EXPLICATION OF SOCIAL CUES ON PERSUASIVE ROBOTS FOR MENTAL HEALTH SUPPORT AMONG MALAYSIAN YOUTH

BY

MUHAMMAD HARIZ BIN HAFIZALSHAH

A thesis submitted in fulfillment of the requirement for the degree of Master of Science in Engineering

Kulliyyah of Engineering
International Islamic University Malaysia

JUNE 2024

ABSTRACT

Many people with mental health issues suffer from stress, which eventually can lead to depression if no intervention steps are taken. Physical activities such as exercise and sports are the most common advice given by therapists to remedy the issue due to their effectiveness. However, the lack of motivation and mismanaged priorities in daily life has hindered many from getting the benefits of a healthy routine. Social robots have been shown to be a great assistive tool to encourage a healthier lifestyle. However, social cues are typically not the focus of studies involving the use of social robots despite evidence suggesting their impact. To help solve these issues, the current research aims to design effective social cues for persuasive robots in motivating and persuading Malaysian youth to do make healthier choices to reduce the risk of mental health problems, specifically stress. This research investigates the influence of language coerciveness and social praises (as social cues) of persuasive robots on social responses by Malaysian youths. Sixty participants were randomly assigned to four separate groups and were asked to play a decision-making game related to exercise. A social robot employing high or low controlling language and with or without social praises were assigned to each of the four groups, depending on the assigned social cues modality (high controlling language with social praise, low controlling language without social praise, etc.). An analysis was conducted and discussed on the perceived social responses, correlations between responses and compliance. The findings suggest that the applied social cues have no effect on compliance with the robot's suggestions. Using statistical analysis, the results demonstrated significant, strong correlations between several social responses, including liking and beliefs. Additionally, a robot with high-controlling language without any social praise was perceived as useful in making decisions. Overall, regardless of the social cues used by the robots, Malaysian youth perceived the robot positively in making persuasive decisions in terms of liking, trusting beliefs, and the intention to use the robot again in the future. This study is crucial to support people in having a better quality of life assisted by social robots, and importantly, to help prevent the occurrence of serious mental illness that can lead to depression.

ملخص البحث

كثير من الأشخاص الذين يعانون من قضايا الصحة العقلية يعانون من التوتر، والذي في النهاية يمكن أن يؤدي إلى الاكتئاب إذا لم يتخذ خطوات تدخلية .الأنشطة البدنية مثل التمارين الرياضية هي النصيحة الأكثر شيوعًا التي يقدمها المعالجون لعلاج هذه المشكلة بسبب فعاليتها .ومع ذلك، فإن نقص التحفيز وسوء إدارة الأولويات في الحياة اليومية قد عرقل الكثيرين من الاستفادة من فوائد روتين صحي .لقد ثبت أن الروبوتات الاجتماعية هي أداة مساعدة رائعة لتشجيع أسلوب حياة أكثر صحة .ومع ذلك، فإن الإشارات الاجتماعية عادة لا تكون محور الدراسات التي تتضمن استخدام الروبوتات الاجتماعية على الرغم من الأدلة التي تشير إلى تأثيرها .للمساعدة في حل هذه المشكلات، يهدف هذا البحث إلى تصميم إشارات اجتماعية فعالة للروبوتات المقنعة في تحفيز وإقناع الشباب الماليزيين لاتخاذ خيارات أكثر صحة لتقليل مخاطر مشاكل الصحة العقلية، وخاصة التوتر .يهدف هذا البحث إلى استكشاف تأثير قوة اللغة والثناء الاجتماعي)كإشارات اجتماعية (للروبوتات المقنعة على الردود الاجتماعية من قبل الشباب الماليزيين .تم تعيين ستين مشاركاً بشكل عشوائي إلى أربع مجموعات منفصلة وطُلب منهم اللعب في لعبة اتخاذ القرار المتعلقة بالرياضة .تم تعيين روبوت اجتماعي يستخدم لغة تحكم عالية أو منخفضة ومع أو بدون ثناء اجتماعي لكل من الأربع مجموعات، اعتمادًا على نوعية الإشارات الاجتماعية المخصصة)لغة تحكم عالية مع ثناء اجتماعي، لغة تحكم منخفضة بدون ثناء اجتماعي، وما إلى ذلك .(تم إجراء تحليل ومناقشة حول الردود الاجتماعية المتصورة، والعلاقات المتبادلة بين الردود والامتثال .تشير النتائج إلى أن الإشارات الاجتماعية المطبقة ليس لها تأثير على الامتثال لاقتراحات

الروبوت .باستخدام التحليل الإحصائي، أظهرت النتائج ارتباطات قوية وهامة بين العديد من الردود الاجتماعية، بما في ذلك الإعجاب والمعتقدات .بالإضافة إلى ذلك، اعتبر الروبوت الذي استخدم لغة تحكم عالية دون أي ثناء اجتماعي كمفيد في اتخاذ القرارات .بشكل عام، وبغض النظر عن الإشارات الاجتماعية المستخدمة من قبل الروبوتات، فإن الشباب الماليزيين اعتبروا الروبوت إيجابيًا في اتخاذ قرارات مقنعة من حيث الإعجاب والثقة والنية في استخدام الروبوت مرة أخرى في المستقبل .فإن هذه الدراسة حاسمة لدعم الناس في الحصول على نوعية حياة أفضل بمساعدة الروبوتات الاجتماعية، وبشكل هام، للمساهمة في منع حدوث .أمراض عقلية خطيرة يمكن أن تؤدي إلى الاكتئاب

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Engineering

....
Aimi Shazwani Ghazali
Supervisor

....
Shahrul Na'im Sidek
Co-Supervisor

....
Hazlina Bt. Md. Yusof
Co-Supervisor

....
Jaap Ham
Co-Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Engineering

………………………………

Muhammad Afif Bin Husman
Examiner

………………………………

Mohammad Faidzul Bin Nasrudin
External Examiner

This thesis was submitted to the Department of Mechatronics and is accepted as a fulfilment of the requirement for the degree of Master of Science in Engineering

………………………………

Ali Sophian
Head, Department of Mechatronics

This thesis was submitted to the Kulliyyah of Engineering and is accepted as a fulfillment of the requirement for the degree of Master of Science in Engineering

………………………………

Khairul Azami Sidek
Dean, Kulliyyah of Engineering

DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Muhammad Hariz Bin Hafizalshah

Signature………………………………… Date……………………… June 5th 2024

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

DECLARATION OF COPYRIGHT AND AFFIRMATION OF FAIR USE OF UNPUBLISHED RESEARCH

EXPLICATION OF SOCIAL CUES ON PERSUASIVE ROBOTS FOR MENTAL HEALTH SUPPORT AMONG MALAYSIAN YOUTH

I declare that the copyright holder of this thesis/dissertation is Muhammad Hariz Bin Hafizalshah.

No part of this unpublished research may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without prior written permission of the copyright holder except as provided below

1. Any material contained in or derived from this unpublished research may only be used by others in their writing with due acknowledgement.

2. IIUM or its library will have the right to make and transmit copies (print or electronic) for institutional and academic purpose.

3. The IIUM library will have the right to make, store in a retrieval system and supply copies of this unpublished research if requested by other universities and research libraries.

By signing this form, I acknowledged that I have read and understand the IIUM Intellectual Property Right and Commercialization policy.

Affirmed by Muhammad Hariz Bin Hafizalshah

………………………………	June 5th 2024 …………………..
Signature	Date

This thesis is dedicated to those that have supported me mentally, spiritually, and financially, for completing this work would not be within the realm of possibility without them.

ACKNOWLEDGEMENTS

All glory is due to Allah, the Almighty, whose Grace and Mercies have been with me throughout the duration of my program. Although, it has been tasking, His Mercies and Blessings on me ease the herculean task of completing this thesis.

I am most indebted to my supervisor, Dr Aimi, whose enduring disposition, kindness, promptitude, thoroughness and friendship have facilitated the successful completion of my work. I put on record and appreciate her detailed comments, useful suggestions and inspiring queries which have considerably improved this thesis. Her brilliant grasp of the aim and content of this work led to her insightful comments, suggestions and queries which helped me a great deal. Despite her commitments, she took time to listen and attend to me whenever requested. The moral support she extended to me is in no doubt a boost that helped in building and writing thedraft of this research work. I am also grateful to my co-supervisors, Prof. Dr. Naim, Assoc. Prof. Dr. Hazlina Bt. Md. Yusof and Assoc. Prof. Dr. Jaap Ham whose support and cooperation contributed to the outcome of this work.

Lastly, my gratitude goes to my beloved family; for their prayers, understanding and endurance while away.

Once again, we glorify Allah for His endless mercy on us one of which is enabling me to successfully round off the efforts of writing this thesis. Alhamdulillah.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

Mental health issues have become a significant concern in today's society, impacting the lives of individuals across various age groups, backgrounds, and cultures. The concern regarding the treatment of mental health was adopted relatively late in human history, especially considering the costly outcomes that severe cases may bear (Robinson et. al., 2013; Brådvik, 2018). Before mental health issues were even acknowledged, many that were exhibiting symptoms were woefully disregarded or discriminated against resulting in the culmination of the stigma that persisted for much of human history. Consequently, those afflicted by such ailments were further distanced from resolving the issue and the increase in negative cognitions of their surroundings lead to isolation which exacerbated the matter.

Largely due to the collaboration of human effort, this stigma has been subdued in major regions around the world (Bischoff, Springer, and Taylor, 2016). The recognition and understanding of mental health problems have increased, leading to a growing focus on developing effective interventions and support systems. Also, much progress has been made in the attempt to gain a better comprehension of the matter in recent decades in approaches to the understanding of human cognitive emotions in relation to depression. Adverse living experiences may culminate through stress which may worsen resulting in lesser feelings of content when doing daily habitual activities (LeMoult and Gotlib, 2019). The same effects can be observed for those that are under duress from long working hours, specifically resulting in stress, depression and suicide ideations (Park et. al., 2009).

Several programs for mental health support and awareness such as community events and assessments have been established and are actively run by a designated government body in Malaysia (MIASA, n.d.). The services offered include counseling, assessments, psychological support and other programs to assist those in need. Most of the available programs are offered both online and on-site, which further permits accessibility. International institutions also offer resources such as toolkits on how one may strive to improve themselves from dire situations (MHM, n.d.)

Despite progress in recent years, there remains a pressing need for a deeper understanding of mental health issues and the development of comprehensive approaches to address them. A recent study showed that feelings of stress have been shown to be alleviated through engaging in physical activities such as exercise and sports through the promotion of arousal reappraisal techniques (Jacquart et. al., 2020). Hachenberger et. al. (2023) further contributes to this statement through the effects of undergoing light physical activities yields feelings of less stress. Caplin et. al. (2021) accentuates previously established effects of the reduction of stress hormones, specifically through exercise.

Technology plays an increasingly prominent role in supporting individuals experiencing mental health issues. In line with that, this study proposes an approach towards encouraging Malaysian youths to participate in physical activities as a means of a mental health support system through the use of an automated, programmable social robot. The employment of a social robot would allow for the implementation of an effective social agent capable of accommodating a vast variety of social interactivity to aid in offering mental health support. Accessibility is a clear benefit achievable through the utilization of the mental health support system in this manner as the accompaniment of a social robot unrestrained by the typical personnel-based administered counsel allows for more people to potentially seek assistance. In other words, the applied system would be of better availability and convenience than current means. A well-developed social robot with a robust deployment system would also serve to offer support in a more consistent fashion in addition to making the system available in especially rural locations.

Conceptually, a robot that is programmed with the directive to encourage people to comply and commit their time and energy to doing strenuous activities would need to exercise some form of persuasive capability. To clarity, persuasion is described as an applied effect of leveraging among available options (Perloff, 2020). The persuasive effects enacted by the social robot, however, may conceive contracting effects from the receiving participants. In other words, one may react negatively or positively to the persuasive attempts conveyed by the social robot (Alam, 2021). Plainly stated, those who are experiencing a positive interaction by engaging with a social robot are more likely to form a connection with the robot and comply with the robot's suggestion. Social cues in particular have been shown to carry a significant impact on the persuasive power of persuasive technology (Voorveld and Araujo, 2020). Other social cues perused by robots such as facial expressions and gaze direction have also been shown to have an effect towards the engaged conversation partner, as seen in a study in manifested robot personality (Paradeda, Martinho and Paiva, 2020).

Social cues, defined as either verbal or non-verbal expressions during communication play a crucial role in human-human interactions, enabling individuals to interpret and exhibit emotions, intentions, and subtle nuances to convey their perception at specific moments (Adams, Albohn and Kveraga, 2017). Extending this understanding to human-robot interactions (HRI), which are denoted as the manner in which humans and robot communicates with one another (Sheridan, 2016), becomes vital in developing persuasive robots capable of empathetic and persuasive communication. By incorporating social cues into the design and behavior of these robots, researchers and developers can enhance user engagement, establish trust, and foster a more conducive environment for mental health support (Rasouli et. al., 2022). Expressions artificially communicated by the robot such as smiling which is an example of a social cue would likely incur a positive response as opposed to the robot producing a frowning expression. Social acceptability is a concept to which one may consider the extent they would find a particular entity is appropriate to be communicated with.

The robot's capacity to construct a desirable level of social acceptability and be engaging is considered a positive experience (Niemelä and Melkas, 2019). Conversely, the implications of triggering feelings such as anxiety and distrust result in a negative experience towards the participant, should the robot ineffectively wield the appropriate social cues (Nomura et. al., 2019). Aesthetical properties of the social robot are properties that affect how one perceives the impressions given off by the robot. Robots lacking in sociability and anthropomorphic properties cause those interacting with the robot to feel like the robot is evoking a sense of untrustworthiness (Liaw, Driver, and Fraune, 2019). Those suffering from mental health issues tend to distance themselves from others and the lack of self-agency to resolve the issue. Persuasive attempts that result in the invocation of feelings of anger and negative cognitions are described as psychological reactance (Dillard and Shen, 2005). Poorly communicated social cues may produce the effects of psychological reactance. Consequently, persuasive attempts may prove to be worthless as the feelings of aversion towards the robot diminish any persuasive potency delivered by the social robot. The worst possible case would be the effect in which the participants would socially disengage from interacting with the robot or outright dismiss the persuasive attempts entirely due to feelings of distrust (Alam et. al., 2021). It is critical for the notion of social robots to be perceived as support to those in need. While the efficacy of social robots as assistive tools has been extensively researched such as the study done by Inoue, Wada, and Shibata (2021) and Crossman, Kazdin, and Kitt (2018), explicit use of social cues by robots are generally applied as an inconsequential variable. This study shifts the focus towards the use of social cues by robots and its effects on HRI.

An approach on the topic of the procurement and design of persuasive robots utilizing social cues to effectively persuade Malaysian youth into doing physical activity-based actions to alleviate feelings of stress while attaining a positive perception was explored and researched through this study. Traditional research methods often rely on self-report measures or simulated stress-inducing scenarios, which may not capture the intricacies and nuances of real-world stressors (Checa and Bustillo, 2020). For this study, a decision-making serious game with the theme of exercise was developed using the adaptation of the Ren'Py game engine. Ren'Py is usually made for visual novels; a genre of typically story-driven computer games. The participants were a collective made up of Malaysian youths and were instructed to independently make several decisions. Following that, the social robot will selectively peruse consistent use of high or low controlling language in conjunction with the absence or presence of social praise at specific points in the game. The study has been broken down into four main phases namely the preliminary setup, the design of the experimental setup, data collection and analysis. During the preliminary setup, the problem statement, objectives, and scope were formulated to be coordinated for the consequent phases in addition to securing ethical clearance from IIUM. Following that, the design of the experimental setup, which consists of serious game development, robot programming, game-robot integration and experimental setup would be depicted. Afterwards, the data collection phase begins and is followed by data analysis.

To identify the most effective social cues modality of persuasive robots aligns with the third Sustainable Development Goal (SDG) of Good Health and Wellbeing and the Nationality Priority Areas for Research and Development. The end goal consists of the implementation of social robots designed with positively perceived persuasive robots as a mental health support system for Malaysian youths. The research outputs bring forward applications of social robots as cohesive social agents employing persuasive elements and accentuate the significance of focusing on critical aspects of dealing with mental health issues among Malaysian youths through human-robot interaction. Ultimately, this research endeavors to pave the way for more inclusive, culturally appropriate, and impactful mental health interventions through the utilization of persuasive robots in the Malaysian context.

