one's own free will, which can induce a feeling of autonomy. Games often provide the opportunity to interact with other players in various ways, which can induce a feeling of relatedness (Ryan, Rigby & Przybylski 2006; Rigby & Ryan, 2011; Deterding, 2015; Koivisto, 2016). Gamification, in essence, tries to transpose the intrinsic motivation generated from video games to a non-gaming context, by using various gamification elements. This raises the following question related to the current research project: How does the intrinsic motivation generated from a gamified interface lead to an increase in employee engagement and performance?

Job Demands-Resource Model

To answer the above-stated question, we must first understand the job demands-resource model (JD-R), originally conceptualised by Karasek (1979), but later revised by Demerouti et al. (2001). This model states that job demands and job resources have an interactive effect on various aspects of workplace success and well-being. Job demands are characterised as aspects of work that put strain on employees (e.g., high workload, pressure, and emotional demands), whereas job resources are defined as features of work that reduce strain on employee (e.g., support from supervisor and peers, autonomy, and role-clarity) (Bakker, Demerouti, Taris, Schaufeli, & Schreurs, 2003). When job demands are more prominent than job resources, there is an increased risk for burnout and other factors that negatively affect work well-being and performance. On the flipside, when job resources are sufficient to deal with the job demands, a work environment where engagement and other factors that increase employee performance and well-being can proliferate (Van den Broeck, Vansteenkiste, De Witte, & Lens, 2008). The JD-R model and SDT are conceptually related, in the sense that they both consider that certain needs (motivational resources/three basic psychological needs) are motivational mechanisms (Gagné, 2014). Research linking the JD-R model and SDT has found that the satisfaction of the three basic psychological needs is a mediator of the relationship between job resources and engagement, of the relationship between job demands and burnout, and of the relationship between job resources and exhaustion (Van den Broeck et al., 2008). In other words, the intrinsic motivation generated from the satisfaction of SDT's three basic psychological needs leads to an increase in job/motivational resources, which in turn, increase employee engagement. It is through this process that we believe gamification can positively affect engagement and performance as a result.

Cognitive and Emotional Employee Engagement

Engagement, specifically employee engagement, is central to this research. It is therefore important to properly conceptualise engagement. Although there is still no clear consensus to define engagement, the main elements can be derived from the most popular conceptualizations (Gagné, 2014). One of the first definitions included physical, emotional, and cognitive facets of engagement (Kahn, 1990). Other definitions included vigour, dedication, and absorption as components (Wilmar B Schaufeli, Salanova, González-Romá, & Bakker, 2002). Later, Fredricks et al. (2004) attempted to bring together existing literature and proposed that engagement is a multifaceted concept consisting of cognitive, emotional, and behavioural components. Cognitive engagement related to thoughtfulness, investment, willingness to put in effort. At its core, cognitive engagement represents the psychological investment and effort put towards a task (Fredricks et al., 2004 2004). Emotional engagement comprises affective/emotional reactions, such as interest, boredom, happiness, and sadness (Connell & Wellborn, 1991; Skinner & Belmont, 1993). Interest and boredom coincide with the concept of emotional arousal, i.e., high emotional arousal corresponds to interest and low emotional arousal corresponds to boredom (Lang, 1995). Happiness and sadness coincide with the concept of emotional valence, i.e., high emotional valence corresponds to happiness and low emotional valence corresponds to sadness (Lang, 1995). Behavioural engagement relates to active participation, positive conduct, and involvement. Examples of behaviours associated with behavioural engagement are adherence to rules and norms, absence of disruptive behaviours, attention, and persistence (Fredricks et al., 2004). These three facets of engagement encompass and overlap with past research on engagement. We use the latter definition because it synthesises past definitions and research. This research evaluates emotional and cognitive engagement types. Behavioural engagement, mainly focusing on visible observations of behaviours related to engagement, is not applicable to the current thesis because participants do not have the opportunity to display observable engaged behaviours. We thus proposed the following hypotheses on the effect of gamification on employee engagement and performance.

- H1a: A gamified interface will lead to higher emotional engagement, when compared to a non-gamified interface.
- H1b: A gamified interface will lead to higher cognitive engagement, when compared to a non-gamified interface.
- H2: A gamified interface will lead to better performance, when compared to a non-gamified interface.

Goal-Setting Theory

Goal-setting theory is another well-established psychological theory of human motivation. Originally created by Locke (1968), this theory provides further insight into the motivational effects of gamification. This theory, having emerged from hundreds of empirical findings, posits that when individuals have goals, motivation is increased and therefore so is performance (Gagné, 2014; Tondello, Premsukh, & Nacke, 2018)). This theory aims to understand in what situations/contexts goals increase performance. Two main principles are at the core of goal-setting theory: (1) Goal difficulty and performance are positively related, up until a certain point; (2) Difficult/ specific goals lead to higher performance than abstract, or no goals (Locke & Latham, 2002). As Tondello et al. (2018) have noted, it is surprising that goal-setting theory has not been widely integrated in the design and study of gamified interfaces since goal setting is central to many of the most common gamification elements (leaderboard, challenges, quests, progress bars, etc.) (Mora, Riera, Gonzalez, & Arnedo-Moreno, 2015). Goal-setting theory and gamification are a great/logical fit because gamification often includes specific and difficult goals; goal-setting theory can therefore be used to explain why gamification leads to improved performance, when goals are involved (Tondello et al., 2018). In addition, this theory, throughout the last three decades, has identified the mediators and moderators of the relationship between goals and performance, which will aid in the interpretation of the results of this thesis. In the following paragraph, the relevant mediators and moderators of this relationship, and their implications for gamification will be summarised, based on Tondello et al. (2018).

The relevant mediators are as follows: (1) Effort: Once a goal is set, people will tend to exert effort proportional to the difficulty of the goal (Locke & Latham, 2002) Gamification is a great platform to implement difficult goals, thus increasing expended effort and performance, as is stated in goal-setting theory; (2) Persistence: People tend to be more persistent towards reaching a goal when it is specific and difficult, rather than easy or vague (Locke & Latham, 2002). Within gamification, it is possible to set difficult and specific goals, but it is also possible to provide encouraging feedback when a person has failed to reach a certain goal. This mechanism can therefore increase performance through a person's persistence. The relevant moderator of the relationship between goals and performance is feedback: When feedback/progression towards a goal is known, goal-setting is much more effective (Locke & Latham, 2002). Feedback, along with goals and challenges, is recommended by most gamification design methods (Deterding, 2015; Mora et al., 2015; Tondello et al., 2018).

Goal-setting theory also makes distinction between goals that are chosen by an individual (self-set goal), versus a goal that has been assigned (assigned goal). In a meta-analysis and an experiment by Harkins and Lowe (2000), it was found that self-set goals induce better performance, but only when two conditions are met: (1) participants must have participated in a pretest task that is of equal length, before the experimental condition; (2) the experimenter must have access to the goals and performance of the participant, and this must be known by the participant (both conditions are satisfied in this experiment). Additionally, Erez and Arad (1986) found that self-set goals generate more engagement, and therefore better performance. However, there is still much debate within the literature about which type of goal-setting produces better performance. For example, a meta-analysis by Gollwitzer and Moskowitz (1996)shows no differences in performance when comparing self-set versus assigned goals. Nevertheless, we posit the two following hypotheses.

- H3: Self-set goals will lead to better performance, when compared to assigned goals.
- H4a: Self-set goals will lead to more emotional engagement, when compared to assigned goals.
- H4b: Self-set goals will lead to more cognitive engagement, when compared to assigned goals.

3.3 Materials and Methods

Experimental Design

This thesis used a within-subject design. Twenty-one subjects participated (13 female, 8 male). The average participant age was 24.20 (SD=2.21). According to the United States Department of Labour (2018), the 20 to 24 age group is the second most common for labourers, freight, stock and material movers (by hand), 16 to 19 being the first. These occupations are therefore more common in this age range than other age ranges, thus making our sample age selection adequate. Participants were recruited from our institution's participant pool. This experiment was approved by our institution's ethics board. Two experimental factors, the presence of goals and feedback, were manipulated, leading to three conditions: no gamification condition (control), self-set goals and feedback condition, and assigned goals and feedback condition.

Experimental task, setup, and stimuli

Item/order picking is defined as retrieving items from a stored location to satisfy a customer's specific order (Chackelson et al., 2012). Employees typically use a WMS to guide them during item picking (Bartholdi & Hackman, 2017). In our experiment, participants completed one picking task per condition. A picking task consisted of picking various quantities of 12 items from specific locations on bookshelves, then placing them into a bin. For example, participants were instructed to pick eight blue pens from location "A01003". This would be one of the 12 items/picks in the picking task. Not all picks are equal in complexity (e.g., two erasers versus five small white paper clips in a small box with about 100 paper clips in various colours). Pick complexity therefore had to be operationalised to assure equal complexity in all conditions. An order picking complexity matrix was created based on prior research (Chackelson et al., 2012; Errasti, 2011). Simply put, pick complexity was determined by the quantity of the picked item, and its number of characteristics that add complexity (e.g., size, colour, brand, type). Because each of the 12 picks had a score, we are able to ensure that pick complexity was constant across all conditions.