1.1 Problem statement

In Malaysia, mental health issues such as depression accounts for 25% of adolescents (Taufik et. al., 2022). Malaysian youths face a multitude of challenges, including academic pressure, societal expectations, and limited accessibility to mental health services. As such, there is a growing need for innovative and culturally sensitive approaches to address these issues. While the general public has gotten more receptive to consoling the issue through community exposure to the effects and establishment of institutions dedicated to solving the concern, other factors may still inhibit those suffering from mental health issues such as personal availability or mismanaged priorities. It is believed that using positively perceived persuasive robots may be able to offer a promising solution by providing accessible and personalized support in a non-judgmental and confidential manner (Stroessner, 2020). Social cues as a persuasive element are however typically not the focus of development of agent-assisted therapists despite prior findings corroborating to their effect. Thus, controlled studies on these effects could be presented as a foundation for implementation of social robots with social cues. Other environmental factors such as the upbringing of Malaysian youths may not fully align with results of foreign demographics as a potential point of variance in effectiveness. This project investigated the development and design of persuasive robots that use social cues to urge Malaysian youths to make optimal decisions without causing further stress. Results attained from the experiment may contribute towards outlining the effects of a robot perusing social cues to persuade them to make better choices.

1.2 Objectives

There are several key elements such as social cues and human-robot interaction that has been presented in the development of persuasive social robots to support matters that are caused by mental health issues. These elements have been decoded through a series of objectives as follows:

1. To design a game with decision-making elements integrated with a robot in a low stress environment.
2. To establish fundamental social cues modality for positively perceived social robots (how the robots should talk in terms of language coerciveness and social praise) based on human responses after the interaction.
3. To benchmark the correlations between social responses provided by participants after interacting with designated social robots.

1.3 Research Methodology

The execution plan for this study can be divided into five phases. Phase one consists of comprehensive literature review, preliminary research information & ethical clearance from IIUM Research Ethics Committee. In this phase, a review was conducted, particularly on social cues used in the earlier studies for persuasive social robots and find the research gaps. This review comprises of reading and referring to the latest journal publications, conference papers, browsing, and books. Additionally, the problem statements, objectives, and scope of the study were formulated. These interviews discuss and explore their perspectives on the ideas in designing the persuasive social robot and the proposed social cues in addition to developing an exercise module in alleviating stress for Malaysian youth. Phase one also includes securing approval from the IIUM Research Ethics Committee

(IREC) to conduct a study on the IIUM students within a maximum of 6 months after the grant is secured.

Phase two describes the design of experimental setup which includes recruitment of 60 target participants among IIUM students between the age of 18 to 25 years old. An honorarium was given as a token of appreciation to each of the participants at the end of the session. The experimental design peruses the assignment of the participants to a two-by-two conditions in a within-subjects experimental design with the modality of high or low controlling language with the presence of social praise. The participants were tasked to collaborate with a humanoid robot as a persuasive social agent. Using exercise as a theme, this research designed a decision-making game that induces minimal stress, in which the participants were asked to make several decisions by themselves. After that, a persuasive robot with designated social cues would consistently persuade them to change their mind and select other options. To illustrate, in the first task, the participants were asked to choose any given option. In case the participants choose makes any particular choice, the persuasive robot would ask them to change their minds and choose an alternative option. The concept of the game, by asking the participants to make their own decision first followed by attempts to change their minds by influencing them to select other options, has been proven successful in functioning without eliciting stress. The participants were also reminded that the social robot has a similar level of social power to the participants in deciding. Specifically, participants were reminded that they are free either to follow or to ignore the advice given. There are no right and wrong answers in this game. Two questionnaires; an intertwined model consisting of negative cognitions and feelings of anger to measure the psychological reactance experienced by the participants used in this study. Other than that, the compliance of participants was measured as the number of times participants changed their initial decision to comply with the robot's advice. For trust and liking measures, questionnaires were utilized accordingly.

The third phase consists of collecting signed informed consent from the participants before the experiment. The form explains the aim and benefit of the study, procedure, risks, duration, voluntary, compensation, and confidentiality of the participants' identities. Following this, the fourth phase consists of data collection and analysis. In the experimental setups, a persuasive robot was placed in front of the participants during the experiment. The participants will be assigned randomly to any combination of social cues of either high or low coercive with the absence or presence of social praise before the experiment. The session starts after the robot introduces itself and briefs on the experimental procedure. After several persuasive attempts and the decision-making game ends within an allotted time of approximately 45 minutes, the participants were asked to evaluate their experience of playing the game together with the persuasive robots. Before analyzing the responses provided through questionnaires, outlier checking, skewness and kurtosis analyses were performed on the collected data.

After that, some statistical tests were done using SPSS software to investigate the influence of social cues on the participants' responses. Phase five capitalizes on the outcomes of this research, of which the respective researchers would write a report and articles for publication purposes. Any necessary improvement suggested by experts will be included in the report. The outline of the research methodology is depicted through a flow chart in Figure 1.1

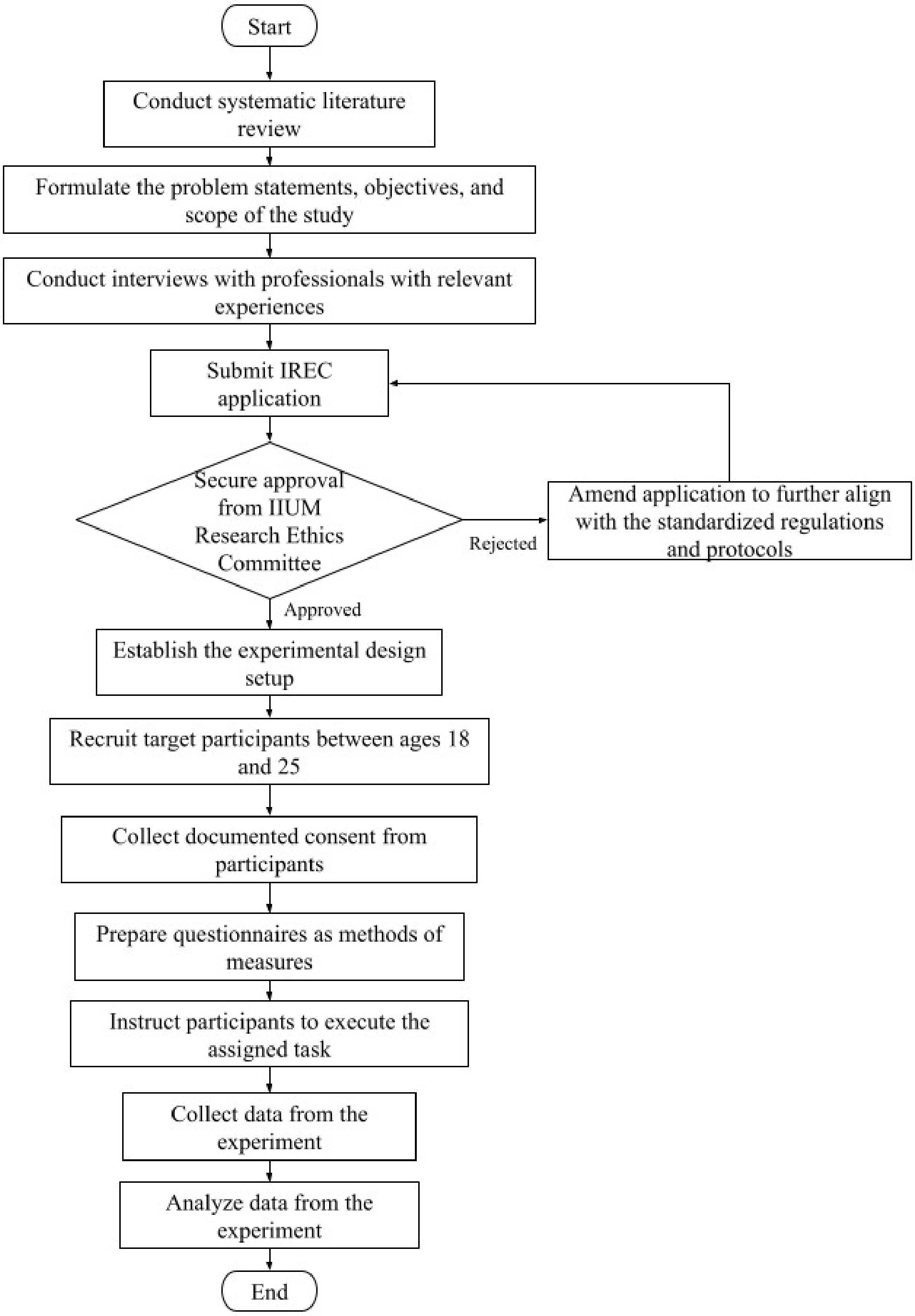

Figure 1.1. Full research methodology

1.4 Research Scope

The scope of this research is described through the following three criteria:

1. The participants involved in the study are of ages 18 to 25.
2. The participants are of Malaysian nationality.
3. Social responses under considerations are limited to usefulness, attitude, intention, enjoy, liking, belief and reactance towards the robot.
4. The use of a singular robot type, specifically the humanoid Alphamini robot.

1.5 Thesis organization

Several key elements are present as expressed through the chapters present in this thesis:

1. Chapter 1: Presents the overview of the study by discussing the problem statement, research objectives, methodology and scope of the research.
2. Chapter 2: Compiles and discusses literature contents on the social cues of persuasive technology and development of serious game.
3. Chapter 3: Describes the processes involved in the study that was conducted, including the game design and experimental protocol.
4. Chapter 4: Details the analyses and discussion on the collected results based on statistical analyses.
5. Chapter 5: Contains the summary of the study including the achievement of the objectives, limitations (and recommendations) of the current study and the thesis contribution.

CHAPTER TWO

LITERATURE REVIEW

2.1 Mental Health

According to the World Health Organization (Roberts et. al., 2019), over 260 million people in the world suffer due to mental health issues, and the number increased significantly. A proper mental health support system is essential therefore for those with mental health issues in the hope of saving them from falling under severe depression cases which could lead to suicide.

In reducing the barriers to getting proper treatment for mental health issues, this project proposes to persuade Malaysian youth to make healthier life choices using persuasive robots through exercise (Berger and Owen, 1988; Jacquart et. al., 2020; Lopresti and Drummond, 2019). The advantages of using persuasive robots in providing constant mental health support among people with mental health issues have been highlighted in an earlier study (Shamsuddin et. al., 2016). A study conducted by Inoue, Wada, and Shibata (2021) found that the use of social robots managed to produce positive responses from elderly adults with dementia. Enjoyment is important to reduce stress level. In a different age group, children also found that interaction with persuasive robots can promote positive emotions (Crossman, Kazdin, and Kitt, 2018). Being aware of the severity of mental health issues among young adults, this study will be conducted with a group of Malaysian youth. Earlier research (Björling et. al.,2019) demonstrated that teenagers have positive impressions that social robots could emotionally support their social needs. Also, Yin (2009) found that social robots known as “Chatbot” shows that the use of social robots not only to relieve anxiety, but also to treat teenagers with mental health issues. The use of chatbots is gaining prominence due to their capacity for accessibility and convenience

(Desovitsky et. al., 2020). The treatment of mental health issues with HRI is a trending debate as some applications of the system are generally underdeveloped as particular elements were not fully considered (Wynsberghe and Li, 2019). However, some properly implemented systems have showcased the potential of which the system could be utilized (Scoglio et. al., 2019). Guemghar et. al. (2022) concludes that the applications of a HRI based system for mental health support generally yields positive results. Peer Support Services is one such applied system that has shown to be reliably effective through the means of support from those that has coped with mental health issues could offer those who are currently suffering from similar ailments (Shalaby and Agyapong, 2019). Many different systems were established in conjunction to the variety of mental health issues such as the study on validating the screening systems for detecting perinatal depression that was done through a literature review by Fellmeth et. al. (2021).

Continuous advancements in technology offer persistent support to mental health patients that evolves to address the concern as the understanding on the topic improves in addition to conforming to the need for better accessibility (Seiferth et. al., 2023). Digital implementations of mental health support systems gained prominence due to the constrictions as a result of the COVID-19 pandemic and were largely welcomed by healthcare practitioners and patients alike (Torous et. al., 2021). Chatbots are an example of a type of mental health service that is generally well perceived as social agents to combat mental health issues, though a concern to note is the unstandardized evaluation procedure as they are developed (Vaidyam, Linggonegoro and Torous, 2020). A notable consistency on the ethical concern on the misuse of such a technology was noted in relevant aforementioned studies as they may lead to irreparable effects.

2.2 Persuasive Technology

Persuasive technology is described as technology developed or used with the intent of affecting the behaviour of those that interact with it. Valenti and Giacco (2022) discuss how the implementation of leverage may function to persuade someone to conduct a certain action. Proper execution of persuasive technology would yield beneficial results, particularly when the goals are in alignment between the relevant parties (Wenker, 2022). These positive effects are also not limited to circumstantially restricted environment as observed by Widyasari, Nugroho and Permanasari (2019) as several different settings complies to the same findings. However, Aldenaini (2020) suggests that long term evaluations are typically not scrutinized for the designs for persuasive technology in addition to perusing the most appropriate technology platform during the design process. There are several potential mediums of which persuasive technology could be applied. Implementation of robots perusing persuasive technology is one such adaptation. Certain design qualities of robots could be focused on to propagate their persuasive capability. Social cues in particular have shown to be particularly effective at contributing to this effect.

A robot utilized to persuade humans to conduct demanding tasks would offer consistent and unbiased suggestions as they are set to function under predefined parameters. Additionally, robots are not prone to compassion fatigue or emotional exhaustion that typically plagues healthcare professionals (Poku, Donkor and Naab, 2020; Mollica and Fricchione, 2021). A robot's state of being as an object also isolates it from conflicting with social and cultural barriers. The NAO and Pepper robots are prominently utilized in social robot applications studies, not dissimilar from the previously referred literature, each exhibiting traits unique to each other. (Amirova et. al., 2021; Sara and Oliver, 2023). The robot utilized in this study, Alphamini has numerous features that make it particularly attractive as a social robot as highlighted by the research done by Bendel (2024). The Alphamini robot shares many features with the NAO robot albeit available at a lower price point, specifically in its functions and designs for articulation, range of motion, text-to-speech functions and several others.

2.3 Social Cues

Similar to human-human interaction (HHI), one of the basic elements in human-robot interaction (HRI) is social cues. Social cues portrayed indirect communication signals which express the intentions or thoughts of the social actors (in this case the persuasive social robots) verbally and non-verbally. Fogg (2002) highlighted that social cues in persuasive technologies such as social robots are known to showcase a large overlap in social interaction with how humans communicate and coordinate with one another (Yang et. al., 2019). Examples of verbal social cues are controlling language (forceful vs. pleasant language) (Ghazali et. al., 2017) and native vs. non-native language (Fischer and Niebuhr, 2020) used in communication while non-verbal social cues include body movement (Wasala et. al., 2019) and roles of the social actors (e.g., as a mediator) as demonstrated in a study by Gammanpila et. al. (2020).

Designing a set of social cues in promoting positive interaction in HRI is critically important as the social cues can elicit either positive interaction experiences such as increasing the engagement level between autistic children and robots (Rakhymbayeva, Amirova, and Sandygulova, 2021) or conversely, eliciting a negative experience through an offset during learning (Kennedy, Baxter, and Belpaeme, 2015). Social Agency theory is one of several theoretical frameworks regarding social cues (Jackson and Williams, 2021); suggested a social actor, or more accurately described as persuasive robots for this study equipped with more social cues leads to more natural social interaction (high score for living creature likeness and representation of real person) compared to a social actor with less social cues (Ghazali et. al., 2019). Contradictorily, the Media Equation hypothesis

(Reeves and Nass, 1996) claimed that a simple social cue suffices to elicit humans' social responses when interacting with social actors, even when they were perfectly aware that the social actors (the robots) are machines. This hypothesis is supported by the findings in a study conducted by Puglisis et. al. (2022) which found that a robot with minimal cues is sufficient to encourage positive interactions between autistic children in therapy sessions. Elprama et. al. (2016) found that human-robot collaboration supports the multiple social cues effectiveness to some degree which supports the Social Agency theory. Nevertheless, it can be found an overlap between the Social Agency theory (Jackson and Williams, 2021) and Media Equation hypothesis (Reeves and Nass, 1996), in which the theory recommends using more social cues for better responses in HRI while the hypothesis advises using only a simple cue.

As a means of correlating the Social Agency theory (Jackson and Williams, 2021) and Media Equation hypothesis (Reeves and Nass, 1996), the type of social cues to be embedded onto persuasive social robots will be investigated profoundly in the study. The modality of the types of social cues include: (1) language coerciveness: high vs low (2) social praise: presence vs absence. To date, only a few studies have investigated how the coerciveness of language used by robots influences human social responses. Examples of wordings for lowly coercive language include 'please' and 'may' while highly coercive language includes 'must' and 'have to'. Earlier studies (Ghazali et. al., 2017; Roubroeks, Ham, and Midden, 2011) have produced mixed results on the effect of the coerciveness of language on reactance. Another study by Roubroeks et. al., (2011) however showed that people experienced low reactance when a virtual robotic agent used slightly coercive language in persuasive attempts. Further works by Ghazali et. al. (2017) showed that people experienced high reactance when a humanoid robot used slightly coercive language in persuasive attempts.

Another salient human-like feature that can be implemented into robots is social praise. Praises such as 'Good job' and 'Nice work!' by robots is one of the most powerful persuasive strategies which can lead to positive impressions for such interaction in encouragement-based collaborative learning (Tanizaki et. al., 2017). Earlier research showed that subtle praise works as positive social reinforcement in HRI (Ghazali et. al., 2019). Using a similar decision-making game that will be designed for this research, Ghazali et. al., (2019) investigated the effect of a persuasive robot with praise (and head mimicry) on its persuasive power to influence people in making decisions. That is, the participants were asked to choose their favorable pictures and mystery rewards which pertain to persuasive attempts with incongruous and ambiguous goals.

Importantly, the design of social cues in any advanced technology related to humans including persuasive social robots is vital in avoiding the uncanny valley phenomenon (Mori, 1970). This phenomenon provokes unsettling feelings and negative interaction experiences toward humans when interacting with a robot that has a high degree of resemblance to a real person. Not only related to the social cues embedded into the social robots, the uncanny valley phenomenon also can occur due to the selection of the robot used in the study. Using multiple robot variations to human scales, Jussi et. al. (2018) studied the uncanny valley phenomenon as a means by the opinions of 260 participants. The research revealed that once a robot's appearance surpasses a certain level of human resemblance, it can be appropriately labelled using the term "uncanny", as observed by the phenomenon.

2.4 Decision-making Serious Games

A person's daily actions are dictated by the choices made throughout the day. The choices one makes may be inconsequential, or they may result in critically adverse outcomes. As such, rational, deliberate choices are not made impetuously, but through a series of actions. Prior research illustrates how the decision-making process can be separated into four phases: framing, intelligence-gathering, choice, and learning (Schoemaker and Russo, 2014). Turpin et. al. (2004) discusses how personnel at high-level management positions deliberate through decisions with regard to existing decision-making theory and how people in different positions approach the decision-making process.

Negative effects such as stress and anxiety are found to be correlated to the decisions that one makes in conjunction with risky decisions that may yield regret or disappointment (Hengen and Alpers, 2021). Aspects such as the detail of regret and disappointment originating from different sources should be noted. Specifically, effects such as regret are defined as an emotion where one is under the impression of being a contributor to a negative event whereas disappointment is an emotion due to experiencing a negative event (Zeelenberg et. al., 2000).

Games are normally used as a medium where its design is to induce a sense of fun and enjoyment as one or more players aim to achieve predetermined objectives. Serious games are an adaptation of the gaming medium to utilize the capabilities of an enjoyable and immersive environment for more practical applications. This type of game has gained significant attention as an effective tool for learning, training, and behaviour change in various domains. Typically, serious games are designed with features of being engaging, enjoyable and immersive. These features contribute to the overall effectiveness of serious games as tools. Aliyari et. al. (2018) showcased that; depending on the type of game played, stress could be increased or alleviated. Ajmal et. al. (2022) further corroborated this information through their study on stress-relieving video games. Among the different types of serious games, decision-making games hold promise in eliciting stress (Williams-Bell et. al., 2015). Participants are presented in a simulated environment to engage in activities to ultimately fulfil the games' core design objectives (Kara, 2021). Braad, Žavcer, and Sandovar (2016) elaborates on the specific processes and models that are considered during the development and design process of a serious game. Also defined as gamification, the process of introducing practical or theoretical information within the concept of a game has shown great potential (Reynaldo et. al., 2021).

Rebah and Slama (2019) and Maheu-Codette et. al. (2018) studied the efficacy of serious games as a tool for education with the latter emphasizing healthcare professionals and students. A practical study on a serious game for skill development through dentistry training due to restrictions brought upon by the Covid-19 pandemic has shown the viability of digitally developed serious games by exploiting an uncommon period of human history during a pandemic (Wu, Du and Lee, 2021). The participant that undergoes the virtual dentistry training must click on the correct options that reflect the decision-making process that would be present in an actual clinic. Schönbohm and Zhang (2021) also took advantage of the recession induced by the COVID-19 pandemic to discuss the effectiveness of serious games for strategic decision-making. Dallas and Gogoulou (2022) showcases an educational game known as "Digiworld" as a virtual learning platform for students as a tool for education on in which students apply basic Python programming techniques to progress through the game.

Researchers and game developers can build a controlled, immersive environment that closely mirrors daily obstacles by designing a decision-making game to study the participants' response towards the robot when it exhibits certain social cues (Ghazali et. al. (2019). Smiderle et. al., (2020) further connects the positive behavioural changes to participants exposed to gamified versions of educational tools. Damon, Fotios and Kamal (2022) also introduced the applicability of using biological sensors as another method of data collection for specific applications using a serious game based on a fire evacuation scenario. The customizability of a decision-making game may become a necessity for applications such as when unique participants may require a specialized interactive setting (Flogie et. al., 2020). However, under certain circumstances, specifically when emotions are utilized to affect behaviour based on logic, this may produce adverse effects (Alam et. al., 2021). Therefore, proper deliberations must be made when designing social robots. While there are many instances of serious games being applied for varying sectors of study, there are not many depictions of a system using the serious games as a medium to offer mental health support. Rodrigues et. al. (2022) is a particular instance whereby they developed a game that serves as mean to spread mental health awareness.

2.5 Chapter summary

To summarize, this chapter discussed topics regarding mental health awareness and treatment, current implementation and theoretical aspects of persuasive technology, social cues terminology and its effect on communication, and the development of serious games appropriated to the specified application. Resolving mental health issues are a constant focus for concerned parties and multiple avenues are presented to rectify the matter, particularly to matters relating to stress. Persuasive technology is an emergent approach to strengthen engagement between one or multiple people to a particular social agent specifically with the perusal of social cues of controlling language and social praise have shown to be particularly effective. Social cues have been extensively studied in many sectors such as psychology and social robots has shown records of being able to effectually imitate social cues and its corresponding effect as human responses such as usefulness, liking and reactance. Variance between applied social cues may be assigned as the independent variables to study the effects of each mode. Based on reviews of recent literature, the social responses towards robots exhibiting the combination of controlling language and the presence of social praise has not previously been studied. Historically, serious games have shown to be an effective tool to emulate concurrent issues so that they may be studied or trained. Therefore, based on current literature relevant to the topic, the following hypothesis were proposed and tested in the study:

H1: The presence of the social robot during an engagement with the participants in an activity will be stress-free.

H2: The use of high controlling social cues would elicit a positive response in usefulness, attitude, belief, enjoyment, intention to use and liking.

H3: The presence of social praise contributes greatly to the overall positive perception of the social agent.

H4: There are significant, positive correlations between all dependent variables except for reactance which is negatively correlated with others.

H5: The use of high controlling language with the presence of social praise by the robot would elicit significant positive social responses from the participants.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The following sections describe the processes undergone to conduct the study. They are broken down into four subsections which are game development, game-robot integration, experiment setup, and analysis. The game development subsection explicitly describes processes that deviate from the typical game development procedures as exploring the full capabilities of the game engine exceeds the scope of the study. The following subsection discussed the process in which the game engine was integrated with the Alphamini robot. The experiment setup subsection describes aspects present during the data collection which include the elements present during the experiment and the procedures involved. Lastly, the final subsection describes the procedures conducted for analysis. However, attaining an ethical clearance needs to be conducted first and foremost prior to the execution of the study. Clearance from the IIUM Research Ethics Committee must be obtained before the data collection process proceeds. The process of attaining ethical clearance consists of the submission of a copy of the project proposal, the questions to be included in the questionnaires and other details that qualify as data that would be collected from the participants. The approved by the International Islamic University Malaysia Ethics Committee and the application was designated with the identifier IREC 2022-044.

3.2 Game Development

To fulfil the first objective, a decision-making game has been developed using free game development software. Designing and developing games is a multi-disciplinary field that would result in the production of a game that is made up of audio, visual and game mechanical design. Each design element requires some level of competence to produce a tangible component that would be essential for an effective game. As previously stated, many considerations must be made when developing a game as increasing complexity would raise the amount of time and effort required to develop. For this study, a software named Ren'Py has been used to develop a decision-making serious game.

3.2.1 Ren'Py

Ren'Py is a game engine that is specifically designed for the applications of developing visual novels. Prevailing game engines such as Unity and Unreal Engine are dedicated to offering numerous applicable systems for a more comprehensive availability of game elements which increases their overall development complexity. Coincidentally, most game mechanics present within the Ren'Py game engine are not dissimilar to mechanics applied in the development of simpler serious games which typically consist of clicking context-sensitive elements on a game screen. This study aims to describe a conceptual framework for the design and development of a serious game using Ren'Py to simulate virtual scenarios that may include decision-making prompts. Figure 3.1 depicts the Ren'Py project launcher and directory access management.

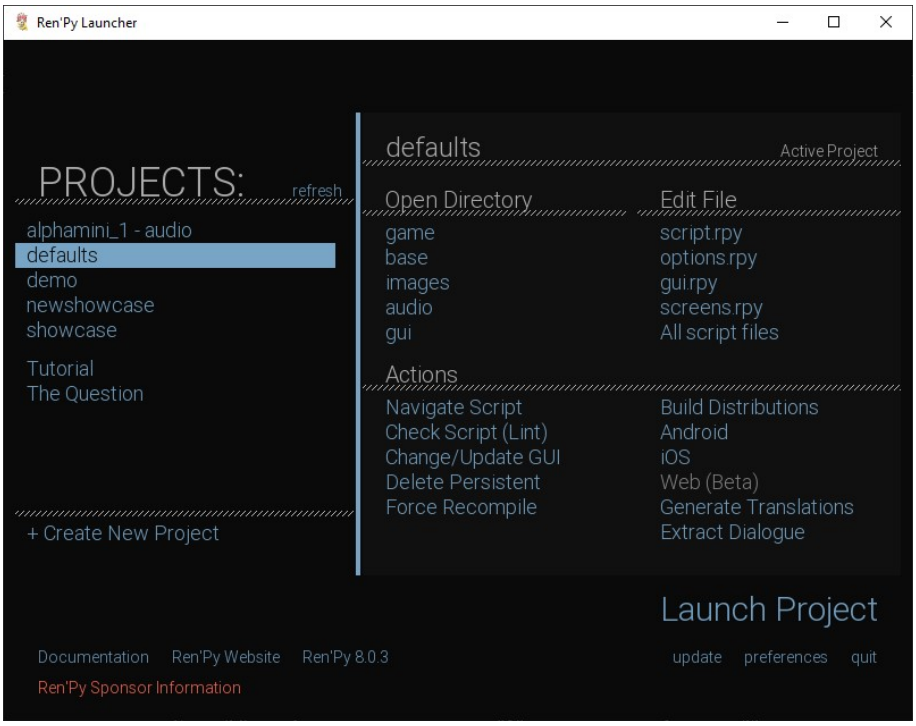

Figure 3.1. The Ren'Py Launcher window.

The most current version of Ren'Py is selected to be used in developing a decision-making game to enhance human-agent interaction. Ren'Py 8.0.0 supports built-in modules currently available in Python 3.9. Ren'Py is a Python-based program that is streamlined to utilize the Python programming language using custom syntax to program a visual novel. For a typical visual novel development, given that the assets are readily available, the core mechanics of a game can be developed much more easily compared to mainstream game engines such as Unity or Unreal Engine (Consalvo and Staines, 2020).

Python modules can be initialized within the game script to be utilized in the game to expand the game engine's capability. At the cost of the range of capabilities of other game engines studied in a study by Sharif and Yousif (2021), Ren'Py alleviates the demand for the time and effort required to develop a functional game. During development, a supporting tool such as Simva can be integrated into the system for games with more complex properties (Pérez-Colado et. al., 2019). Crossing out the fulfilled criteria as specified in a study by Caserman et. al. (2020) study will ensure that the game meets the desired level of quality.

3.2.2 Game Engine Adaptation

Ren'Py is a visual novel engine developed to provide those that have an interest in telling stories in a visual novel format. However, default elements that are typical of a story-driven visual novel may conflict with the intended use of virtual environment simulation.

3.2.3 Disabling Default Game Elements

The following describes how alterations are applied to the default for game elements for configurations adapted for serious games. Figure 3.2 depicts the visual elements that are present in most visual novels that typically appear throughout gameplay. As the name implies, the "quick menu" allows for quick access to basic visual novel functions. One may choose to remove the "quick menu" function by changing the default "quick_menu" object within the "screens.rpy" file from "True" to "False". Games typically developed for visual novels typically use the "namebox" and "textbox" as the method to narrate the story. The "namebox" contains the name of the characters and the "textbox" contains the dialogue spoken by the characters. Both the "namebox" and the "textbox" are in the GUI folder with their corresponding file names in the png format. The namebox GUI is transparent by default and as such can be left as is if the game is to be designed without it. However, the "textbox" GUI may have to be removed for certain applications.

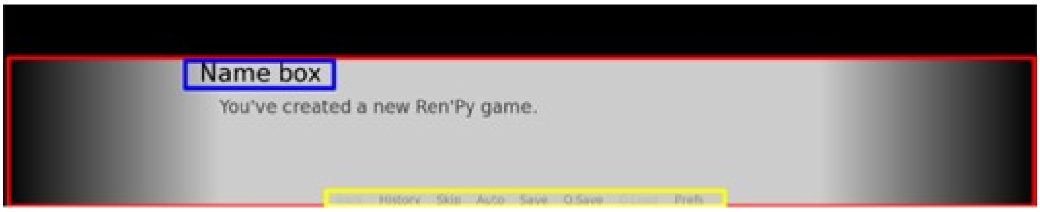

Figure 3.2. The "namebox", "textbox", and "quick_menu" GUI elements are highlighted in blue, red and yellow borders respectively.

The "textbox" GUI can effectively be hidden by changing the opacity of the corresponding textbox.png file using any image editing software. The main menu is the first screen that appears in the game window each time the game starts. The main menu section of the game can be completely skipped by placing the "main_menu" label within the code which will cause the game to begin at the start label. If the "main_menu" label is called and subsequently returns, the game will immediately begin at the start label. The "textbox.png" file is then replaced with the edited file. Consequently, lines with empty quotations with no character addressing can be used so that no text appears in the game but still requires a mouse click at every instance to progress the game.

3.2.4 Disabling Player Inputs

By default, Ren'Py allows players to rapidly click on the screen to progress through the game faster, which may be an issue in situations in which the pace of the game needs to be at a set period. A "hard pause" parameter can be used to nullify any interaction from the player until the designated period is over. The scroll-up wheel on the mouse may also trigger the built-in rollback function in Ren'Py that allows players to revert to previous points in the game. The right mouse button also opens the pause menu by default. The key bind for the mouse scroll-up and right mouse button input can be done by removing the "mousedown_4" assignment in the text file of the following directory: "renpy/common/00keymap.rpy".