An example of participants' progress through a picking task is shown by a dotted line in Figure 1: Participants begin at the "pickup" location with a trolley with a bin on it; participants go

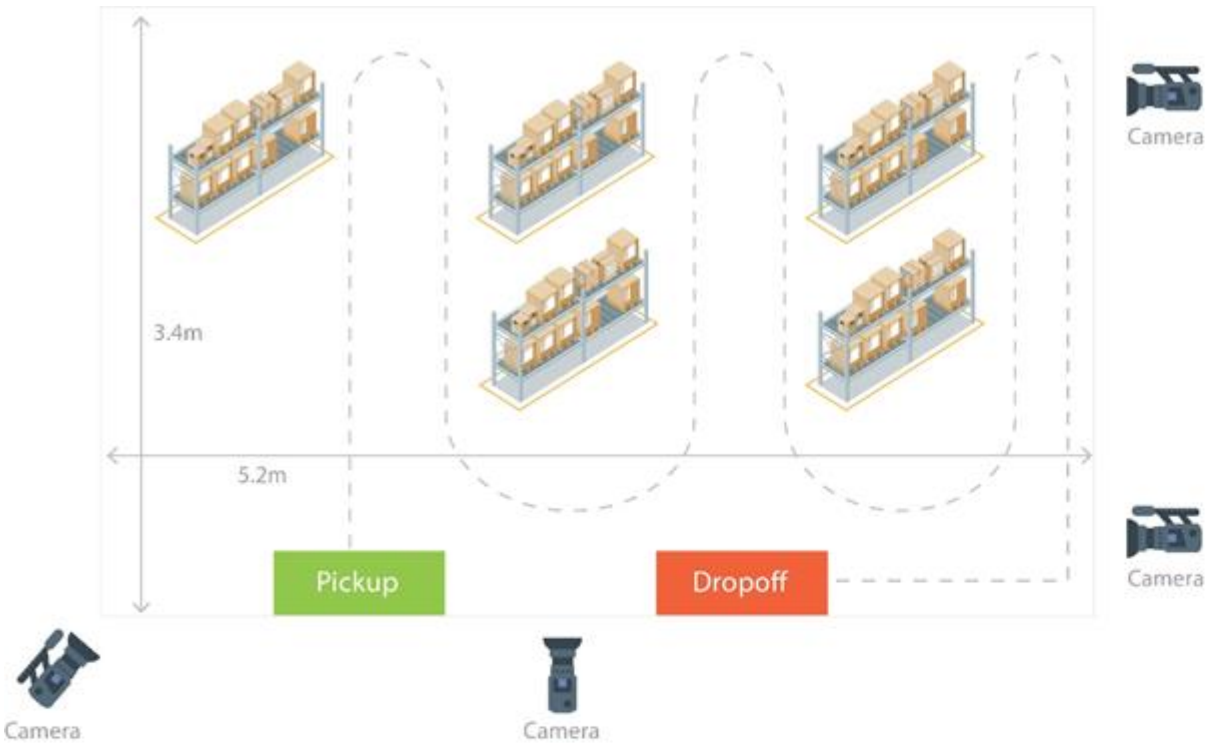

Figure 2: Diagram of the experimental layout

pick various quantities of 12 different items from 5 different bookshelves, as instructed on the wearable WMS they are using; they then drop off the bin at the "dropoff" location.

A small warehouse was set up in our institution's research laboratory. The room was 5.2 x 3.4 metres and had five metal bookshelves, placed as shown in Figures 2 and 3. Four cameras were placed around the room in order to observe and record the participant at all times. Please see the video in Appendix 1 for an overview of the task and experimental setup. Participants received picking instructions from a wearable WMS. Participants had to enter the quantity of the picked item directly on the wearable (see Figure 4).

Figure 3: Experimental layout

Figure 4: Participant interacting with wearable WMS interface

Procedure

Participants were first outfitted with all physiological equipment. They were then given instructions about the picking task, followed by a training task which consisted of six picks without any sort of gamification. Once the participant was comfortable and understood the task, they proceeded with Condition 1.

Condition 1 (No Gamification - NG) consisted of 12 picks, without any sort of gamification, meaning no goal or feedback, but only an upwards-counting timer. Figure 5a shows the picking screen on the wearable device, with the timer being in the top right corner. As is seen in the figure, this is the third pick out of 12. Figure 5b shows the deposit screen, shown after the task has been completed. After each of the three conditions, the affective slider was administered (see measurement scales below). Participants then completed either Condition 2 or Condition 3, followed by the remaining condition.

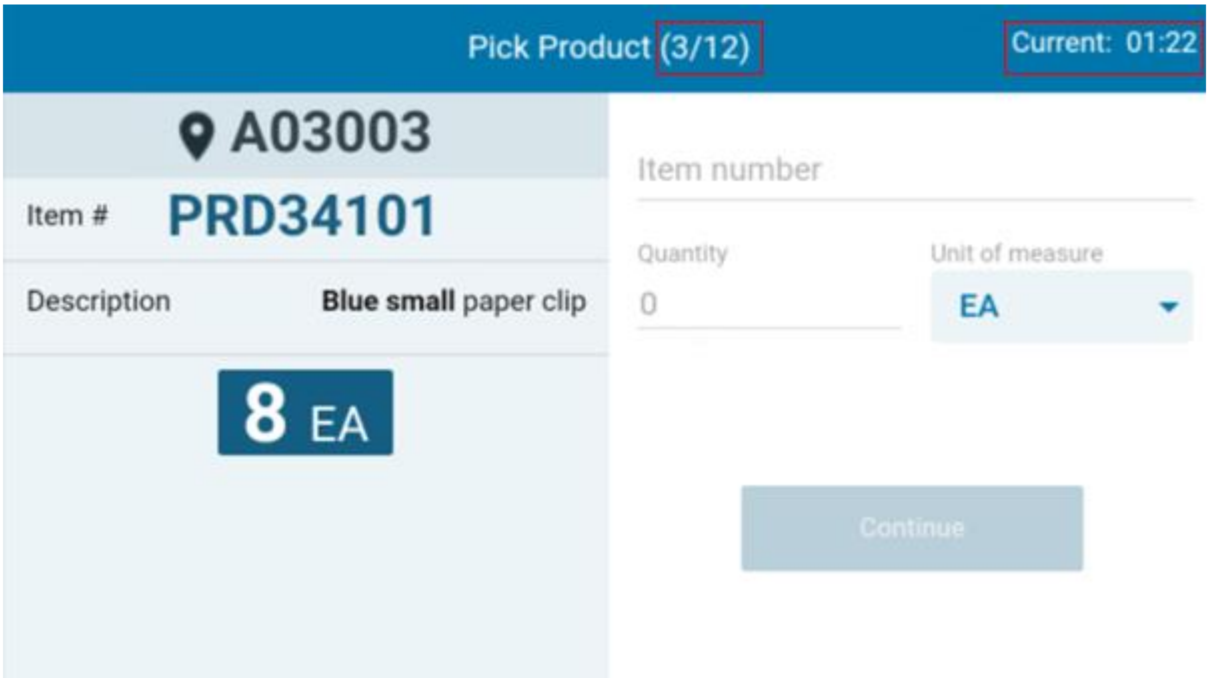

Figure 5a: Picking screen (Condition 1 (NG))

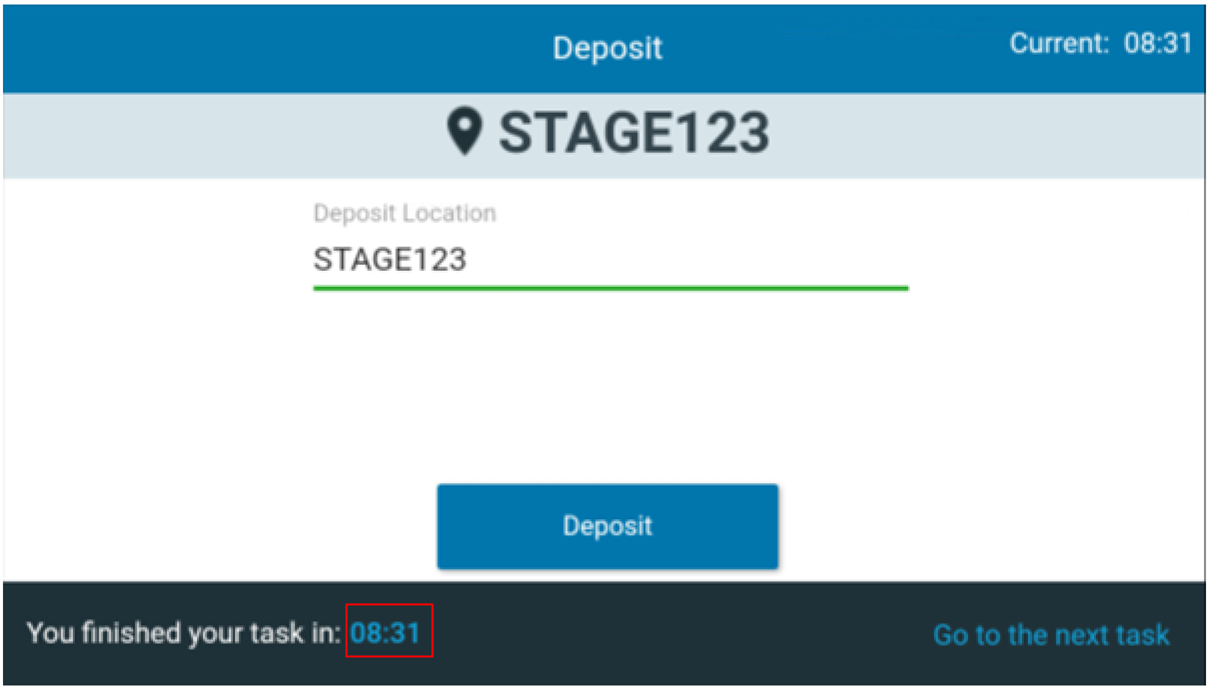

Figure 5b: Deposit screen (Condition 1 (NG))

Condition 2 (Self-Set Goals - SSG) also consisted of 12 picks; however, before beginning the task, participants had to choose one of three performance goals (see Figure 6): average time (6:38), one minute under average (5:38 minutes), or one minute over average (7:38). The average time was derived from nine pretest participants. All participants were offered the same choices.

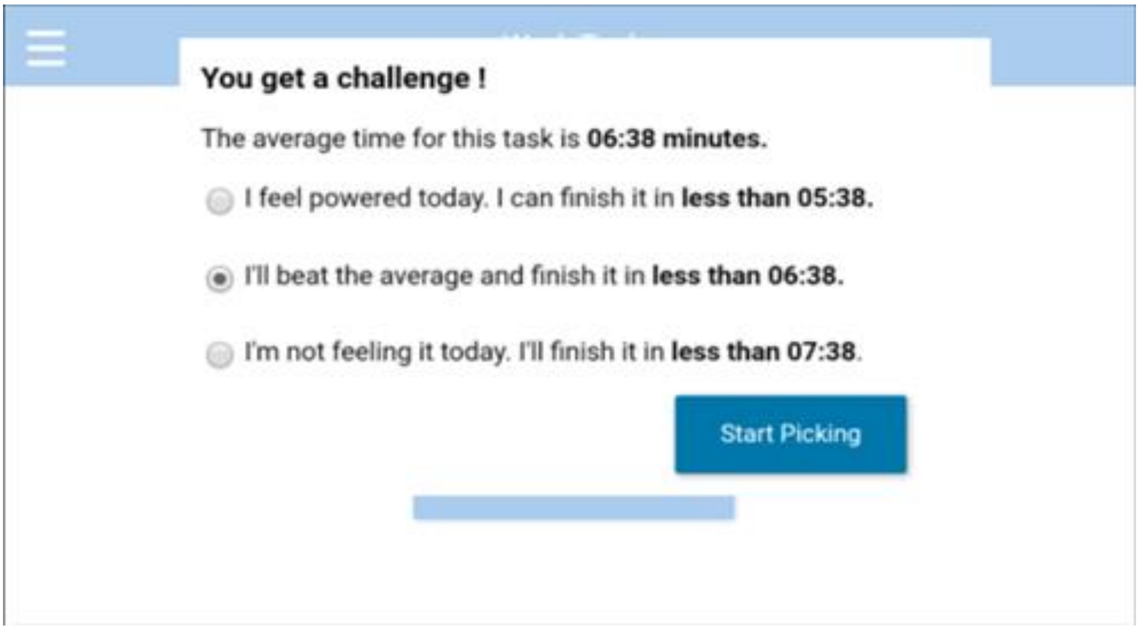

Figure 6: Goal Selection (Condition 2 (SSG))

Figure 7 shows the picking screen in this condition and in Condition 3 (AG). In the top right corner, an upwards-counting timer, as well as the goal time are displayed. When a participant reached the goal, the following on-screen message was presented: "You've reached your goal. You finished in XX:XX". When a participant did not reach the goal, this message was displayed: "Almost there! You finished in XX:XX".

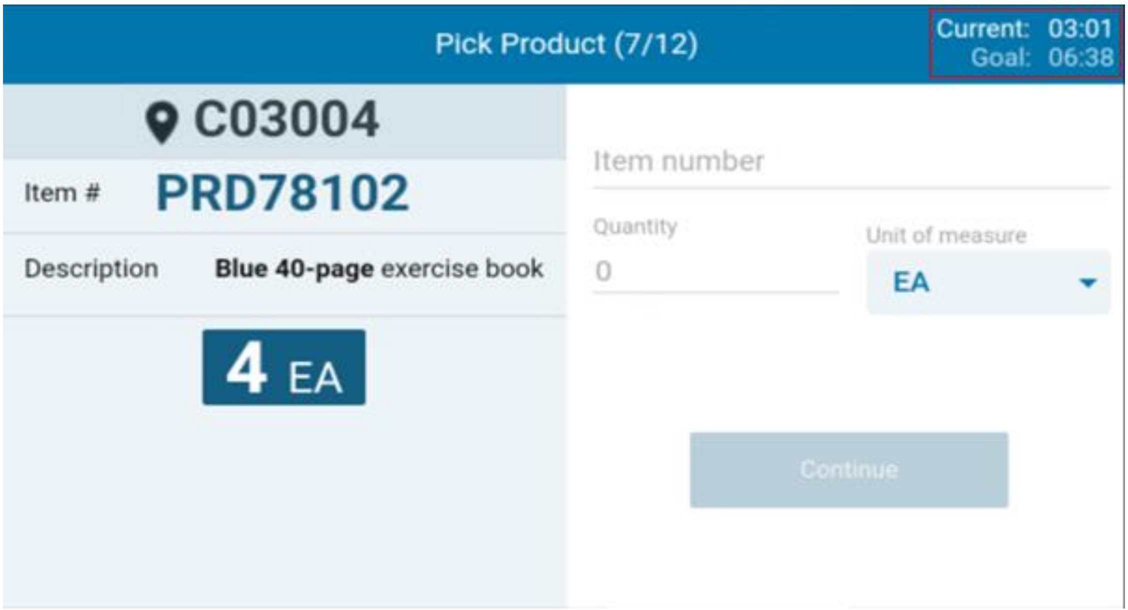

Figure 7: Picking Screen (Conditions 2 (SSG) and 3 (AG))

Figures 8a and 8b show the screen where these messages are seen. **Condition 3 (Assigned Goals - AG)** also consisted of 12 picks. In this condition, a performance goal was assigned to the participant before beginning the task. The goal consisted of the average time (6:38). All participants were assigned the same goal. The same feedback messages as in Condition 2 (SSG) were shown when participants reached/did not reach the goal.

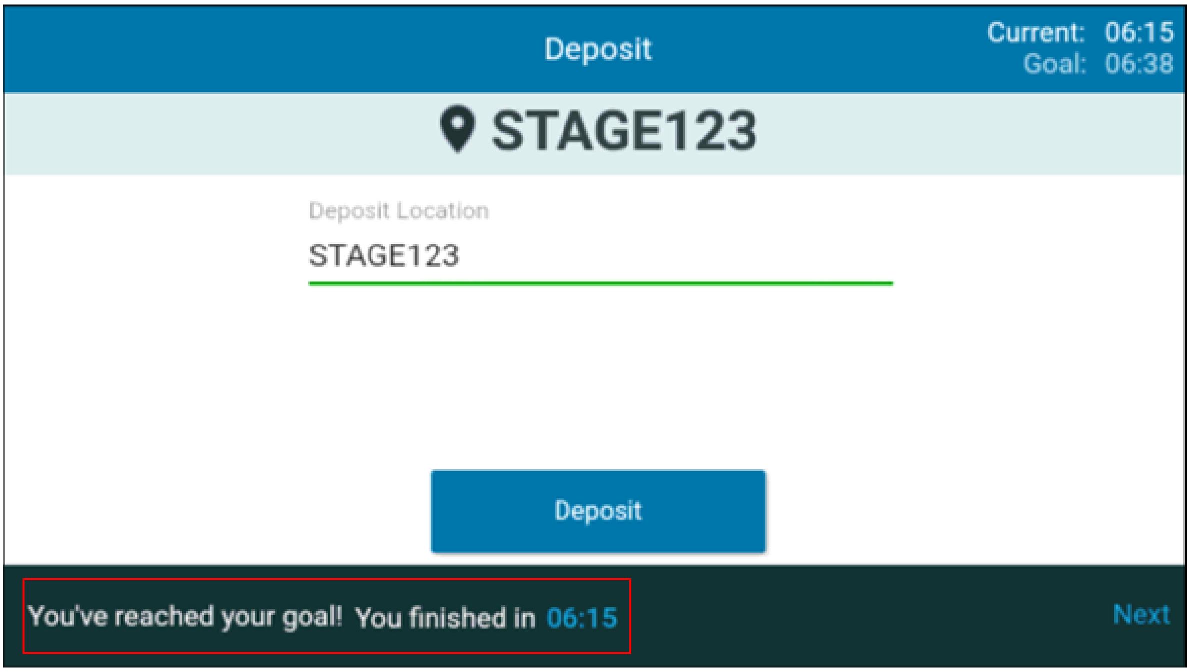

Figure 8a: Deposit Screen when goal is reached (Conditions 2 (SSG) and 3 (AG))

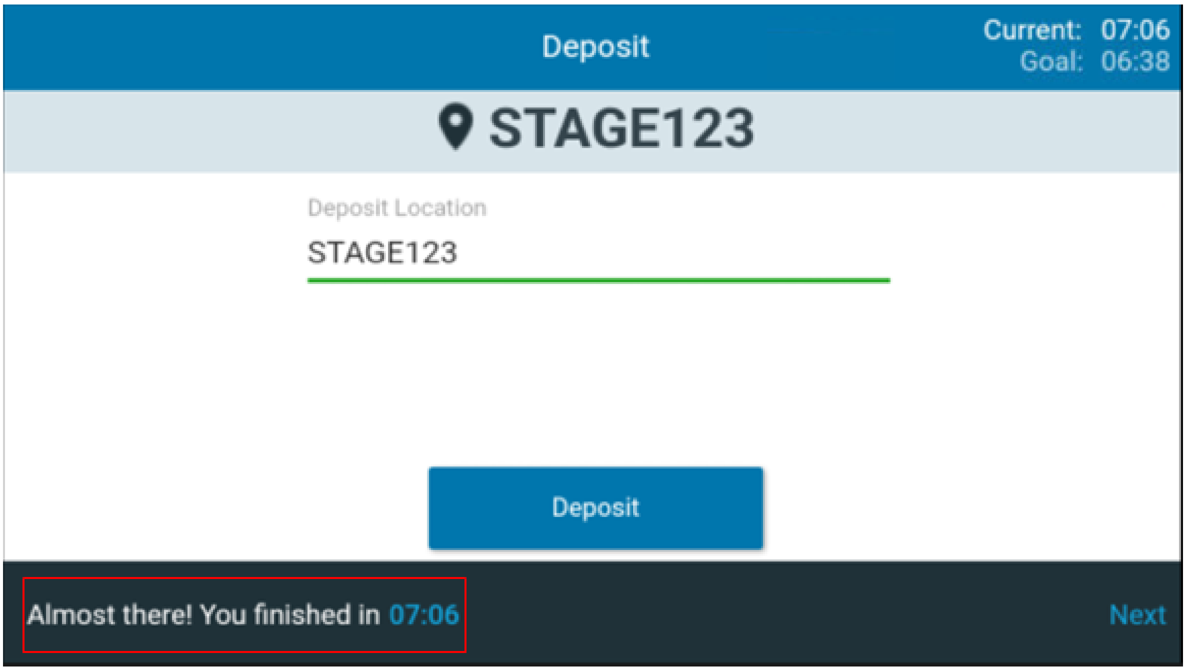

Figure 8b: Deposit Screen when goal is not reached (Conditions 2 (SSG) and 3 (AG))

Related literature states that having a task without a goal after a task in which a goal was present leads to lower performance and engagement in the task without a goal (Locke & Latham, 2006). We have therefore decided to always present Condition 1 (NG) first. Conditions 2 (SSG) and 3 (AG) were randomised to avoid any ordering effect. To avoid a learning effect, all participants went through a six-pick training task before Condition 1. In the training task, we made sure that participants fully understood the task at hand. To conclude the experiment, a five open-ended question interview was administered. It was used to gain insight into system and interface usability, as well as condition preference (NG, SSG, or AG). Figure 9 illustrates the experimental procedure.