3.2.5 Storyboarding

Storyboarding is the process of designing the overall narration of the game. For most applications of serious game development, storyboarding is a necessary process to ensure a coherent game flow. Jantke, Klaus and Knauf (2012) succinctly describe storyboarding concepts to be considered when designing serious games. Additionally, the storyboard framework can be designed as proposed by (Yessad, Labat and Kermorvant, 2010). Scenario narrations are typically written without character addressing. The game progresses at every instance by clicking anywhere on the game after the text within the quotation marks is displayed for each line. Empty quotation marks show a blank textbox with the character addressing in the "namebox" if present.

3.2.6 Game Engine Mechanics

Displayable assets are visual elements that appear in the game window when prompted according to programmed code. The Animation and Transformations Language (ATL) allows for various alterations of the displayable in Ren'Py. The "align" property defines two ATL properties; "anchor" and "pos" to the same float values. The "anchor" property designates the reference point on the displayable and the "pos" value assigns the displayable's anchor point at the specified position in the game window. The points

(0.0,0.0) for both the displayable and game window are at the top left corner and extend to the points (1.0,1.0) at the bottom right corner respective to each. Other “align” values beyond this range will cause the displayable assets to appear outside the game window border due to exceeding the boundary for both the displayable and game window. Unless detriment to focus or clarity, almost every asset invoked and presented in the game in a monochromatic depiction. Assets were rendered through Blender; a 3D digital modelling program and static images were obtained at specific points of the room. The combination of the use of zooming and panning was utilized to apply an immersive dynamic effect as the participant shifts their focus around the room.

Figure 3.3 illustrates how to align designations for each displayable that appears in the game window. The red and blue square grid displayable assets have the “align” values set to (0.3,0.7) and (0.7,0.4) respectively. The “show” statement places a displayable at the aligned values of (0.5,1.0) by default. The display order is dependent on the order of the “show” statement in the code with the latter statements overlapping the previous asset. Alternatively, the “hide” statement removes the image from the layer. The “scene” statement clears the layer and optionally shows an image. The inclusion of a visual asset representing the virtual agent can be executed using the same process.

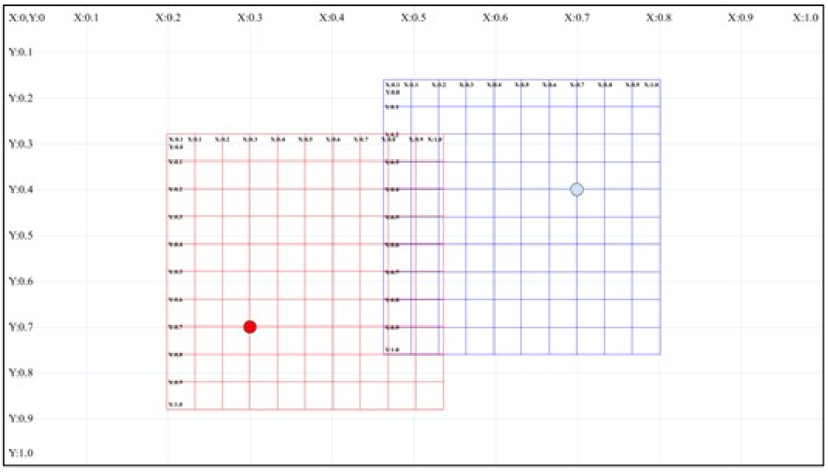

Figure 3.3. Two square grid images at different position assignments

Zooming and panning are fundamental animation techniques to provide better focus or context on specific game contents and create a more dynamic gameplay visual. The scale of each image at default zoom values is following the original file resolution with regard to the display window resolution. "Zoom", "align", and "linear" are the three ATL properties necessary to apply zooms and pans. The "zoom" property applies a zoomed effect on the displayable by a certain magnitude with a float type variable. Panning is an animation effect in which a section of a displayable is shifted to another section. It should be noted that any events occurring with the zoomed images will require that the zoom value of the changed image match the zoomed image property. Panning requires an image to be at a zoomed position before it shifts to a different section. Alternatively, the image used for panning is at a larger scale than the game window. The "zoom" and "pan" properties can be used simultaneously.

By default, three audio channels are present when a project is created named "music", "sound" and "voice". As the names imply, each channel can be utilized to play specific audio files present within the audio folder. The "music" channel is intended for use as a background song or music whereas the "sound" and "voice" channels are designated as the channels to play sound effects and verbal speech audio files respectively. Each channel can only play one audio file at a time, but all channels can be simultaneously played.

For simple menus, the statement in Figure 3.4 can be used to show the built-in choice menu. The choice menu is simple and can fit a certain number of characters and options. Simple applications such as confirmation prompts should utilize this function.

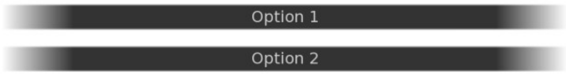

Figure 3.4. Simple menu statement that can be configured for a different number of options that will automatically center on the screen

Alternatively, a specialized menu can be used to display a custom-designed menu. This method allows for more variety in the options that can be shown. Figure 3.5 depicts how a custom menu may appear in-game. Each button is an independent UI element requiring the mouse to click on it to proceed with the game. Each button is displayable matching the game window resolution on transparent background with a "png" format. Hovering the mouse over one of the buttons will highlight the button by invoking the hover variant of the .png image. The highlight functions by showing a different image of the button with the highlighted property.

Figure 3.5 also depicts how the "imagebutton" statement can be applied to show the assets as a custom menu that returns a variable value varying depending on the button clicked on. A custom image can be generated and used to be placed in desired positions but for basic applications, designing the asset to fit the intended game window is a more efficient method. The auto statement automatically designates the asset files ending with the "_idle" or "_hover" file names to the corresponding property. The file names ending with "_idle" will be shown on the custom menu when the mouse is not hovering over the asset. Inversely, the file names ending with "_hover" will be shown when the mouse is hovering on the asset. The "focus_mask" value ensures that only the opaque elements of the asset are interactive. The modal True assignment limits the participant from interacting with other assets below the currently displayed assets.

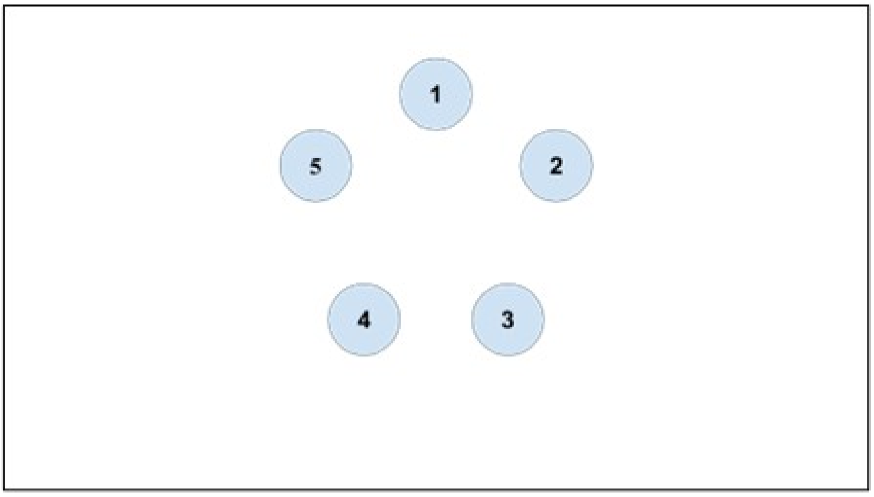

Figure 3.5. Custom menu screen consisting of 10 different image files

The following is a module installation command that can be executed using the computer's terminal window such as the command prompt or PowerShell window. A new folder named "python-packages" will be generated in the project directory with the corresponding files required to allow the module to function. Note that not all Python modules are compatible with Ren'Py and some alterations might be required before the game functions as designed. For example, the installation of the "openpyxl" module can be done using the following command:

```
pip install --target game/python-packages openpyxl
```

Errors are automatically checked for upon launch and detected errors present during development will be displayed upon launching the game from the project launcher. If present, the errors are stated consecutively in the error window. After resolving the errors, the "reload" button can be clicked on to reload the game without closing the game window. Additionally, simultaneously pressing the "shift" and "r" keys on the keyboard when the game is running will enable the "autoreload" function. "Autoreload" will automatically reload the game at any point Ren'Py detect changes in the files associated with the game.

Occasionally, unexpected anomalies occur during development due to human errors that are undetected by Ren'Py. Bugs can be discovered when the game performs differently than intended and are usually replicable. Monitoring the game as it plays through all possible programmed sequences is a reliable brute-force method to detect bugs. The inclusion of the use of labels at specific points in the script may accelerate the debugging process by jumping to relevant labels to skip sections of the game. Pressing the "shift" and "o" keys on the keyboard enables the built-in console which allows for the use of several commands which can be executed by typing in the command and pressing the enter key.

The "jump" command allows for the game to immediately go to the labelled point. Variables can also be assigned through the console. An important point to note is that using the "jump" command to a specific label will skip through any code between the instance in which the jump command was executed and the point of the game jump. Returning from the console back to the game can be done by pressing the escape key.

Ren'Py has a built-in save system but the process of accessing the saved variable through this method is relatively complicated. Using the persistent variable function and the "openpyxl" module, the progress and selection options of the player can be directly saved into a Microsoft Excel spreadsheet. This method would allow for the recorded data to be easily processed. Alternatively, the game can be recorded using screen recording software and the relevant points are manually marked afterwards.

After establishing an understanding of the development of both overt and underlying concepts of the Ren'Py game engine, a serious game was developed utilizing standard and customized properties. Preserving the base Ren'Py functions in addition to modifications to the game engine files allows for the development of decision-making serious games. Figure 3.6 depicts the full game flow as programmed through Ren'Py and the integration with Alphamini's Text-to-Speech (TTS) command scripts. While on standby, the robot was set to privacy mode which inhibits the robot from taking any verbal commands during executions of TTS instructions from the game up until the robot receives a startup input as a trigger to start the game of which the robot would offer its introduction and a description of the setting of the game.

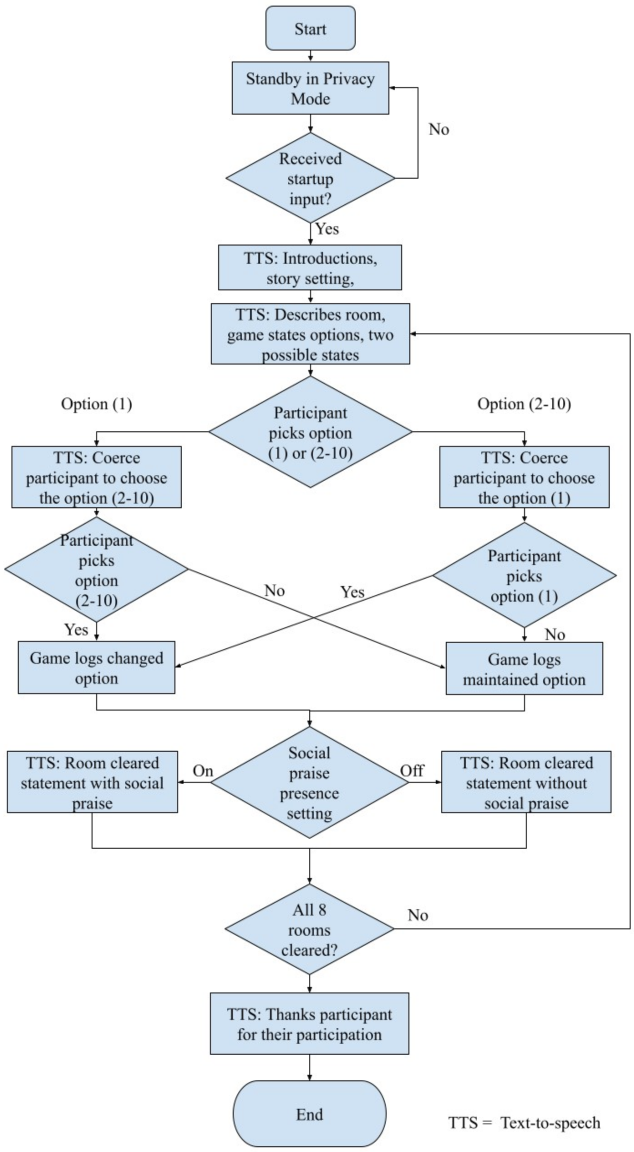

Figure 3.6. Robot instruction execution flow

The different states of the game could be described through the following series of individual "rooms" with their respective challenges or problems. All the prompts for choices will appear twice, once after the problem is identified and again after the participant makes the initial choice. In some of the rooms, text is used instead of images as the context given to the participant to resolve the challenge varies. Figures 3.7 and 3.8 show the two variants of how the choices are presented to the participant with images and text respectively. Like most rendered assets, the options given are monochromatic so as to not apply bias. The contents of prompts will vary depending on the room in which the prompt was triggered. The three main user interface element that is presented at each choice prompt are the options themselves, a text caption at the top left of the screen each time the participant hovers the cursor over an option, and a cursor icon at the bottom right to denote the use of the mouse to interact with the game as seen in Figure 3.7 and Figure 3.8. Figure 3.9 depicts the first visual appearance of the game that is one screen shown the to the participant. The participant would need to click on the door to begin the game, inadvertently as an application of a previously described game mechanic regarding the prompt for interaction.

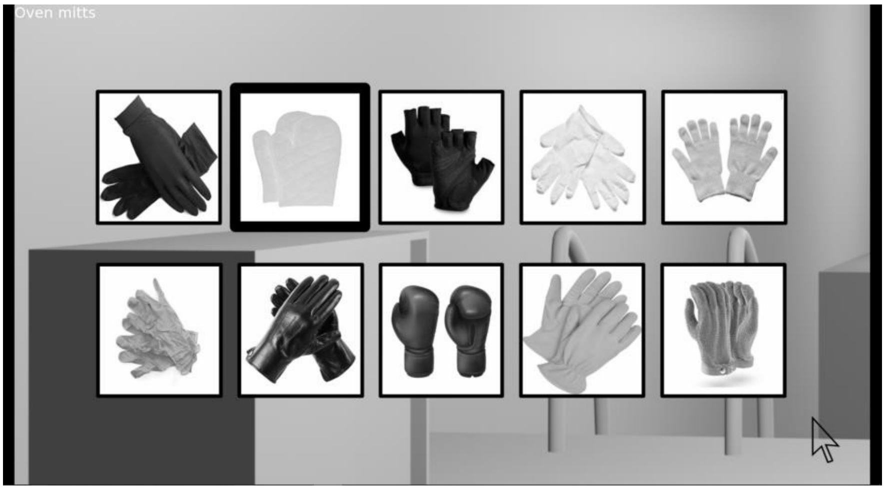

Figure 3.7. A custom menu consisting of 10 images of items arranged in a 2 by 5 pattern.

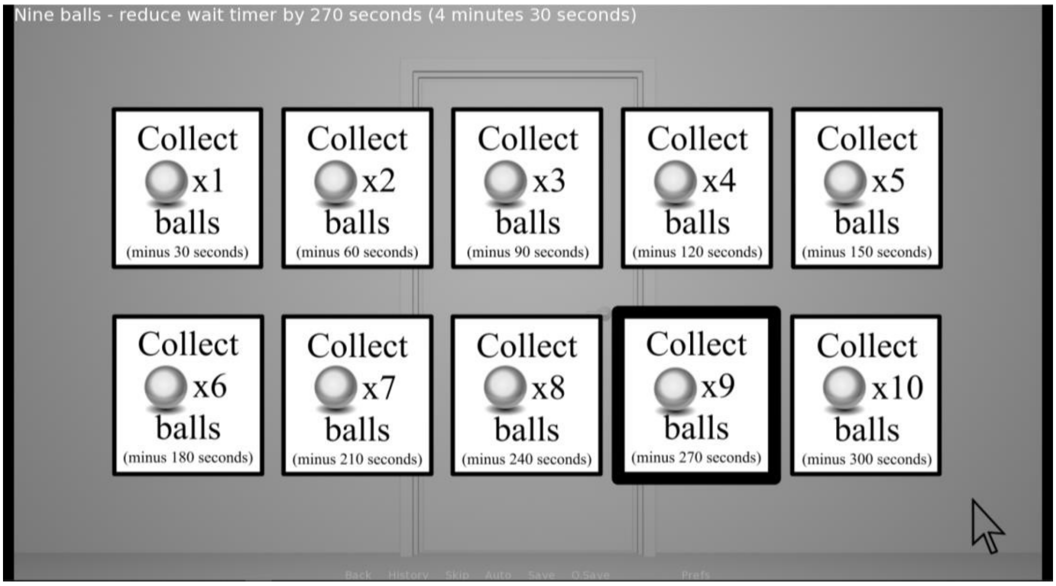

Figure 3.8. A custom menu consisting of 10 items in no particular arrangement.