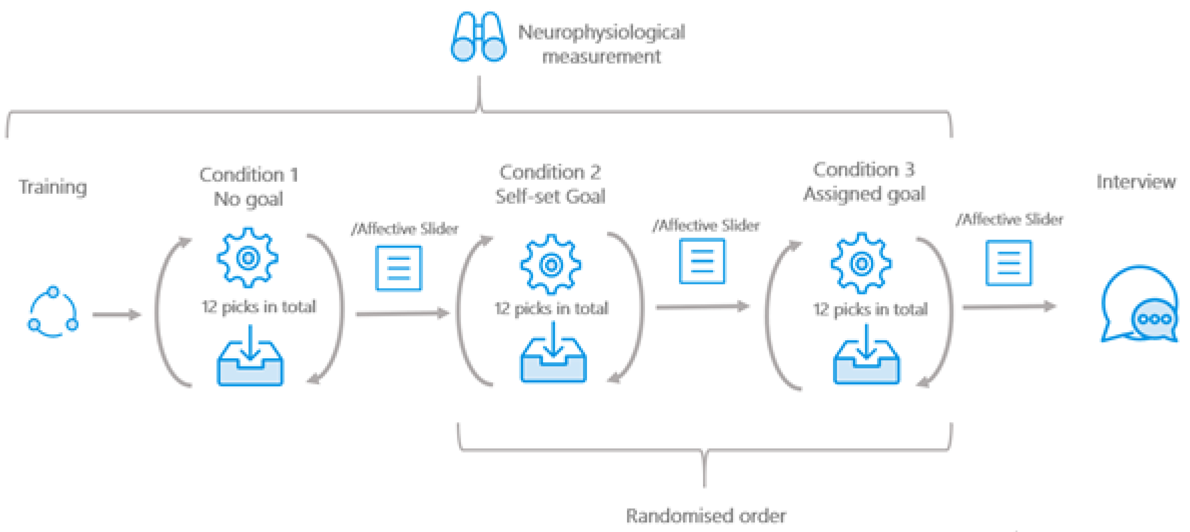

Figure 9: Experimental procedure

Operationalisation of research variables

As is mentioned, this thesis looked at performance, implicit engagement, and explicit engagement as research variables. Using NeuroIS measurement tools (Riedl, Fischer, & Léger, 2017), implicit measures can assess processes or constructs in real-time without interfering with the task, and without participants being aware of what is measured (Charland et al., 2015). Thus, having both implicit and explicit measures of engagement limits biases resulting from using only explicit measures and increases the ecological validity, therefore leading to increased results validity (de Guinea et al., 2014). All physiological data was synchronised to allow for the best possible quantification of engagement elements, as per the guidelines of Charland et al. (2015).

Cognitive engagement

Explicit cognitive engagement: Self-reported cognitive engagement was measured using a two-item scale (Rodríguez-Sánchez, Schaufeli, Salanova, Cifre, & Sonnenschein, 2011), adapted from the Utrecht Work Engagement Scale (Wilmar B. Schaufeli, Bakker, & Salanova, 2006), which measures work engagement. The two items were designed to measure the cognitive absorption in a task and were scored on a 7-point Likert scale. The two items were chosen based on face validity and high factor loading. The two items were "I'm engrossed in what I'm doing" and "I enjoy what I'm doing now".

Implicit cognitive engagement: This variable was measured using a 32-electrodes electroencephalography (EEG) cap especially designed for participant mobility. Neurophysiological tools such as EEG allow for the real-time detailed collection of cognitive processes such as cognitive engagement (Charland et al., 2015). EEG, unlike self-reported and most physiological measures, is particularly accurate in terms of temporal precision, allowing for the detailed capture of variations in cognitive processes. Cognitive engagement was measured using an index created by Pope et al. (1995). This index was extensively validated in neuroergonomics (Arrabito, Ho, Aghaei, Burns, & Hou, 2011; Courtemanche et al., 2019), and is based on the premise that an increase in beta activity indicates more arousal and attention, while an increase in alpha or theta activity indicates less arousal and attention (Scerbo, Freeman, & Mikulka, 2003). Specifically, cognitive engagement was measured by isolating data from 4 of the 32 electrodes in the EEG signal (P3, P4, Cz, Pz), by isolating specific bands (which allows to extract beta, alpha, and theta bands), and by applying an engagement index (beta / (alpha + theta).

Emotional engagement

Explicit emotional engagement: Explicit emotional engagement was inferred by using the affective slider, a well-established and reliable way to measure valence and arousal (Betella & Verschure, 2016). The slider, a self-report measure, consists of two sliders: one for valence (happiness on one end, sadness on the other) and one for arousal (interest on one end, boredom on the other. The participant must slide the cursor to indicate his/her level of valence and arousal.

Implicit emotional engagement: As mentioned, emotional engagement can be split up into valence and arousal. Multiple measures are used to infer the participant's psychophysiological state. Specially, three are used in this thesis to evaluate implicit emotional engagement: skin conductance level (SCL), heart rate (HR), and frontal alpha asymmetry. SCL, measured using electrodes, is the tonic level of electrical conductivity of the skin when a small electrical current is passed between the electrodes. SCL has been shown to be a valid indicator of emotional arousal (Cacioppo et al., 2007). Another validated indicator of emotional arousal is HR, measured using an electrocardiogram (ECG). A faster HR is an indicator of more arousal (Cacioppo et al., 2007). SCL and HR data has been adjusted for baseline at participant level, then standardised to (-1,1) at entire sample level using a min-max approach (Boucsein, 2012). Emotional valence is measured as frontal alpha asymmetry, which is the asymmetrical activation of left and right frontal area of the brain. Frontal activity on the left side is associated with positive valence, while activation on the right side is associated with negative (Davidson, 2004; Quaedflieg et al., 2015).

Performance

Performance was measured by using the time taken to complete a task and by number of errors, two of the main warehouse key performance indicators (Bartholdi & Hackman, 2017).

When comparing the three conditions, time taken to complete the task is directly compared. However, when comparing both gamified conditions, performance time can be further broken down since they both have goals (self-set or assigned). When comparing these two conditions, we deducted the goal time from the time taken to complete the task (time to task completion – goal time). This allowed us to compare both conditions relative to the goals that were chosen/given, which leads to a more accurate comparison.

Errors with regards to performance are measured using % of correctness. As is mentioned, participants completed 12 tasks per condition. These tasks had various levels of complexity; however, complexity was the same across all three conditions. Errors are weighted based on their complexity: an error in a more complex task resulted in a smaller deduction in the % of correctness. Participants made two types of error, each weighted equally: quantity and type of item.

Apparatus

Four cameras (Logitech, Newark, USA) were used to record the participant at all times. Electrocardiogram sensors (Biopac, Goleta, USA) were placed on the surface of the skin to measure the heart's electrical activity, which allows to measure HR. Sensors (Biopac, Goleta, USA) were placed on the surface of the skin to measure the activity of the sweat glands, which allows to SCL. A 32-electrode electroencephalography cap (Electrical Geodesics, Eugene, USA) was placed on participants' heads to capture the brain's electrical activity. This was used to measure cognitive engagement and frontal alpha asymmetry. A ruggedised wearable Android device, Panasonic FZ-N1 (Osaka, Japan), was strapped to the participants' arms. This device contained the WMS that instructed participants for the experimental task. The WMS (mobile application within the wearable) was developed by JDA (Waukesha, USA), and presented through Axure RP 8 (San Diego, USA).

Media Recorder (Noldus, Wageningen, Netherlands) was the audio and video recording software used. Observer XT (Noldus, Wageningen, Netherlands) was used to synchronise all the equipment and to add markers (event time). Acqknowledge (Biopac, Goleta, USA) was the software used to capture and analyse SCL and HR. Netstation (Electrical Geodesics, Eugene, USA) was the software used to collect EEG data. Brainvision Analyzer (Brain Products, Munich, Germany) was used to analyse EEG data. Teamviewer (Göppingen, Germany) was used to record and control the wearable device's screen.

Statistical Analysis

Wilcoxon signed-rank non-parametric tests were used to analyse explicit emotional engagement, explicit cognitive engagement, and performance (time) because they are more robust when testing a small to moderate sample size, and because our data was not normally distributed. In order to account for repeated measurements from the same individuals across different conditions, mixed Poisson and mixed linear regressions models have shown that the order in which tasks were presented had no effect on the results. No significant gender differences were observed. All statistical analyses employed Statistical Analysis System (SAS) 9.4.

3.4 Results

See Appendix 2 for the mean and standard deviation of all variables, by condition.

A gamified interface leads to higher emotional engagement (H1a)

Explicit emotional engagement

Results of the Wilcoxon signed-rank test when comparing conditions 1 (NG) and 2 (SSG) show a significant effect for both valence ($r= 0.70$, $p< 0.01$) and arousal ($r= 0.81$, $p< 0.001$). When comparing Conditions 1 (NG) and 3 (AG), results also show a significant effect for both valence ($r= 0.75$, $p< 0.001$) and arousal ($r= 0.85$ $p< 0.001$). Specifically, Conditions 2 (SSG) and 3 (AG) elicited more positive valence and more arousal than the non-gamified condition (NG), supporting H1a for explicit emotional engagement. Figure 10 shows results related to explicit emotional engagement, separated by condition.

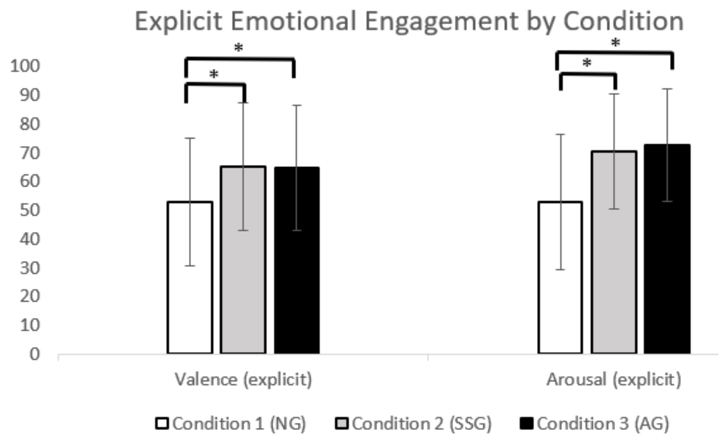

Figure 10: Explicit emotional engagement by condition

Implicit emotional engagement

Results of the mixed linear regression model when comparing Conditions 1 (NG) and 2 (SSG), show a significant effect for both SCL (arousal) ($d= -0.17$, $p< 0.05$) and HR (arousal) ($d= -0.11$, $p< 0.05$). When comparing Conditions 1 (NG) and 3 (AG), results show a significant effect for HR ($d= 0.22$, $p< 0.001$), but no significant effect for SCL ($p= 0.19$). Results show no significant effect for frontal alpha asymmetry (valence) between Conditions 1 (NG) and 2 (SSG) ($p= 0.32$) or 1 (NG) and 3 (AG) (p=

0.55). In other words, Condition 2 (SSG) generated a stronger skin conductance level than Condition 1 (NG); Conditions 2 (SSG) and 3 (AG) generated higher HR than Condition 1 (NG). H1a is generally supported for implicit emotional engagement. Overall, results supported H1a (implicit and explicit emotional engagement.)