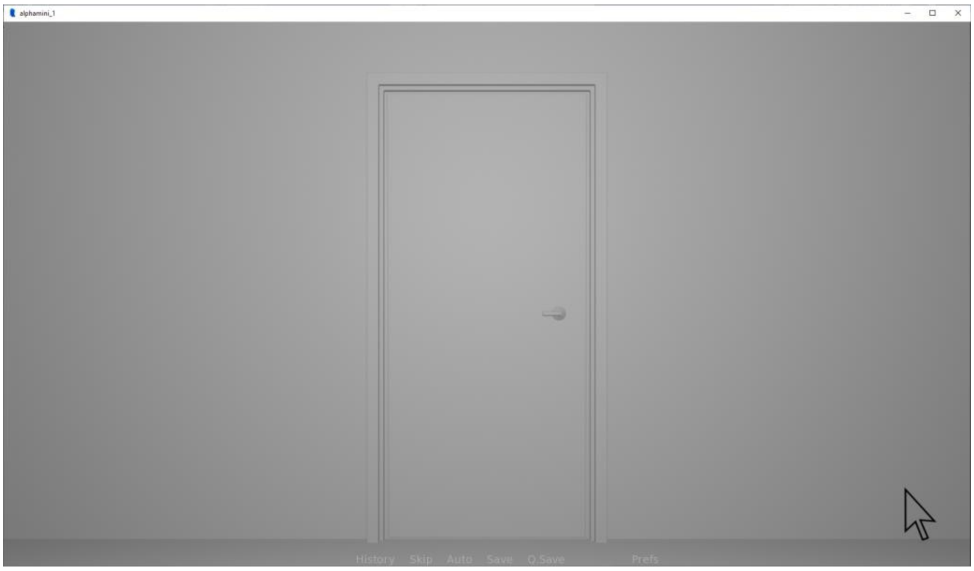

Figure 3.9. Starting room that consists of a single door with the cursor icon to prompt interaction.

Figure 3.10 depicts the first challenge room that is shown to the participant. The premise for challenge room 1 was to cross the ditch between the participant and the next room. The participants were to utilize the zipline to progress but were presented with the problem of the lack of grip on the zipline handle. The options given to the participant were a selection of gloves of varying types. The gloves include silk gloves, oven mitts, fingerless gloves, plastic gloves, cotton gloves, latex gloves, leather gloves, boxing gloves, farming gloves and chain gloves as offered to the participants in Figure 3.11. The variation in materials and designs serves to conduce or hinder the deliberation process as the options were not clear-cut and would perform in accordance with the participants' perceived effectiveness of the chosen option. The reconfirmation and transition phase would then follow as the next series of actions. The reconfirmation phase consists of the robot offering an argument for an alternative choice from among the selectable options to the participant and the game would present the options again. The transition phase consists of the robot describing the enaction, the resolution of the challenge before offering social praise to the groups with the designated setting before proceeding to the next room.

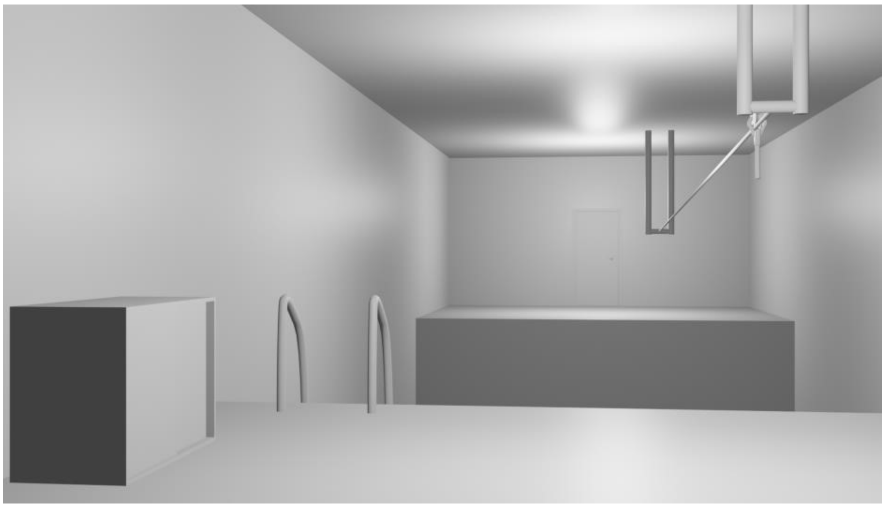

Figure 3.10. Challenge room 1: Zipline room

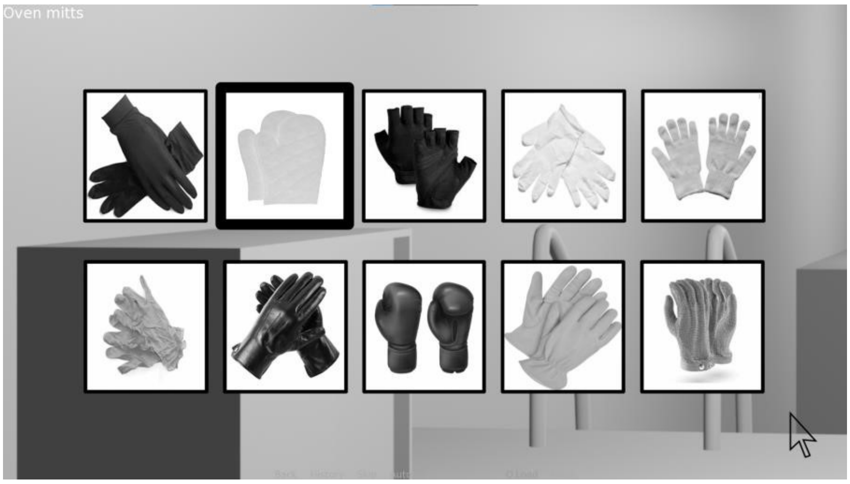

Figure 3.11. Challenge room 1: Zipline room options

Following that, Figure 3.12 depicts the second room that is shown to the participant. The premise for challenge room 2 was to hit three separate targets before they left for the next room. The participants were to select an item for a nearby cabinet as shown in Figure 3.13. The options given to the participant were a selection of spherical throwing objects of varying types of which participants must choose their preferred object that best fits their predisposition either through balance, conformity or others. The specific items were a beachball, a takraw ball, a cannonball, a baseball, a soccer ball, bowling ball, a softball, ping-pong ball, a volleyball and a golfball. This is then followed by the reconfirmation and transition phases.

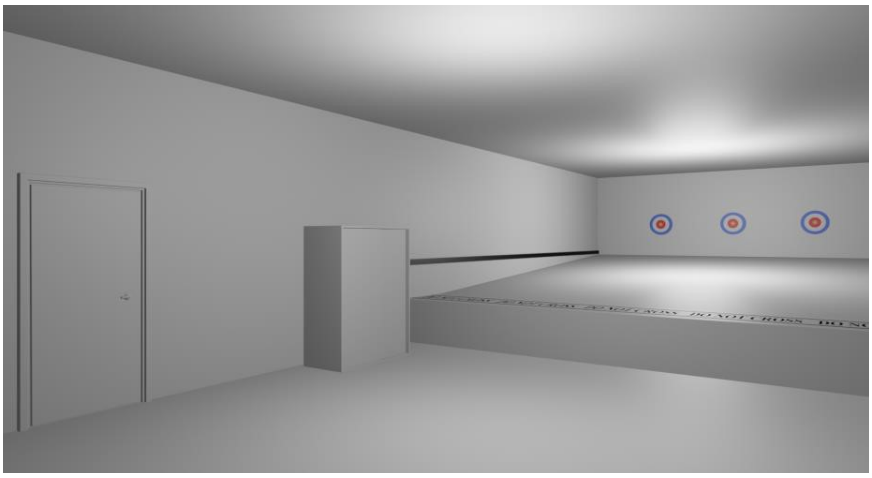

Figure 3.12. Challenge room 2: Throwing room

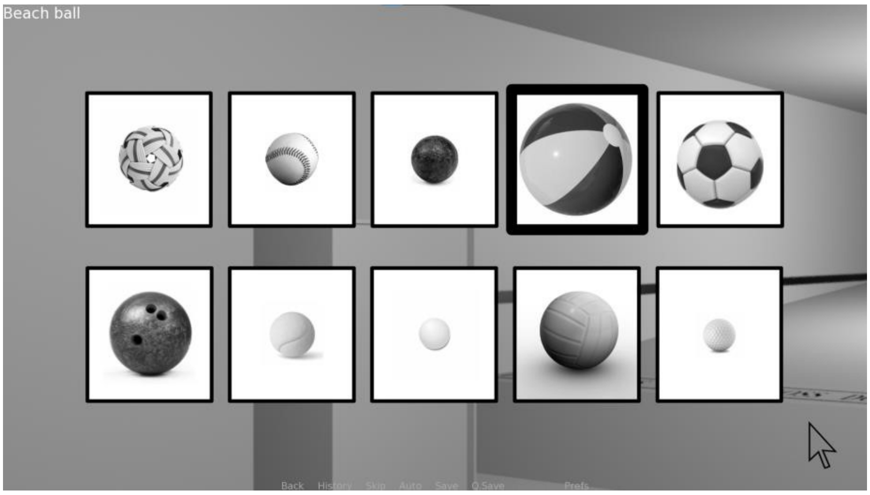

Figure 3.13. Challenge room 2: Throwing room options

In the following room, Figure 3.14 depicts the third room that is shown to the participant. The premise for challenge room 3 was to hit a punching bag in the middle of the room. The participants were to select an item for a nearby cabinet as shown in Figure 3.15 of which there were a crowbar, brick, mace, baseball bat, tonfa, frying pan, wooden sword, nun chucks, sledgehammer and boxing gloves. The options given to the participant were a selection of items that could be used to improve the participant's capability to apply physical force based on their perceived confidence on using the desired options. The reconfirmation and transition phases are then followed.

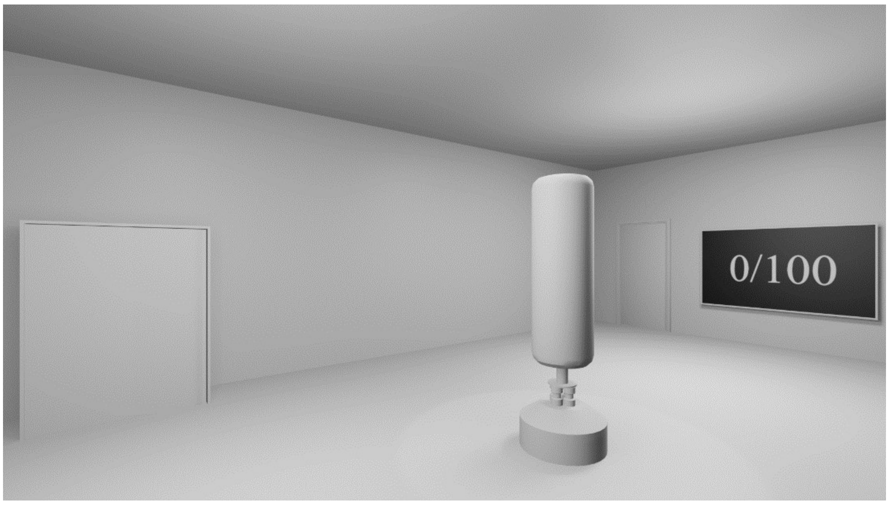

Figure 3.14. Challenge room 3: Punching bag room

Figure 3.15. Challenge room 3: Punching bag room options

Figure 3.16 depicts the fourth room that is shown to the participant. The premise for challenge room 4 was to collect a number of balls at the bottom of the pool to reduce the wait time before the door to the next room unlocks as the presented option can be seen in figure 3.17. The options given to the participants were the number of balls they would choose to dive and collect. Collecting more balls would reduce more of the wait time but they would need to spend more time collecting and the inverse applies with less balls. Participants were to consider their confidence in the time and effort they would like to expend to collect the ball. The game then moves forward to the reconfirmation and transition phases.

Figure 3.16. Challenge room 4: Swimming room

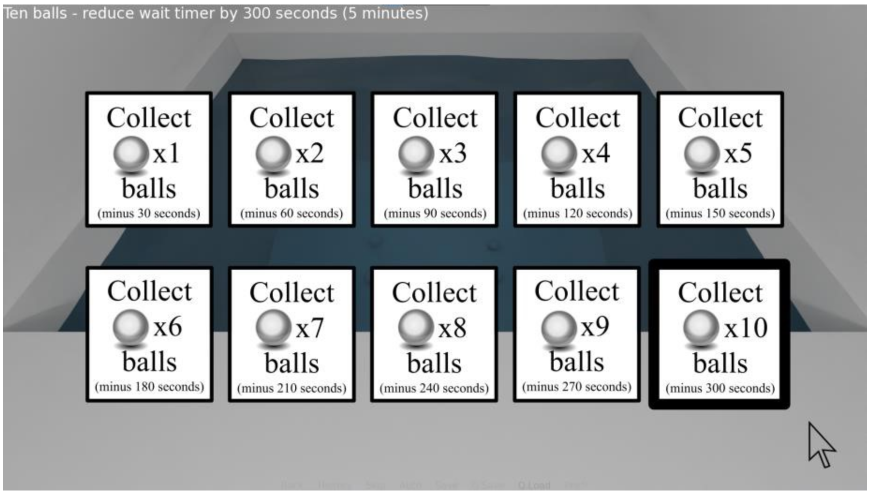

Figure 3.17. Challenge room 4: Swimming room options

Figure 3.18 depicts the fifth room that is shown to the participant. The premise for challenge room 3 was to fill a tank in the middle of the room to activate the fire extinguisher. The participants were to select an item for a nearby cabinet. The options given to the participant were a selection of items that can be used to carry water from the well to the water tank. Namely, the items were a funnel, syringe, mug, towel, glass bottle, teapot, ladle, bowl, plastic bag and sponge as seen in Figure 3.19. Participants were to determine the most ideal option that could reliably carry water as they take the size and suitability into account of the offered options. The game then proceeds to the reconfirmation and transition phases.

Figure 3.18. Challenge room 5: Wall of fire room

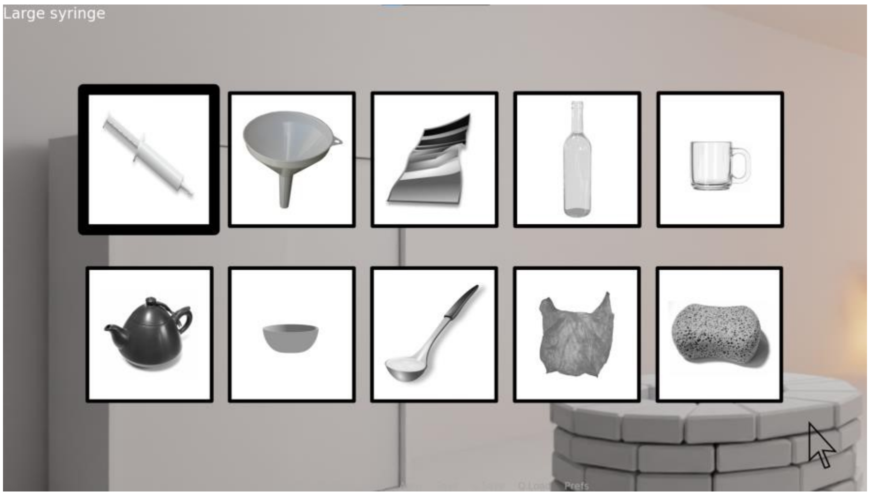

Figure 3.19. Challenge room 5: Wall of fire room options

Figure 3.20 depicts the sixth room that is shown to the participant. The premise for challenge room 6 was to run to a specific door with a certain number of locks at varying distances in a short period as presented as a side view of the room in Figure 3.21. The closest door would have the most number of locks, specifically 10, whereas the farthest would have the least number of locks of which there is only one lock. The scenario prompts the participants to deliberate on rushing to the door with the optimal distance from the button with regard to the number of locks. The options given to the participants were the door they would like to run towards. The process would then continue with the reconfirmation and transition phases.