A gamified interface leads to higher cognitive engagement (H1b)

Explicit cognitive engagement

Results of the Wilcoxon signed-rank test show a significant effect for explicit cognitive engagement when comparing Condition 1 and 2 (r= 0.92, p< 0.01), and when comparing Conditions 1 and 3 (r= 0.99, p< 0.01,). Specifically, participants were more cognitively engaged during Conditions 2 and 3, supporting H1b for explicit cognitive engagement.

Implicit cognitive engagement

When looking at implicit cognitive engagement, a mixed linear regression model showed no significant difference between conditions 1 and 2 (p= 0.34), 1 and 3 (p= 0.52), thus H1b is not supported for implicit emotional engagement. Figure 11 shows results related to explicit and implicit cognitive engagement, separated by condition.

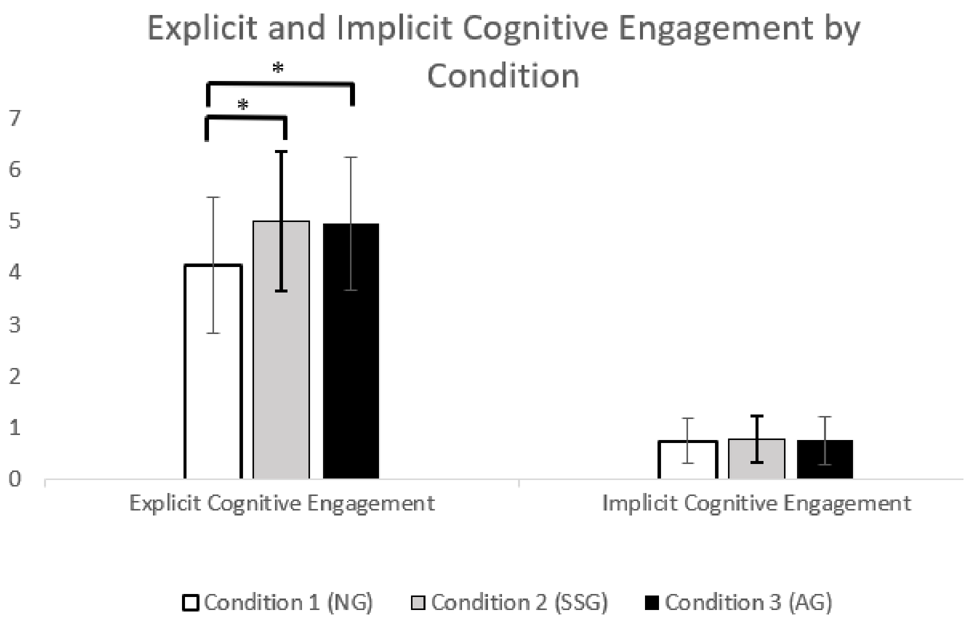

Figure 11: explicit and implicit cognitive engagement by condition

A gamified interface leads to better performance (H2)

A Wilcoxon signed-rank test was used to compare performance (time) between conditions. A larger time indicates a lower performance. A mixed Poisson regression model was used to compare performance (errors) between conditions. Results show a significant effect for performance (time) when comparing Condition 1 (NG) to both Condition 2 (SSG) (r= -0.98, p< 0.001) and 3 (AG) (r= -0.99, p< 0.001). Specifically, participants were significantly more performant in Conditions 2 (SSG) and 3 (AG). No difference was found for performance (errors) between Conditions 1 (NG) and 2 (SSG) (p= 0.25), or between conditions 1 (NG) and 3 (AG) (p= 0.25). Figure 12a shows results related to performance time and Figure 12b shows results related to performance errors, separated

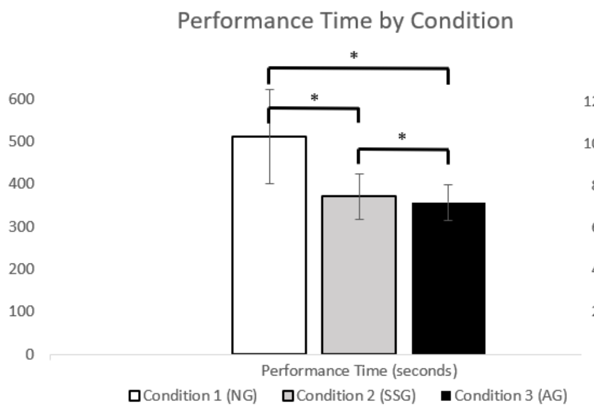

Figure 12a: Performance time by condition

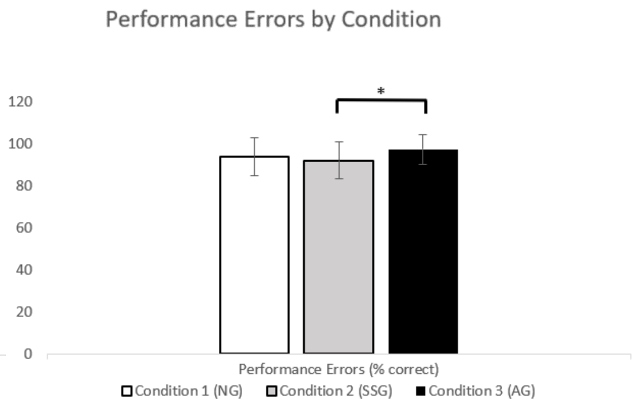

Figure 12b: Performance errors by condition

by condition. Thus, H2 is supported for performance time, but not for performance errors. Thus, H2 is partially supported.

Self-set goals lead to better performance, when compared to assigned goals (H3)

A Wilcoxon signed-rank test showed a significant difference for performance (time) between Conditions 2 (SSG) and 3 (AG) (r= -0.43, p< 0.01). Specifically, participants were quicker in Condition 3 (AG), which is contrary to H3.

In addition, time distance relative to the goal (time taken *minus* chosen/assigned goal) was analysed for Conditions 2 (SSG) and 3 (AG). In other words, the goal time (e.g. 6 minutes and 38 seconds) was subtracted from the time it took participants to complete the task, thus providing a task completion time relative to the goal. A negative score indicates that the participant was quicker than the goal. In the SSG condition, participants were on average 10.29 seconds faster than the goal they had chosen. In the assigned goal condition, participants were on average 41.81 seconds faster than the assigned goal. This difference between conditions is statistically significant (r= 0.90, p< 0.0001). These results are also contrary to H3. Figure 13 shows results relative to performance time relative to the goal.

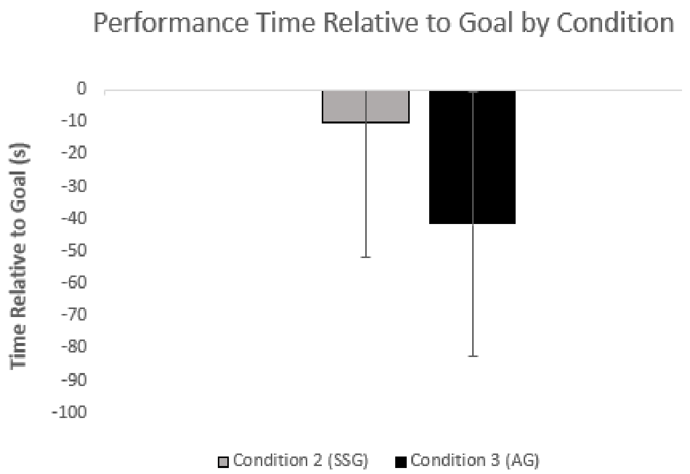

Figure 13: Performance time relative to goal by condition

A mixed Poisson regression model was used to compare performance errors between conditions. Results show a significant difference between Conditions 2 (SSG) and 3 (AG) (r= -0.75, p< 0.05). Specifically, participants made fewer errors in Condition 3 (AG) than in Condition 2 (SSG). Thus, overall results do not support H3.

Interview analyses revealed that 12 participants preferred Condition 2 (SSG), whereas nine participants preferred Condition 3 (AG). When segmenting participants based on condition preference, results showed that participants who preferred Condition 2 (SSG) had better performance (time) (r= 0.71, p< 0.05) in Condition 2. In terms of performance (errors), no difference was found (p= 0.83). In Condition 3 (AG), there were no significant differences in performance time (p=0.2469) or errors (p=0.85) between participants who preferred Condition 3 (AG) and those who preferred Condition 2 (SSG).

Self-set goals lead to more emotional engagement, when compared to assigned goals (H4a)

Explicit emotional engagement

A Wilcoxon signed-rank test showed no differences when comparing Conditions 2 (SSG) and 3 (AG) for valence ($p= 0.91$) and arousal ($p= 0.48$). Thus, H4a is not supported for explicit emotional engagement.

Implicit emotional engagement

When comparing Conditions 2 (SSG) and 3 (AG), results show a significant effect for HR ($d= -0.12$, $p< 0.001$), but no significant effect for SCL ($p= 0.19$). Results show no significant effect for frontal alpha asymmetry (valence) between Conditions 2 (SSG) and 3 (AG) ($p= 0.36$). In other words, Condition 3 (AG) generated higher HR (higher arousal) than Condition 2 (SSG). Thus, in general H4 is not supported for implicit emotional engagement.

Self-set goals lead to more cognitive engagement, when compared to assigned goals (H4b)

Explicit cognitive engagement

A Wilcoxon signed-rank test showed no difference between Conditions 2 (SSG) and Condition 3 (AG) ($p= 0.97$), thus not supporting H4b.

Implicit cognitive engagement

When looking at implicit cognitive engagement, a linear regression with mixed model showed no significant difference between Conditions 2 (SSG) and 3 (AG) ($p= 0.15$), thus not supporting H4b. However, when separating results by condition preference, a mixed linear regression model showed that participants who preferred Condition 2 (SSG) were more engaged in that condition than in Condition 3 (AG) ($d= 0.13$, $p< 0.05$).

Table 2 show a summary of the results grouped by hypothesis

Table 2: Summary of results grouped by hypothesis

Hypothesis Number	**Hypothesis name**	**Support**	**Variables in support**	**Variables not in support**
H1a	A gamified interface leads to higher emotional engagement	Generally supported	Valence (explicit), Arousal (explicit), SCL, and HR.	Frontal alpha Asymmetry
H1b	A gamified interface leads to higher cognitive engagement	Partially supported	Explicit cognitive engagement	Implicit cognitive engagement
H2	A gamified interface leads to better performance	Partially supported	Performance (time)	Performance (errors)
H3	Self-set goals lead to better performance, when compared to assigned goals	Not supported	-	Performance (time), Performance (errors)
H4a	Self-set goals lead to more emotional engagement, when compared to assigned goals	Not supported	-	Valence (explicit), Arousal (explicit), SCL, HR, and Frontal alpha asymmetry
H4b	Self-set goals lead to more cognitive engagement, when compared to assigned goals	Not supported	-	Explicit cognitive engagement and Implicit cognitive engagement

3.5 Discussion

Results show that gamification with either type of goal-setting (self-set or assigned) increases implicit and explicit emotional engagement (H1a), implicit and explicit cognitive engagement (H1b), as well as performance (time) (H2) when compared to no gamification. Post-experiment interview analyses further showed that participants were more engaged with a gamified interface. When comparing assigned-goal versus self-set-goal gamification, participants were significantly more performant (time and errors) (contrary to H3) when goals were assigned, rather than self-set. In other words, participants were quicker and made fewer errors when they were assigned a goal. In terms of engagement, participants had higher HR (higher arousal) (H4a) when goals were assigned, than when goals were self-set, indicating higher implicit emotional engagement. However, results show no differences in explicit emotional engagement, SCL (arousal), frontal alpha asymmetry (valence) and explicit and implicit cognitive engagement (H4b) goals are self-set versus assigned.

Goal-setting theory is useful in understanding why goals and feedback lead to better performance. First of all, goal-setting theory states that specific and clear goals lead to persistence to reach the goal, and optimal performance. In this experiment, goals were specific and clear because they consisted of a precise time (e.g., 6 minutes and 38 seconds). Therefore, theoretically, the goals lead to optimal performance. Secondly, the presence of constant goal progress feedback, through a timer right next to the goal time on the wearable device, encourages users to direct their attentional resources and effort towards the goal at hand, leading to better performance (Locke & Latham, 2002). These two factors (specific/clear goals and constant feedback) could have contributed to the observed effect that the gamified conditions led to better performance than the non-gamified condition.

Goal-setting theory also states that more difficult goals lead to better performance. The third self-set goal option (7 minutes and 38 seconds) is less difficult than the assigned goal (6 minutes and 38 seconds). If enough participants chose this particular self-set goal, the self-set goal condition could be less difficult than the assigned goal condition, thus explaining the difference in performance between conditions. However, only one participant selected that particular self-set goal option (7 minutes and 38 seconds). In fact, 14 participants selected the most difficult self-set goal (5 minutes and 38 seconds), while 6 chose the middle goal (6 minutes and 38 seconds). Therefore, the self-set goal condition could actually be considered more difficult. Alternatively, it is possible that external pressure to perform generated in the assigned goal condition led to more effort and persistence towards the assigned goal than the self-set goal. Both effort and persistence are mediators of the relationship between goals and performance.

When dividing participants into condition preference segments, it was found that participants who preferred self-set goals were more performant and more implicitly cognitively engaged in this condition. Interview analyses have brought to light interesting insight related to the motivational underpinnings of this preference. These participants reported feeling a sense of freedom of choice because they were able to choose their own goal. Participants felt as if the goal came from themselves, even though we offered three predetermined choices. This freedom of choice and feeling that the goal came from within conceptually coincide with one of the three drivers of intrinsic motivation stated in SDT: Autonomy. Participants also reported that choosing their own goal allowed them to adjust their goal based on how they performed (in terms of time) in the previous task(s) or based on how they were feeling in that moment. This freedom of goal adjustment could have led to participants feeling more competent, more confident in their ability to reach the chosen goal, therefore satisfying a second driver of intrinsic motivation: Competence. Theoretically, the intrinsic motivation generated from the satisfaction of these two psychological could increase job/motivational resources available to the employee, leading to a greater long-term potential for engagement and performance (Deci, 2017). This interpretation provides a motivational pathway by which gamification affects performance.

Participants who preferred the assigned goal condition did not perform better and were not more engaged in this condition. This result is interesting considering that the best performance, when looking at all participants, was achieved in this condition. Interview analyses were once again useful to gain motivational insight. Participants who preferred this condition said that they enjoyed and took this goal more seriously because it came from a "company" or an authority figure, whereas the self-set goal had less meaning to them. When examining the interview analyses for all 21 participants, it can be seen that this condition generated an external pressure to perform, which seemed to be effective: overall, participants performed better and had higher HR when the goal was assigned. However, this motivation is extrinsic, because it comes from an external source (pressure from authority figure). Extrinsic motivation has not been shown to generate long-term engagement, whereas intrinsic motivation has (Deci, 2017). It is also necessary to discuss the possible pervasive effects resulting from pressure to perform, namely exhaustion or burnout. The JD-R model's (Karasek, 1979) theoretical framework is a valuable tool to understand these pervasive effects, as well as the interaction and results of job resources and job demands. When job resources are sufficient to meet the job demands, an employee is more engaged and performant. However, when resources and insufficient, an employee is at risk for exhaustion, burnout and a plethora of adverse health effects resulting from these. The aforementioned increased external pressure resulting from assigned goals can lead to an imbalance in job-demands resources, in the sense that job demands would increase. Employees having an imposed, rather than a chosen goal, can further amplify this imbalance, by reducing job resources, through the decrease in autonomy, as stated in the JD-R model. With job demands increasing and job resources decreasing in the assigned goal condition, participants are more at risk for exhaustion and burnout over the long term.

In addition, arousal measured from heart rate is a well-documented measure of sympathetic nervous system activation, the same system activated in "fight or flight" situation or in any general stressful situations (Cacioppo et al., 2007). A higher HR is an indicator of sympathetic nervous system activation. Long-term sympathetic activation at high enough levels has been shown to negatively impact health (cardiovascular disease, mental health issues, etc.) (Fisher, Young, & Fadel, 2009). The assigned goal condition, generating a higher HR and thus more sympathetic activation, should be implemented with caution. Although assigned goals do lead to better performance, it would be wise to consider the possible ill effects of long-term implementation. Self-set goals can be seen as a more long-term solution because of the intrinsic motivation it generates, which increases job resources and therefore leads to a greater potential for engagement and performance at work.

4. Conclusion

This thesis' main objective was to determine whether implementing gamification into an employee interface could be a viable solution to increase employee engagement and performance. The two research questions were as follows:

1. Can the integration of gamification into an employee interface significantly increase employee engagement?
2. Can the integration of gamification into an employee interface significantly increase employee performance?

4.1 Main Results

Overall, this thesis' main hypothesis is supported; a gamified interface of any kind led to an increase in engagement and performance, thus providing evidence that gamification can indeed be an appropriate remedy for a lack of employee engagement and performance, at least on a short-term scale. From a theoretical standpoint, the integration of self-set goals and feedback game elements have the greatest potential to generate long-term intrinsic motivation, which leads to greater employee engagement and performance. Although the integration of assigned goal led to the best performance, it is clear within the motivation literature that the extrinsic motivation generated is not ideal for long-term employee engagement and performance. Although this experiment was restricted to a warehouse setting, the underlying motivational mechanisms at play in the presence of gamification elements can arguably be transposed to a variety of job domains involving a measurable performance metric (e.g. time, number of items, accuracy).

4.2 Contributions

Theoretical Contributions

This thesis presents a motivational pathway by which self-set goals and assigned goals affect engagement and performance. Simply put, the motivational resources generated from the satisfaction of SDT's three needs (autonomy, competence, relatedness) lead to an increase in intrinsic motivation, generating motivational resources, which translates to a greater potential for employee engagement and performance. This pathway can be useful to interpret results from future gamification studies.

In addition, there is no consensus in the literature when it comes to comparing self-set and assigned goals. Results for this study allow for this comparison in terms of the motivational mechanisms that affect engagement and performance. Self-set goals generate autonomy and competence, increasing intrinsic motivation, which leads to increased available motivational resources, thus increasing long-term employee engagement and performance. Assigned goals, on the other hand, decrease autonomy and generate extrinsic motivation external pressure, leading to a decrease in motivational resources and an increase in job demands, which does not lead to long-term employee engagement and performance.

Practical Contributions

Results from this study are particularly useful for employee retention. Many companies now understand that attracting and retaining talent are important for their success. Employee retention is associated with engagement. In other words, an engaged employee will be less likely to leave the company. Integrating self-set goals into an employee interface will lead to long-term engagement, and therefore better employee retention. Long-term employee engagement, as seen in the literature, can also lead to better less absenteeism, less employee mental health issue, less burnout, more company sales, better profitability, and better customer satisfaction.

When looking the integration of self-set goals and feedback into an employee interface, it can be said that it is a rather simple implementation: three goals to choose from and a timer to monitor goal progress. These two gamification elements can easily be implemented into a variety of interfaces, thus offering a rather simple solution to lack of employee engagement.

4.3 Methodological Contributions

The experiment in this thesis brought forward many challenges that had to be overcome before formal data collection could begin.

During the experiment conception phase, two outcome constructs were chosen (i.e. employee engagement/motivation and employee performance). Employee performance was straightforward: company key performance indicators (time and errors) were used. Employee motivation/engagement was much more difficult. At first, engagement and motivation were treated as the same construct. They may seem synonymous, but organisational psychology literature differentiates them. Motivation, specifically intrinsic motivation, is the antecedent of engagement. Motivation is a volatile concept, in the sense that it is very difficult to operationalise. However, engagement has been successfully operationalised by various researchers. The challenge here was to integrate operationalisations of sub-types of engagement (emotional, cognitive, and behavioural) and various operationalisations of types of measurement (implicit and explicit). This led to 4 constructs (implicit emotional engagement, explicit emotional engagement, implicit cognitive engagement, and explicit cognitive engagement), each with their own validated way of being measured.