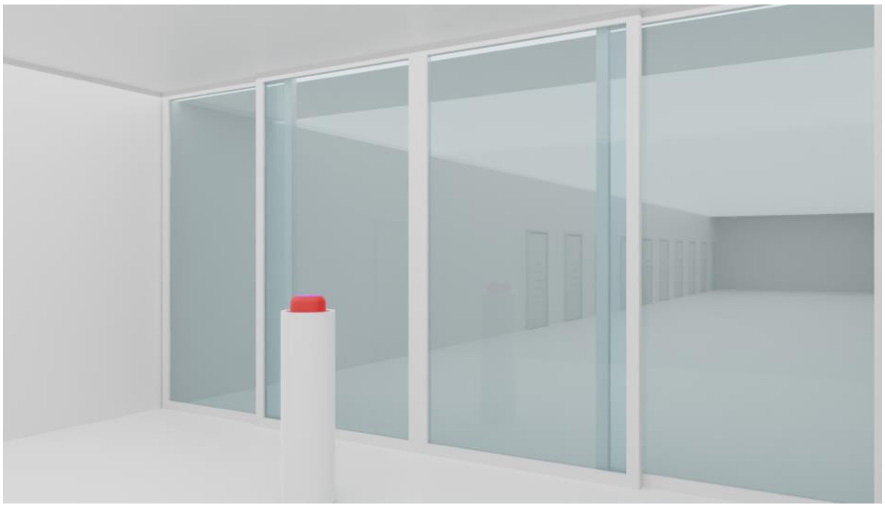

Figure 3.20. Challenge room 6: Running room

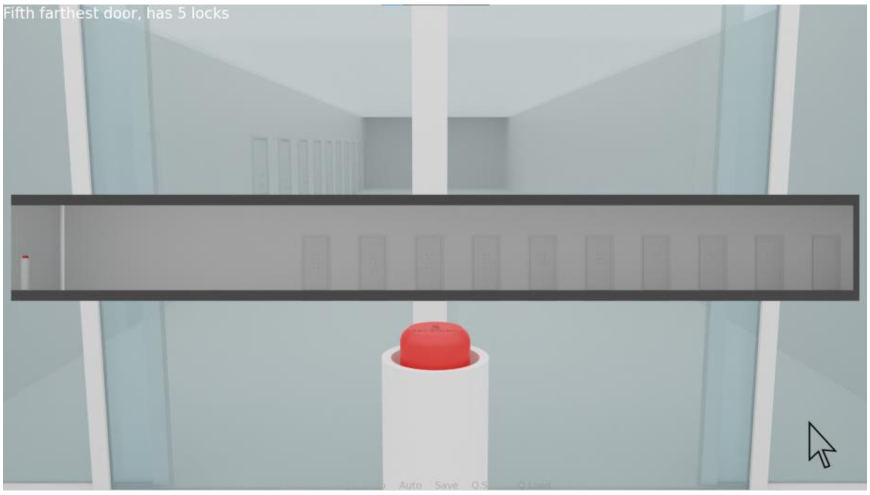

Figure 3.21. Challenge room 6: Running room options

Figure 3.22 depicts the seventh room that is shown to the participant. The premise for challenge room 7 was to choose a heavy-looking object to carry over to be placed on an uneven platform so that they may reach the key to the next room that is hooked onto the ceiling. The options as seen in Figure 3.23 were given to the participants. The selection of items of varying shapes which were a cylinder, sphere, cube, cone, ring, stone, pyramid, diamond, star and gear. Each object may conform more easily than another to the uneven surface but may not offer the most ideal support point and vice versa. The reconfirmation and transition phases then follow.

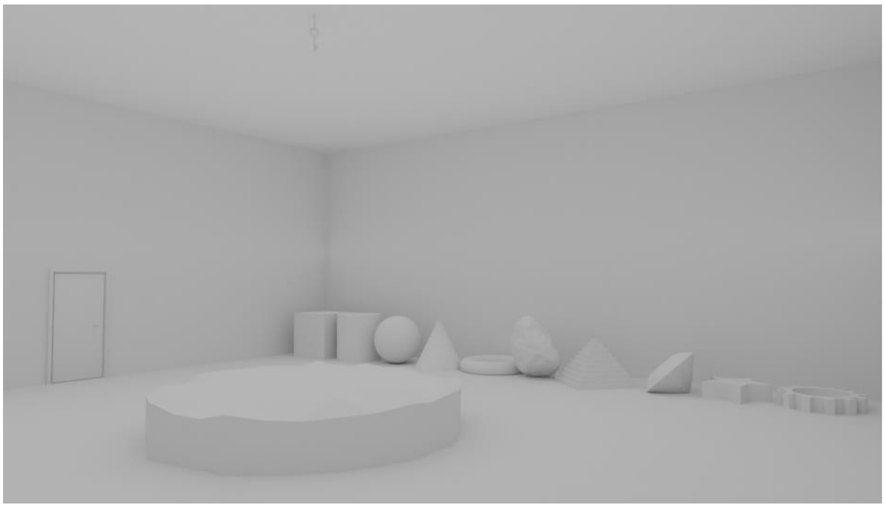

Figure 3.22. Challenge room 7: Balancing room

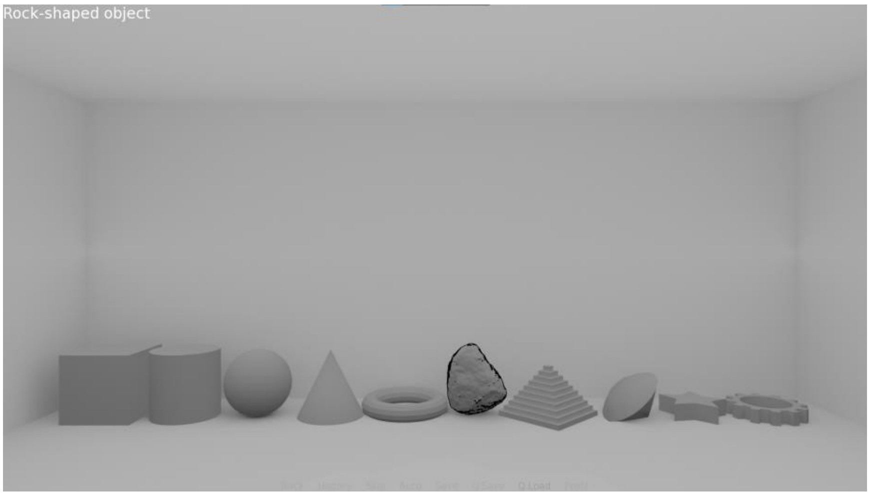

Figure 3.23. Challenge room 7: Balancing room options

Figure 3.24 depicts the eighth and last room that is shown to the participant. The premise for challenge room 8 was to choose a heavy-looking object to the side of the room opposing a door that was raised above the ground. The ground tilts to one side when an object is pushed towards it. The options of heavy objects, a tombstone, water-filled barrel, bell, anchor, cabinet, rolled carpet, sandbag, fire hydrant, metal safe and large tyre were given to the participants as shown in Figure 3.25. Some objects are notably heavier than others whereas others might be easier to maneuver to move. Following this, the reconfirmation phase would proceed, and the game would show the final room of the game which consists of a single exit door. The robot states the completion of the game to participants and reminds them to fill out the questionnaire that appears later after the game ends. The game closes automatically at the end of the game and shows the questionnaire window.

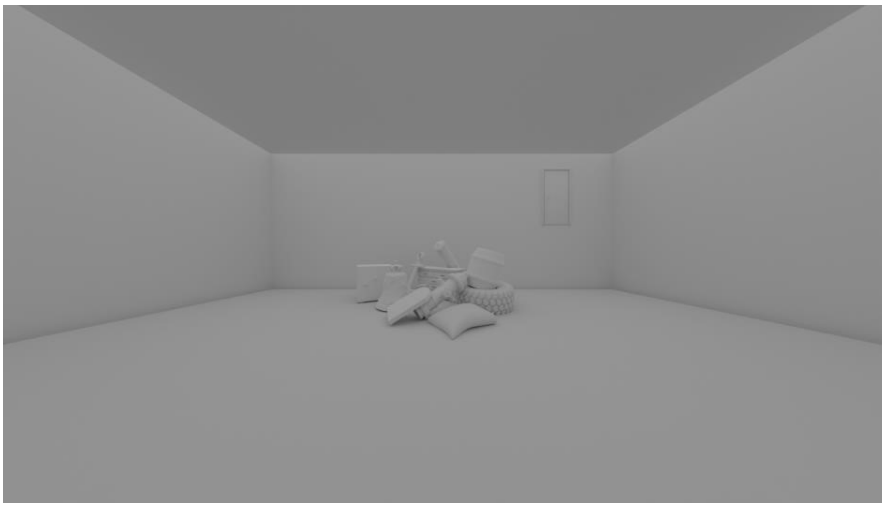

Figure 3.24. Challenge room 8: See-saw room

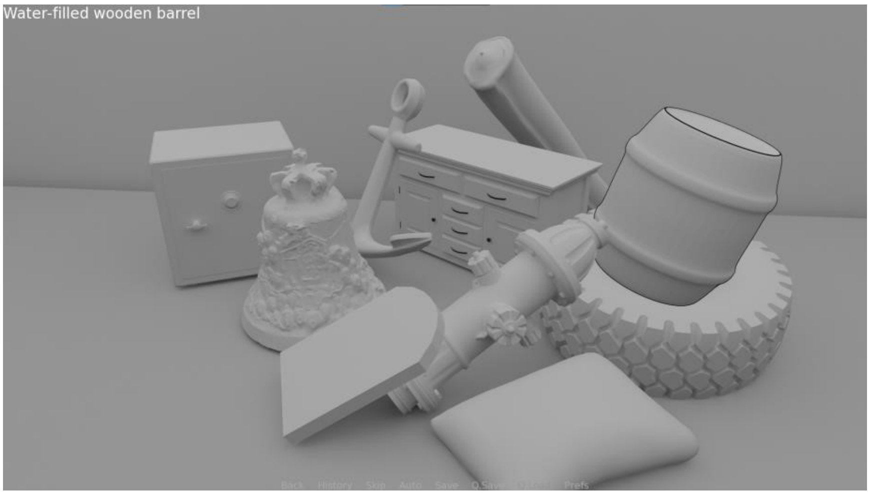

Figure 3.25. Challenge room 8: See-saw room options

3.3 Game-Robot Integration

Initially, it was presumed that seamless integration between Alphamini and the developed Ren'Py game would be possible, considering that both systems function on similar syntaxes, which are based on the Python programming language. Ren'Py also has shown promise with its capability of Python module integration. However, several issues arose throughout development. An issue persistent throughout development was the mismatched Python version between the Python scripts conveying the commands to the Alphamini robot and the Python version Downgrading to a previous version of Ren'Py fundamentally incompatible with the Alphamini Python module. Furthermore, the system relies on Google's cloud-based processing of TTS application programming interface (API). Thus, any irregularities on the internet network connection may cause the robot to interrupt itself mid-speech or drop whole commands entirely. This issue is resolved in the final iteration of the integration.

As Ren'Py was inherently incompatible with the Alphamini Python module, a separate Python module that was compatible was used instead to function as the interface between the robot and the game. The module used was called "subprocess". The module allows for the execution of the Alphamini TTS scripts on a separate, non-intrusive Python terminal with the option of waiting for the execution to complete before progressing through the game.

To resolve the potential connection and sentence-dropping issues, the socket Python module was used. The socket module allows for communication between multiple Python terminals at a time. Essentially, a Python script consisting of TTS commands was executed before the start of the game. The script waits for string-type data from the game before executing specific TTS commands.

3.4 Experiment Setup

Several core components make up the collection of elements present in the system. The core components were the Alphamini robot and game inputs for hardware elements and the Python server, Ren'Py and Excel file for software elements as seen in Figure 3.26.

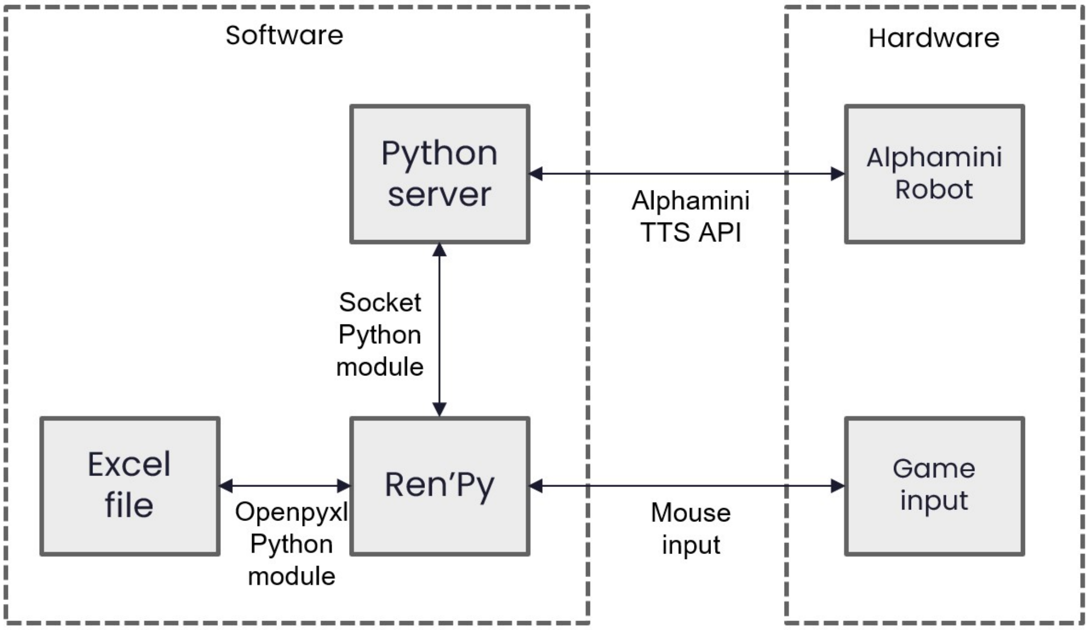

Figure 3.26. Overview of the system's core elements

3.4.1 Position of Experiment Setup

As designated to investigate the second and third objectives, a fully functioning serious game integrated with robot as a system was developed (objective one). The main elements present during the full experiment setup were a mouse, a keyboard, the Alphamini robot, and a monitor screen that depicts the game. The experimental set up was sectioned off using black cloth to avoid distractions from other objects present within the room. A partial view of the setup is seen in Figure 3.27. Figure 3.28 shows the arrangement of the other elements of the system. A closer look at the social robot used in the study, Alphamini can be seen in Figure 3.29.

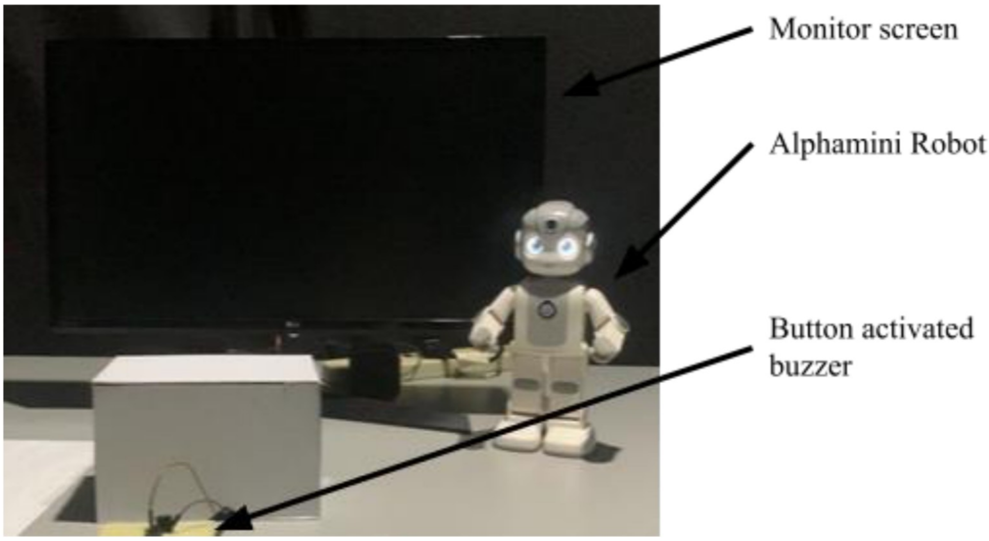

Figure 3.27. Participant's point of view during the experiment

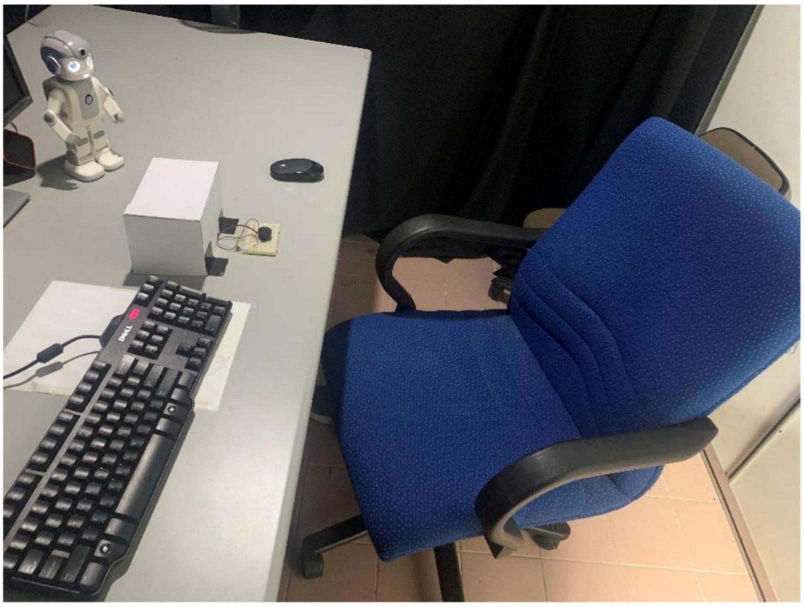

Figure 3.28. Placement of system elements

Figure 3.29. Alphamini robot while on standby

3.4.2 Experiment Procedure

Participants were randomly assigned to four separate groups, each representing a social cues modality. The groups were subjected to engagement with the robot in a two (high vs. low controlling) by two (with social praise vs. without social praise) in a between-subjects experimental design. Figure 3.30 showcases the flowchart of the experiment. This flowchart was also given to participants for their perusal for reference throughout the experiment. Before the experiment began, the participants were guided towards a room, separate from where the experiment was conducted. The experimenter would then introduce themselves and give the participant a consent form, which contains the details of the experiment. The participants were then instructed to read through the consent form. Upon agreement, the participants were then asked to fill out and sign the form.

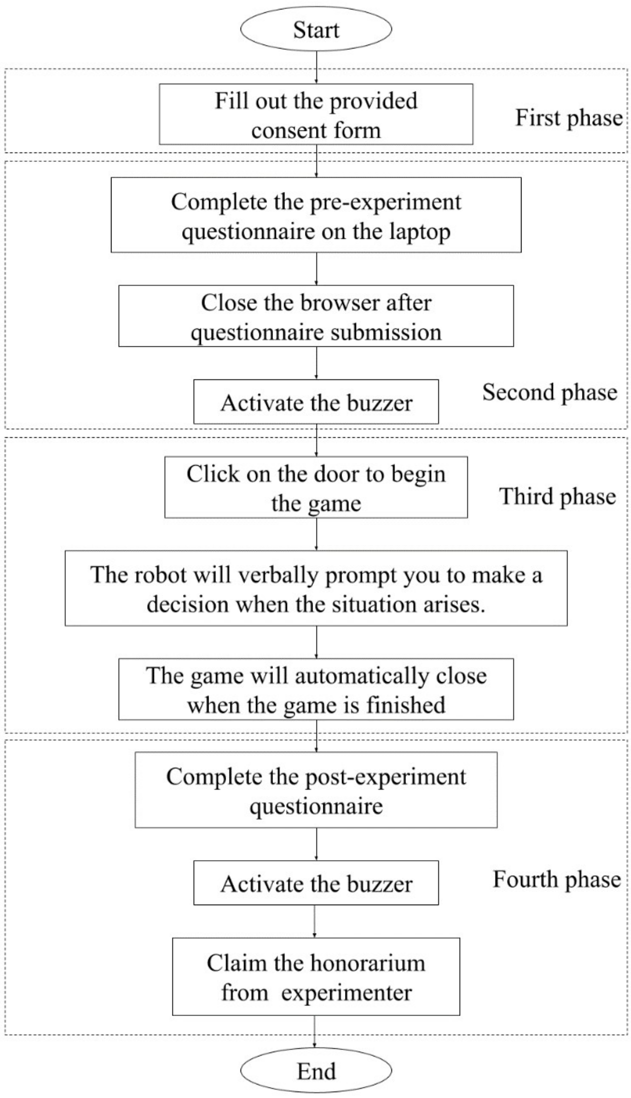

Figure 3.30. Flowchart of experimental procedure

The participants were to make themselves comfortable on the chair facing the monitor screen. The participants were then instructed to fill out the first questionnaire hosted through Google Form on the monitor screen using the accompanying keyboard and mouse after the experimenter leaves the room to offer privacy. The first questionnaire serves as a baseline of the study, which includes the perception of experienced stress. Prior to leaving, the experimenter would demonstrate the use of a button-activated buzzer. Upon completion and submission of the questionnaire, the participant may use the buzzer to prompt the experimenter to reenter the room. After the participants submit the questionnaire and call upon the experimenter using the buzzer, the experimenter would then return and open a game window to demonstrate to the participant how to play the game. The experimenter would launch a demo version of the game showcasing basic game elements and the means of which to interact with in addition to the explanation context sensitive elements. Figure 3.31 shows the demo version of the game and the fundamental game elements and mechanics.

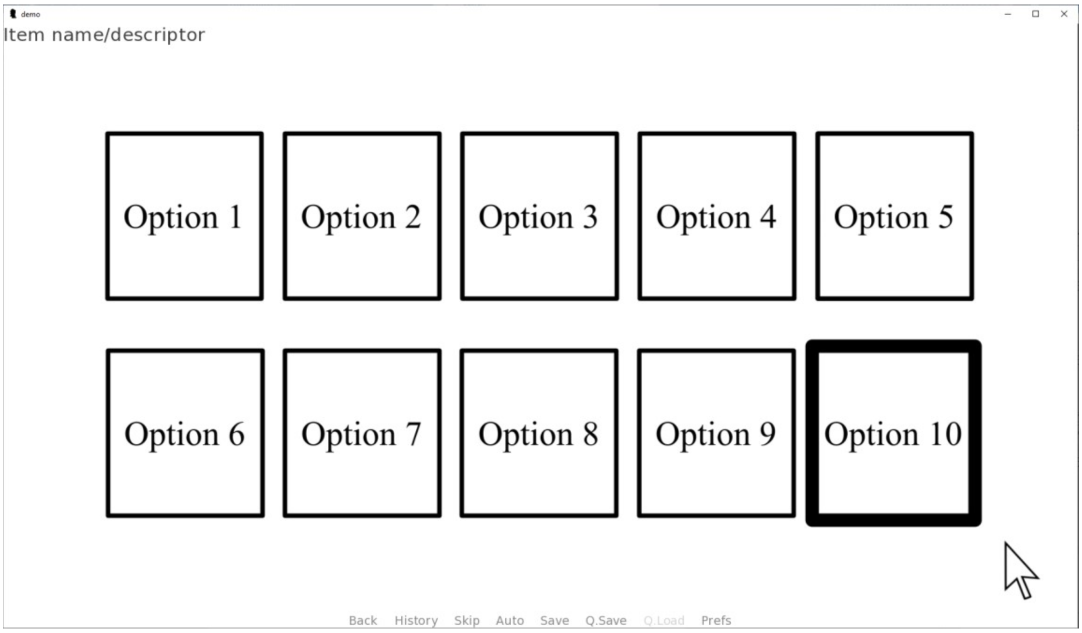

Figure 3.31. Demo game presented by the experimenter prior to the start of the experiment

At the end of the demonstration, the experimenter would answer any question posed by the participant, if any, and would prepare to run the full game. Before launching the full game and leaving, the experimenter would explain that the game would automatically quit, and the second questionnaire should appear on the monitor and the participant were to use the buzzer should any issues arise or upon submission of the second questionnaire. The second questionnaire collects data on the participant's perception of experienced stress and the perception of aspects exhibited by the robot. The experimenter would then leave the room and the experiment would begin. The participant would then click on the door in the game to begin as seen in Figure 3.9. The Alphamini robot would briefly introduce itself before describing the context of the game setting. The Alphamini robot would prompt clicking on certain game elements such as a door, buttons, or other objects throughout the progressing of the game. Section 3.2.8 describes the eight rooms in more detail. When the participant enters a room, the Alphamini robot would essentially describe the items present in each room as the game would zoom and pan to focus on each item. When enough details are obtained, the challenge of each room would be stated phrased as a deduction towards the participant before prompting a game menu showing the options available to solve the challenge. Regardless of which choice the participant chooses, the Alphamini robot would always offer an alternative choice before prompting the same options again. After the participant makes their second choice, the game proceeds towards the next room and the process repeats until all eight rooms are completed. Throughout the entire process, the Alphamini robot would exercise the use of high or low controlling language with or without the use of social praise depending on which group the participants were assigned to. This step is taken to develop the fundamental of social cues applications of the robot that would elicit the least amount of stress which aligns with the second objective.

At the end of the game, the Alphamini robot would remind the participants to complete and submit the second questionnaire before saying farewell and the game quits. Upon submission of the second questionnaire, the participants were then to press on the buzzer signifying their completion of the assigned task. The experimenter would thank the participant, offer further clarification on any inquiry by the participants and disbursed the honorarium before excusing the participants. The honorariums disbursed were in the form of RM15 in cash for each participant. Overall, the tasks could be generalized into four main phases. The first phase consists of filling out the consent form as a preliminary step. The second phase is the process of filling out the first questionnaire. The following phase is the playthrough of the game itself. Lastly, the final phase requires the participants to complete the remaining questionnaire and claim the honorarium from the experimenter.

3.4.3 Preliminary Study on the Developed Serious Game

To address the first objective of designing a minimally stress inducing decision-making serious game, a pilot study was conducted. One group would be undergoing the experiment without the robot whereas the other group would be proceeding through the experiment with the robot present. The aim was to determine whether the game by itself would incur a stress response from the participants.

For the group of participants without the robot, the lines that would have been said by the robot were shown on screen instead as seen in Figure 3.32 The settings used for the in-game text narration peruse the high controlling language without the use of social praise. An example of the high-controlling language line used is “It seems to be locked. We will have to clear this rooms challenge before we can unlock the door to the next room.” An example of the same line using low-controlling language is “It seems to be locked. We might have to clear this rooms challenge before we can unlock the door to the next room.” All other parameters of the game remain unchanged from the main procedure.

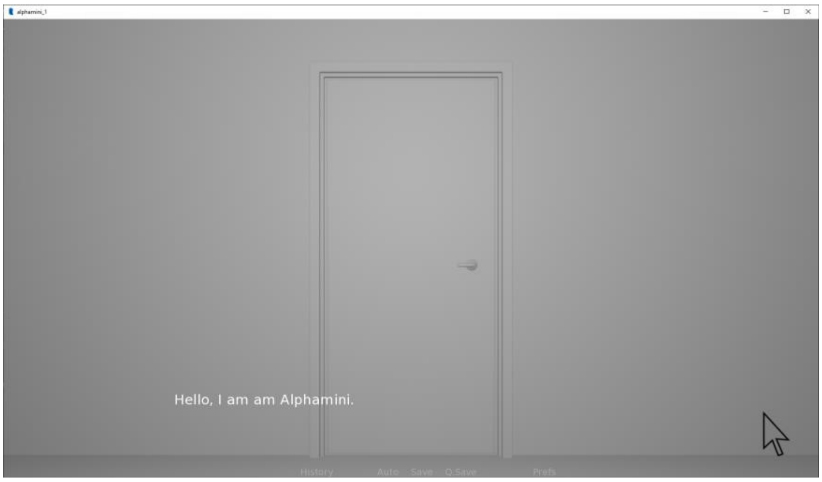

Figure 3.32. Depiction of the game for the pilot study

3.4.4 Questionnaire

Two separate questionnaires were utilized in the study. The first of which is the State-Trait Anxiety Inventory (STAI) which consists of 6 items on a 4-point Likert scale that measures the participant's general stress state. Each item is a statement that describes a particular feeling, and the participants were to gauge their agreement with the statement with one being least agreed with and four being most agreed with. The STAI questionnaire as depicted in Table 3.1 was prompted to the participants twice, once at the start and again at the end of the experiment as the pre-experiment and post-experiment questionnaire respectively. The second questionnaire is an adaptation of questions that gauge certain qualities that the robot exhibits and the participants' response throughout the experiment as shown in Table 3.2 is prompted as a post-experiment questionnaire that is prompted after the game ends (Ghazali et. al., 2020). The sets of questions could be split into the description of responses namely usefulness, ease, attitude, liking, intention, enjoyment, liking belief and reactance. All sets of statements, except for reactance, are measured using a 7-point Likert scale with one being least agreed with and seven being most agreed with. The reactance question set consists of five statements. The first four statements were measured on a 4-point Likert scale whereas the last question was measured through the frequency of words that represent the negative cognitions expressed. A distinction to note between reactance and stress is that reactance is defined by aversion to the robot explicitly whereas stress is the participants' own expression of emotional displeasure.

Table 3.1 Breakdown of statements for the STAI assessment

Questions
I feel upset
I feel uncomfortable
I feel indecisive (hesitant)
I feel jittery (nervous)
I feel confused
I feel worried

Table 3.2 Breakdown of statements according to participant responses

Responses	Items
Usefulness	I can decide more quickly and easily the options I want to choose than without using this robotic advisor
	I can better decide to which options I want to choose than without using this robotic advisor
	I am better informed about the suggested options
	I can decide more quickly and more easily whether I want to choose the suggested option or not
	I can better decide whether I want to choose the suggested option or not
Ease	Interaction with this robotic advisor is clear and understandable
	Interaction with this robotic advisor does not require a lot of mental effort
	I find it is easy to use this robotic advisor
	I believe that the use of this robotic advisor is trouble-free
Attitude	I have a favorable attitude towards using this robotic advisor
	I like the idea of providing information about the options through this robotic advisor
	I believe that this robotic advisor is beneficial in improving my decision
	Using this robotic advisor to improve my knowledge about the options would be a good idea
Intention	I would intend to use it
	I predict that I would use it
	I would certainly use it
	I would say something favourable about this robotic advisor
Enjoy	I would find using this robotic advisor to be enjoyable
	I would find using this robotic advisor to be fun
	I would find using this robotic advisor to be entertaining
	I would find using this robotic advisor to be exciting

Table 3.2 Breakdown of statements according to participant responses (cont.)

Liking	This robotic advisor was approachable
	This robotic advisor was confident
	This robotic advisor was likeable
	This robotic advisor was trustworthy
	This robotic advisor was interesting
	This robotic advisor was friendly
	This robotic advisor was sincere
	This robotic advisor was warm
	This robotic advisor was competent
	This robotic advisor was informed
	This robotic advisor was credible
	This robotic advisor was modest
	This robotic advisor was honest
Belief	This robotic advisor behaves in an ethical manner
	I am confident of the intentions, actions, and outputs of this robotic advisor
	I am not wary of this robotic advisor
	I am confident with this robotic advisor
	I will trust this robotic advisor if it gives me advice again in the future
	I trust that this robotic advisor can provide me with the best advice
	I will follow the advice that this robotic advisor gives me
Reactance	I feel irritated towards this robotic advisor
	I feel angry towards this robotic advisor
	I feel annoyed towards this robotic advisor
	I feel aggravated (infuriated) towards this robotic advisor
	Please report all the thoughts you had while receiving the advice from this robotic advisor, even those thoughts had nothing to do with the advice. Then, please indicate for all thoughts whether it is positive (P), neutral (Neu) or negative (N) thought.