The experimental layout was another challenge. A realistic simulated warehouse had to be set up in our laboratory. This simulated warehouse had to allow for order picking to be feasible. After viewing hours of footage provided by JDA about the layout of a real warehouse and how picking tasks were performed, 5 bookshelves were placed in the room in a way that would make participant move around in a non-linear fashion, like in a real warehouse. On each of the bookshelves, 20 white bins, separated onto 4 shelves, were placed. Each bin had its own unique identifier (e.g. A03002 (bookshelf A, row 3, column 2)). Each bin was filled with various office supplies. Then, 3 equally-complex realistic picking tasks (one for each condition) were created. An example of one of the picks that can be included in the tasks is: 12 blue paper clips from bin A03002. The exact details of each pick within each task was then given to JDA, which then integrated them into the wearable WMS. After over a month of troubleshooting and refining, the WMS and simulated warehouse were operational. At that point warehouse management experts from JDA were brought in to validate that both the experimental layout and stimuli were as close to reality as possible. The experimental layout and a brief overview of the experimental task are shown in the video in Appendix 1.

The next challenge involved testing all the tools used. Pretests were essential for this study as they allowed for the diagnosis of problems before the formal data collection. During the pretests, ECG and EKG data collections worked seamlessly. Teamviewer, used to record the WMS's screen, had no problem. Synchronisation of EEG, ECG, EKG, and webcam feed data worked well. However, problems arose when testing Media Recorder, which is used to simultaneously record video feeds from 4 webcams. After much troubleshooting, it was determined that the computer did not have enough random-access memory (RAM) to concurrently record 4 webcam feeds. RAM was added and this solved the issue. Another problem arose when evaluating EEG data quality. More precisely, when participants bent their head downwards, the signal was lost. Pretests determined that this could be avoided by not using the bottommost shelf of the bookshelves, and by instructing participants to bend their legs (squat), not their backs, when reaching for a low item.

A final challenge was the cleanup of the EEG data. As participants were moving around during the study, noise had to be removed from the data. First attempts at data cleaning resulting in a loss of too much data. After trying multiple methods of data cleaning, one particular method resulted in little loss of data after cleanup. This method involved loading electrode position from a file, applying and IIR filter, changing the sampling rate, and exporting data to Matlab for cleanup.

4.4 Limitations and Future Research

This thesis is not without limitations. The main limitation is that engagement and performance are measured on the short-term. It is therefore difficult to extrapolate these results for long-term engagement and performance. Another limitation is that not all the mediators and moderators of the relationship between goals and performance were measured (Locke & Latham, 2002; Tondello et al., 2018). Measuring the mediators and moderators would lead to an empirical framework for designing and testing gamified systems, which has value for theory and practice. A final limitation is that the only two of three facilitators of intrinsic motivation have been addressed, as per SDT. Relatedness was not taken into account in the WMS used in this experiment. Future experiments should integrate the concept of relatedness into an interface, possibly through a gamification element such as a team chat. We also suggest that the findings of this thesis be tested in different domains or in a real workspace over a long period of time, to see the long-term effect of these gamification elements on engagement and performance. Other research avenues include testing the effects of different gamification elements (e.g., points, achievements, avatar, narrative) on performance and engagement.

4.5 Final Thoughts

All in all, employee engagement is worth exploring, as it is not only related to company and employee performance, but also employee well-being. This thesis found that a simple yet practical solution, the integration of gamification elements into an employee's interface, leads to better engagement and performance, at least in the short term. This thesis also examined possible motivational mechanisms by which gamification elements affect engagement and performance. Ultimately, we hope to stimulate future research related the optimisation of long-term employee engagement and performance through technological interaction.

References

Alderfer, C. P. (1972). Existence, relatedness, and growth: Human needs in organizational settings.

Allen, F. E. (2011). Disneyland Uses' Electronic Whip'on Employees. *Internet.(21 October 2011). Retrieved January, 8*, 2016.

Arrabito, G. R., Ho, G., Aghaei, B., Burns, C., & Hou, M. (2011). *Effects of vibrotactile stimulation for sustaining performance in a vigilance task: a pilot study.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.

Associates, M. (2017). Is There a Warehouse Employee Engagement Crisis Coming? . Retrieved from https://www.manh.com/resources/articles/2017/05/18/is-there-warehouse-employee-engagement-crisis-coming

Bakker, A. B., Demerouti, E., Taris, T. W., Schaufeli, W. B., & Schreurs, P. J. G. (2003). A multigroup analysis of the job demands-resources model in four home care organizations. *International Journal of Stress Management, 10*(1), 16-38. doi:10.1037/1072-5245.10.1.16

Bartholdi, J. J., & Hackman, S. T. (2017). *Warehouse & Distribution Science: Release 0.98*. Atlanta, GA, USA: The Supply Chain and Logistics Institute.

Betella, A., & Verschure, P. F. M. J. (2016). The Affective Slider: A Digital Self-Assessment Scale for the Measurement of Human Emotions. *PLoS One, 11*(2), e0148037. doi:10.1371/journal.pone.0148037

Boucsein, W. (2012). *Electrodermal activity*: Springer Science & Business Media.

Cacioppo, J. T., Tassinary, L. G., & Berntson, G. (2007). *Handbook of psychophysiology*: Cambridge University Press.

Chackelson, C., Errasti, A., & Tanco, M. (2012). A World Class Order Picking Methodology: An Empirical Validation. In *Advances in Production Management Systems. Value Networks: Innovation, Technologies, and Management* (pp. 27-36): Springer Berlin Heidelberg.

Chaouachi, M., Pierre, C., Jraidi, I., & Frasson, C. (2010). *Affect and mental engagement: Towards adaptability for intelligent.* Paper presented at the Twenty-Third International FLAIRS Conference.

Charland, P., Leger, P. M., Senecal, S., Courtemanche, F., Mercier, J., Skelling, Y., & Labonte-Lemoyne, E. (2015). Assessing the Multiple Dimensions of Engagement to Characterize Learning: A Neurophysiological Perspective. *J Vis Exp*(101), e52627. doi:10.3791/52627

Connell, J. P., & Wellborn, J. G. (1991). Competence, autonomy, and relatedness: A motivational analysis of self-system processes.

Courtemanche, F., Labonté-LeMoyne, É., Léger, P.-M., Fredette, M., Senecal, S., Cameron, A.-F., . . . Bellavance, F. (2019). Testing while Waking: An Expensive Switch Cost. *Accident Analysis & Prevention*.

Davidson, R. J. (2004). What does the prefrontal cortex “do” in affect: perspectives on frontal EEG asymmetry research. *Biological psychology, 67*(1-2), 219-234.

de Guinea, A. O., Titah, R., & Léger, P.-M. (2014). Explicit and Implicit Antecedents of Users' Behavioral Beliefs in Information Systems: A Neuropsychological Investigation. *Journal of Management Information Systems, 30*(4), 179-210. doi:10.2753/mis0742-1222300407

Deci, E. L. (2017). Self-Determination Theory in Work Organizations: The State of a Science. doi:10.1146/annurev-orgpsych-032516-113108

Deci, E. L., & Ryan, R. M. (1980). Self-determination theory: When mind mediates behavior. *The Journal of Mind and Behavior*, 33-43.

Demerouti, E., Bakker, A. B., Nachreiner, F., & Schaufeli, W. B. (2001). The job demands-resources model of burnout. *Journal of applied psychology, 86*(3), 499-512. doi:10.1037//0021-9010.86.3.499

Denny, P., McDonald, F., Empson, R., Kelly, P., & Petersen, A. (2018). *Empirical Support for a Causal Relationship Between Gamification and Learning Outcomes*. Paper presented at the Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18. http://dx.doi.org/10.1145/3173574.3173885

Deterding, S. (2015). The Lens of Intrinsic Skill Atoms: A Method for Gameful Design. *Human–Computer Interaction, 30*(3-4), 294-335. doi:10.1080/07370024.2014.993471

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). *From game design elements to gamefulness*. Paper presented at the Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments - MindTrek '11. http://dx.doi.org/10.1145/2181037.2181040

Deterding, S., Khaled, R., Nacke, L. E., & Dixon, D. (2011). *Gamification: Toward a definition.* Paper presented at the CHI 2011 gamification workshop proceedings.

Erez, M., & Arad, R. (1986). Participative goal-setting: Social, motivational, and cognitive factors. *Journal of applied psychology, 71*(4), 591.

Errasti, A. (2011). *Logística de almacenaje: Diseño y gestión de almacenes y plataformas logísticas world class warehousing*: Pirámide.

Fisher, J. P., Young, C. N., & Fadel, P. J. (2009). Central sympathetic overactivity: maladies and mechanisms. *Autonomic Neuroscience, 148*(1-2), 5-15.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School Engagement: Potential of the Concept, State of the Evidence. *Review of educational research, 74*(1), 59-109. doi:10.3102/00346543074001059

Freeman, F. G., Mikulka, P. J., Scerbo, M. W., & Scott, L. (2004). An evaluation of an adaptive automation system using a cognitive vigilance task. *Biological psychology, 67*(3), 283-297.

Gagné, M. (2014). *The Oxford handbook of work engagement, motivation, and self-determination theory*: Oxford Library of Psychology.

Goffman, E. (1961). Stigma: The presentation of self in everyday life. In: London: Penguin.

Gollwitzer, P. M., & Moskowitz, G. B. (1996). *Goal effects on action and cognition*.

Harkins, S. G., & Lowe, M. D. (2000). The Effects of Self-Set Goals on Task Performance. *Journal of Applied Social Psychology, 30*(1), 1-40. doi:10.1111/j.1559-1816.2000.tb02303.x

Harter, J. K., Schmidt, F. L., Agrawal, S., Plowman, S. K., & Blue, A. (2016). The relationship between engagement at work and organizational outcomes. *Gallup Poll Consulting University Press, Washington*.

Harter, J. K., Schmidt, F. L., & Hayes, T. L. (2002). Business-unit-level relationship between employee satisfaction, employee engagement, and business outcomes: A meta-analysis. *Journal of applied psychology, 87*(2), 268.

Huotari, K., & Hamari, J. (2016). A definition for gamification: anchoring gamification in the service marketing literature. *Electronic Markets, 27*(1), 21-31. doi:10.1007/s12525-015-0212-z

Kahn, W. A. (1990). Psychological conditions of personal engagement and disengagement at work. *Academy of management journal, 33*(4), 692-724.

Kanfer, R., & Ackerman, P. L. (1989). Motivation and cognitive abilities: An integrative/aptitude-treatment interaction approach to skill acquisition. *Journal of applied psychology, 74*(4), 657.

Karasek, R. A. (1979). Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign. *Administrative Science Quarterly, 24*(2), 285. doi:10.2307/2392498

Karoly, P. (1993). Mechanisms of self-regulation: A systems view. *Annual review of psychology, 44*(1), 23-52.

Klein, H. J., Wesson, M. J., Hollenbeck, J. R., Wright, P. M., & DeShon, R. P. (2001). The assessment of goal commitment: A measurement model meta-analysis. *Organizational behavior and human decision processes, 85*(1), 32-55.

Klevers, M., Sailer, M., & Günthner, W. A. (2016, 2016//). *Implementation Model for the Gamification of Business Processes: A Study from the Field of Material Handling.* Paper presented at the Simulation and Gaming in the Network Society, Singapore.

Koivisto, J., & Hamari, J. (2017). The Rise of Motivational Information Systems: A Review of Gamification Research. *SSRN Electronic Journal*. doi:10.2139/ssrn.3226221

Landers, R. N., Bauer, K. N., & Callan, R. C. (2017). Gamification of task performance with leaderboards: A goal setting experiment. *Computers in Human Behavior, 71*, 508-515. doi:10.1016/j.chb.2015.08.008

Lang, P. J. (1995). The emotion probe: studies of motivation and attention. *American Psychologist, 50*(5), 372.

Léger, P.-M., Sénecal, S., Courtemanche, F., de Guinea, A. O., Titah, R., Fredette, M., & Labonte-LeMoyne, É. (2014). Precision is in the Eye of the Beholder: Application of Eye Fixation-Related Potentials to Information Systems Research. *J. AIS, 15*(10), 3.

Li, X., Hsieh, J. J. P.-A., & Rai, A. (2013). Motivational Differences Across Post-Acceptance Information System Usage Behaviors: An Investigation in the Business Intelligence Systems Context. *Information Systems Research, 24*(3), 659-682. doi:10.1287/isre.1120.0456

Liu, D., Santhanam, R., & Webster, J. (2017). Toward Meaningful Engagement: A Framework for Design and Research of Gamified Information Systems. *MIS quarterly, 41*(4).

Locke, E. A. (1968). Toward a theory of task motivation and incentives. *Organizational behavior and human performance, 3*(2), 157-189.

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist, 57*(9), 705-717. doi:10.1037//0003-066x.57.9.705

Locke, E. A., & Latham, G. P. (2006). New Directions in Goal-Setting Theory. *Current Directions in Psychological Science, 15*(5), 265-268. doi:10.1111/j.1467-8721.2006.00449.x

Locke, E. A., Latham, G. P., & Erez, M. (1988). The determinants of goal commitment. *Academy of management review, 13*(1), 23-39.

Mann, A., & Harter, J. (2016). The worldwide employee engagement crisis. *Gallup Business Journal, 7.*

Maslach, C., Schaufeli, W. B., & Leiter, M. P. (2001). Job burnout. *Annual review of psychology, 52*(1), 397-422.

Maslow, A. (1970). Motivation and Personality. 2nd.(ed.) Harper and Row. *New York.*

Mehta, D., & Mehta, N. K. (2013). Employee engagement: A literature review. *Economia. Seria Management, 16*(2), 208-215.

Mora, A., Riera, D., Gonzalez, C., & Arnedo-Moreno, J. (2015). *A Literature Review of Gamification Design Frameworks*. Paper presented at the 2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games).

Moradian, A., Nasir, M., Lyons, K., Leung, R., & Sim, S. E. (2014). *Gamification of collaborative idea generation and convergence*. Paper presented at the Proceedings of the extended abstracts of the 32nd annual ACM conference on Human factors in computing systems - CHI EA '14. http://dx.doi.org/10.1145/2559206.2581253

Müller-Putz, G. R., Riedl, R., & Wriessnegger, S. C. (2015). Electroencephalography (EEG) as a Research Tool in the Information Systems Discipline: Foundations, Measurement, and Applications. *CAIS, 37*, 46.

Nacke, L. E., & Deterding, S. (2017). The maturing of gamification research. *Computers in Human Behavior, 71*, 450-454. doi:10.1016/j.chb.2016.11.062

Palacin-Silva, M. V., Knutas, A., Ferrario, M. A., Porras, J., Ikonen, J., & Chea, C. (2018). *The Role of Gamification in Participatory Environmental Sensing*. Paper presented at the Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18. http://dx.doi.org/10.1145/3173574.3173795

Passalacqua, M., Léger, P.-M., Sénécal, S., Fredette, M., Nacke, L. E., Lin, X., . . . Caprioli, T. (2019). The Impact of Using a Gamified Interface on Engagement in a Warehousing Management Task: A NeuroIS Research Proposal. In *Information Systems and Neuroscience* (pp. 187-194): Springer.

Pope, A. T., Bogart, E. H., & Bartolome, D. S. (1995). Biocybernetic system evaluates indices of operator engagement in automated task. *Biological psychology, 40*(1-2), 187-195.

Quaedflieg, C. W., Smulders, F. T., Meyer, T., Peeters, F., Merckelbach, H., & Smeets, T. (2015). The validity of individual frontal alpha asymmetry EEG neurofeedback. *Social cognitive and affective neuroscience, 11*(1), 33-43.

Ramaa, A., Subramanya, K., & Rangaswamy, T. (2012). Impact of warehouse management system in a supply chain. *International Journal of Computer Applications, 54*(1).

Riedl, R., Fischer, T., & Léger, P.-M. (2017). A decade of NeuroIS research: status quo, challenges, and future directions.

Riedl, R., & Léger, P.-M. (2016). Fundamentals of NeuroIS. *Studies in Neuroscience, Psychology and Behavioral Economics. Springer, Berlin, Heidelberg*.

Rodríguez-Sánchez, A. M., Schaufeli, W., Salanova, M., Cifre, E., & Sonnenschein, M. (2011). Enjoyment and absorption: An electronic diary study on daily flow patterns. *Work & Stress, 25*(1), 75-92. doi:10.1080/02678373.2011.565619

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motivation and Emotion, 30*(4), 344-360. doi:10.1007/s11031-006-9051-8

Santhanam, R., Liu, D., & Shen, W.-C. M. (2016). Research Note—Gamification of technology-mediated training: Not all competitions are the same. *Information Systems Research, 27*(2), 453-465.

Scerbo, M. W., Freeman, F. G., & Mikulka, P. J. (2003). A brain-based system for adaptive automation. *Theoretical Issues in Ergonomics Science, 4*(1-2), 200-219.

Schaufeli, W. B., Bakker, A. B., & Salanova, M. (2006). *Utrecht Work Engagement Scale-9*. Retrieved from: http://dx.doi.org/10.1037/t05561-000

Schaufeli, W. B., Salanova, M., González-Romá, V., & Bakker, A. B. (2002). The measurement of engagement and burnout: A two sample confirmatory factor analytic approach. *Journal of Happiness studies, 3*(1), 71-92.

Schuck, M. B., & Wollard, K. K. (2013). A historical perspective of employee engagement: An emerging definition.

Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies, 74*, 14-31. doi:https://doi.org/10.1016/j.ijhcs.2014.09.006

Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of educational psychology, 85*(4), 571.

Small, A. A. (2010). *Gamification as a Means of Improving Performance in Human Operator Processes*.

Tabor, A., Bateman, S., Scheme, E., Flatla, D. R., & Gerling, K. (2017). *Designing Game-Based Myoelectric Prosthesis Training*. Paper presented at the Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17. http://dx.doi.org/10.1145/3025453.3025676

Tomaselli, F., Sanchez, O., & Brown, S. (2015). How to engage users through gamification: the prevalent effects of playing and mastering over competing.

Tondello, G., Kappen, D. L., Mekler, E. D., Ganaba, M., & Nacke, L. E. (2016). *Heuristic evaluation for gameful design.* Paper presented at the Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts.

Tondello, G., Premsukh, H., & Nacke, L. (2018). *A Theory of Gamification Principles Through Goal-Setting Theory*. Paper presented at the Proceedings of the 51st Hawaii International Conference on System Sciences. http://dx.doi.org/10.24251/hicss.2018.140

Truss, C., Shantz, A., Soane, E., Alfes, K., & Delbridge, R. (2013). Employee engagement, organisational performance and individual well-being: exploring the evidence, developing the theory. In: Taylor & Francis.

Van den Broeck, A., Vansteenkiste, M., De Witte, H., & Lens, W. (2008). Explaining the relationships between job characteristics, burnout, and engagement: The role of basic psychological need satisfaction. *Work & Stress, 22*(3), 277-294. doi:10.1080/02678370802393672

Warmelink, H., Koivisto, J., Mayer, I., Vesa, M., & Hamari, J. (2018). Gamification of the work floor: A literature review of gamifying production and logistics operations.

Wu, J., & Liu, D. (2007). The effects of trust and enjoyment on intention to play online games. *Journal of electronic commerce research, 8*(2).

Zhao, Z., Arya, A., Whitehead, A., Chan, G., & Etemad, S. A. (2017). *Keeping Users Engaged through Feature Updates*. Paper presented at the Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17. http://dx.doi.org/10.1145/3025453.3025982

Appendix

Appendix 1: Video showing overview of experimental setup and procedure

https://youtu.be/30cKT3ZUJ7I

Appendix 2: Variable means and standard deviations, by condition

Variables	Condition 1 (NG)		Condition 2 (SSG)		Condition 3 (AG)	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Valence (explicit)	52.95	22.18	65.19	22.02	64.76	21.71
Arousal (explicit)	52.90	23.60	70.57	19.96	72.71	19.47
Skin Conductance Level (arousal)	0.01	0.48	0.08	0.50	0.05	0.43
Heart Rate (arousal)	0.03	0.35	0.11	0.38	0.13	0.38
Frontal Alpha Asymmetry (valence)	-1.28	2.08	-1.38	2.07	-1.34	2.09
Explicit Cognitive Engagement	4.14	1.31	5.00	1.34	4.95	1.28
Implicit Cognitive Engagement	0.74	0.43	0.78	0.45	0.75	0.46
Performance Time (seconds)	511.33	109.62	370.57	53.86	356.19	40.97
Performance Errors (% correct)	93.73	8.94	91.96	8.67	97.35	7.03