3.4.5 Compliance

Compliance is deliberated through the comparison between the participant's initial choice and subsequent choice after the robot has offered an alternative suggestion. Data is collected using the "openpyxl" module integrated with the Ren'Py game code which allows for the assignment of variable values in a selected Excel spreadsheet. The change or persistence between options was individually compared to identify compliance in which a change in choice would be defined as compliance.

3.5 Analysis

The analysis of the data collected from the experiment was tabulated in a Microsoft Excel spreadsheet and later exported as a ".csv" file to be processed using the IBM SPSS Statistics 27 software. The following subsection for analysis utilizes the use of the exported Microsoft Excel file of the data collected from the questionnaires that was then converted into a comma-separated values file that can be processed using the IBM SPSS Statistics software.

3.5.1 Cronbach's Alpha

The Cronbach's Alpha, denoted with the α symbol, is an especially useful mathematical function that allows for identifying the internal consistency of the collected data (Cronbach, 1951). Identifying Cronbach's Alpha allows for the affirmation of congruency among the collected data points. The Cronbach's Alpha is, as was used in this research, was used on the results obtained from the questionnaires. The mathematical formula to identify Cronbach's alpha is seen below:

$$\alpha = \frac{Nc}{v+(N-1)c} \text{ ……………………..(1)}$$

Where N is the number of items, c is the is the covariance between the items and v is the average variance.

3.5.2 Analysis of Variance (ANOVA)

The statistical significance of the data could be obtained through the use of a selection of mathematical models described as the Analysis of Variance which is abbreviated as ANOVA (Fisher, 1919). ANOVA is a commonly applied statistical analysis technique which allows for the potential identification of aspects that affect the results of an experiment. The process is done through the segregation of variance within the data and corresponding reassignment towards possible associated factors. The effects of the variables induced through the experiment could be quantitively assessed through the use of the software. The following describes the process in which the ANOVA is conducted after the collected data was imported into the SPSS software. Executing the ANOVA allows for the determination of if a set of data results in a credible effect on a certain parameter.

1. Variable assignment: the variables that define each corresponding items were assigned a unique identifier. Additionally, the variable types were also assigned at this stage. Certain processing parameters requires the variables stored to be of a certain type.
2. Generate average values: As the questionnaires contain a set of questions that correspond to a specific dependent variable, the average value of each set must be obtained through a function present within the software.

3. Ascertaining the Cronbach's Alpha: the Cronbach's Alpha value is attained through the use of the reliability analysis tab and inputting the averaged depended variable values.
4. The analysis process is then followed by using the univariate or multivariate analysis of the general linear model tab. Other parameters such as the presence of covariates, output data generation, confidence interval value and others are set at this stage.
5. The data is outputted in the Viewer window in accordance to the set parameters.

3.5.3 Correlation

The Pearson Correlation Coefficient, expressed as *r,* is method of which the level of association between participant responses are measured. Correlation can be described as having a strong or low correlation, linearly described between 0 to 1 and -1. The correlation values would be in correspondence to having either a positive or negative correlation with values further away from 0 signifying a higher correlation value. For example, *r* values between 0 and 0.3 would account for low positive correlation. Inversely, *r* values between 0 and -0.3 represents a low negative correlation. *r* values between 0.3 and 0.5 denotes a medium positive correlation whereas negative values between -0.3 and -0.5 describes a medium negative correlation. A high positive or negative correlation value is depicted as *r* values of ranges between 0.5 and 1 and ranges between -0.5 and -1 respectively (Schober, Boer, & Schwarte, 2018). The variables are keyed in through the analysis tab which contains the bivariate correlation analysis tool.

3.5.4 Compliance

The state of the options selection of which each participant has made was recorded. A matter to note is that the system only records the choices the participants make. The choices must be compared during post-processing through the process of individually comparing the first and second choice the participants make in each room. Upon importing into the SPSS software, a numerical variable of 0 and 1 was assigned for the persistence to their first choice or the change from their initial choice respectively.

3.5.5 Galvanic Skin Response

Initially, the use of a galvanic skin response sensor was proposed as a reference point to measure the biological signal from the participants as a means of measuring the stress response. The sensor functions by measuring the skin resistivity between two points on the skin as the sweat glands produce sweat when the participant experiences stress. However, the use of the sensor as a measure was deemed unusable as the predetermined phases in which the participants experienced stress varied greatly as there were no fixed periods allocated to the participants during the phases. Additionally, the STAI analysis has shown to be effective as the designated tool of the proposed purpose.

3.6 Chapter summary

This chapter discusses the process and procedures that were conducted during the execution at each stage of the research. Topics discussed include the main elements of the experiment, namely the experimental setup and the corresponding procedures perusing the setup. Additionally, methods of processing the data by identifying significant differences between groups through ANOVA and ascertaining Pearson correlations between responses were established. Also processed were the observed internal consistencies of the questionnaire results using Cronbach's Alpha and distribution of compliance across all groups.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The following sections describes the results and the analysis of the data obtained from the studies described in the previous chapter. The sections are mainly composed of the preliminary assessments, data analysis, subsequent results of hypothesis tests and discussions.

4.2 The Development of a Serious Game in a Low-stress Environment

12 participants were recruited to resolve the first objective of identifying the potential elicitation of stress from the serious game with the presence or absence of the robot. The participants were separated into two groups of 6 as depicted in Table 4.1.

Table 4.1 The average anxiety score of participants in the experiment involving the presence or absence of the robot

Robot presence	Mean	Std. Deviation	N
Present	1.43	0.3	6
Absent	1.57	0.47	6

Figure 4.1 depicts the resulting STAI average values of the two groups. Through ANOVA, the results provide no evidence that participants who underwent the experiment with the robot showed had an anxiety score (M = 1.43, SD = 0.3) that was higher than the anxiety score (M = 1.57, SD = 0.47) of participants without the robot, $F(1,10) = 0.35$, p = 0.57. Thus, the current findings suggest that game design can function without eliciting stress from the participants.

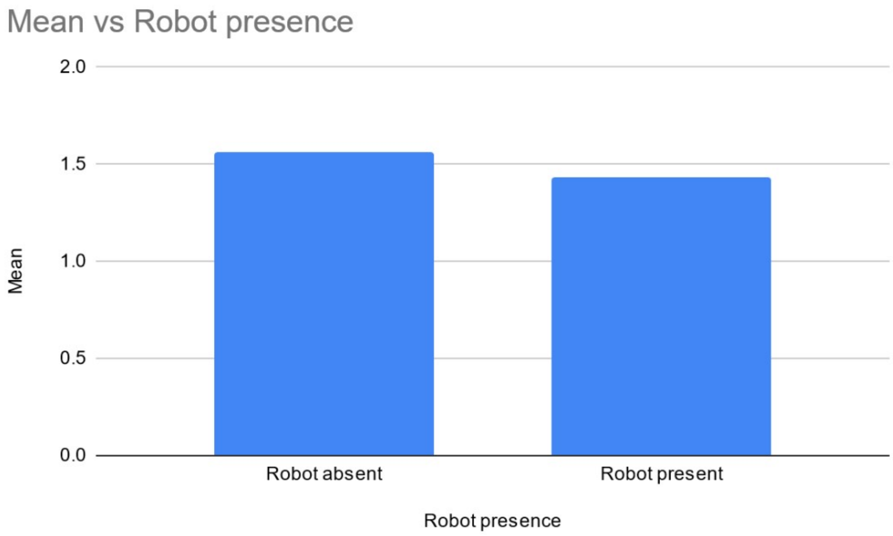

Figure 4.1 Means of STAI questionnaire for the pilot study.

4.3 Determining the Appropriate Social Cues Modality

With the matter on the functional effectiveness of the serious game ascertained, the study proceeded with the system fully integrated with the Alphamini robot. Collected participants were then assigned to groups corresponding to the social cues that would be exhibited by the robot and the output data is prepared for analysis.

4.3.1 Demographic Information

Table 4.2 and Table 4.3 describe the demographic information of the participant's age and gender. 60 participants, 41 males and 19 females took part in the experiment with ages ranging from 19 to 25 years old ($M = 22.17$, $SD = 1.291$). Table 4.4 describes the participant allocation to a mode of utilization of the social cues.

Table 4.2: Participants' age distribution

N	Minimum	Maximum	Mean	Std. Deviation
60	19	25	22.17	1.291

Table 4.3: Participants' gender distribution

Gender	Frequency	Percentage
Female	19	31.7
Male	41	68.3
Total	60	100.0

Table 4.4: Participants' social cues distribution according to experimental design

Controlling language	Social praise	Frequency
High	Present	16
	Absent	15
Low	Present	15
	Absent	14
Total		60

4.3.2 Measurement scale reliability

To assess the internal reliability of the measures used, we calculated for each measure the Cronbach's Alpha (by the SPSS software). As the average value is mostly above 0.7, it is considered to be above the acceptable value and thus further analysis can be conducted (Nunnally, 1978). Table 4.5 lists the Cronbach's Alpha values for the STAI questionnaires that were answered prior to and after the experiment, designated as pre-experiment and post-experiment respectively. Table 4.6 depicts the Cronbach's Alpha values for the participants' responses for each individual variable respectively.

Table 4.5: Cronbach's Alpha value of the STAI questionnaire results

Experiment state	Cronbach's Alpha	N of Items
Pre-experiment	0.814	6
Post-experiment	0.795	6

Table 4.6: Cronbach's Alpha value for each variable

Variable	Cronbach's Alpha	N of Items
Usefulness	0.680	5
Ease	0.718	4
Attitude	0.732	4
Intention	0.882	4
Enjoy	0.955	4
Liking	0.922	13
Belief	0.895	7
Reactance	0.859	5

4.3.3 The Effects of the Robot's usage of Social Cues

The usefulness dependent variable is denoted by the perception of participants towards the usefulness of the Alphamini robot after undergoing a short interactive experience with the robot. Table 4.7 depicts the descriptive statistics of the average value of the perceived usefulness. There was a fairly significant difference on perceived usefulness according to the participants $F(1, 56) = 2.66$, $p = 0.11$ partial $\eta^2 = 0.05$. Based on the produced output, participants found that the social robot is most useful when it exhibits high controlling language without the presence of social praise ($M = 5.19$, $SD = 0.79$). Conversely, the participants found that the social robot is least useful when it utilizes high controlling language with the inclusion of social praise ($M = 4.7$, $SD = 1.13$).

Table 4.7: Descriptive statistics of the usefulness dependent variable

ControllingLanguage	SocialPraise	Mean	Std. Deviation
Low	Absent	4.81	0.95
	Present	5.09	0.69
	Total	4.96	0.83
High	Absent	5.19	0.79
	Present	4.7	1.13
	Total	4.94	0.99
Total	Absent	5.01	0.88
	Present	4.89	0.95
	Total	4.95	0.91

The remaining participant responses for ease $F(1, 56) = 0.001$, $p = 0.98$), attitude $F(1, 56) = 0.34$, $p = 0.56$), intentions $F(1, 56) = 0.145$, $p = 0.71$), enjoyment $F(1, 56) = 0.23$, $p = 0.63$), liking $F(1, 56) = 0.3$, $p = 0.59$), beliefs $F(1, 56) = 0.84$, $p = 0.77$), and reactance $F(1, 56) = 0.02$, $p = 0.89$) did not yield statistically significant difference on social responses from the use the social cues across all four groups. However, interestingly, there were some statistically significant influences of the use of social cues on individual items. Further details will be discussed in section 4.6.

4.3.4 Perceived Stress

Perusing the STAI test questionnaire that was collected prior to and after the experiment, the perceived stress by the participants after conducting the experiment could be studied. Among the four groups, none distinctly experienced more levels of stress than another. However, there was a statistically significant reduction in stress experienced by the participant. $F(1,112) = 5.04$, $p = 0.03$ between the start and the end of the experiment. That is, at the start, participants had an average STAI score that was higher ($M = 1.49$, $SD = 0.41$) than at the end ($M = 1.33$, $SD = 0.38$). This finding supports H1 as corroborated by the findings of robot interaction does not incite stress by Su et. al. (2023).

4.4 Compliance

Using a repeated measures test, a pairwise comparison test can be conducted to identify potentially statistically significant results between the rate of compliance as the participants proceed through each room. Between the four groups, there were no statistically significant differences between the rates of compliance, all Fs < 1. Thereby, results suggested that the use of either high or low controlling language with or without the use of social praise by the Alphamini robot has no significant effect on the participants' compliance $F(6.16, 320.22) = 0.75$, $p = 0.61$. However, some insights could be provided by the average compliance rate of all the participants as shown in in Table 4.8. The distribution of average compliance in each room is visualized as a graph in Figure 4.2 and the standard deviation values are as shown in Table 4.9.

Table 4.8: Mean values of compliance for all participants in each room

Room number	Mean
1	0.50
2	0.41
3	0.61
4	0.70
5	0.46
6	0.55
7	0.54
8	0.61

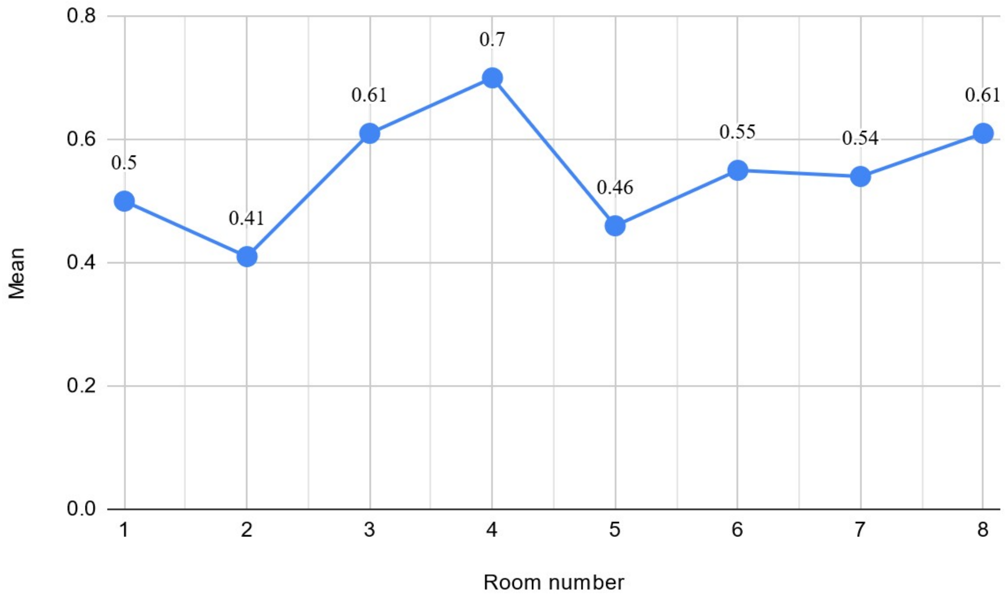

Figure 4.2: Mean values of compliance for each room of all participants

Table 4.9: Standard deviation values for compliance across 8 rooms

Room	Std. Deviation
1	0.95
2	0.69
3	0.83
4	0.79
5	1.13
6	0.99
7	0.88
8	0.95

There was an even split between the participants with one half complying with the robot's suggestion and the other half choosing not to in the first room. In the following room, the compliance rate dropped slightly due to more participants choosing to disagree with the robot. In this particular instance, this drop in compliance rate is potentially due to participants choosing to choose an alternative choice due to curiosity of picking an alternative choice with more choosing to disagree with the robot's suggestion. A notable steep rise in compliance could be seen in the fourth room. The fourth room introduced a relatively intricate problem involving the consideration of spatial and temporal assessment which may have confused some of the participants, resulting in deferring the choice to the robot. Incidentally, the fourth room also introduced a visually different selection menu prompt, which might have further contributed to the matter. From the fifth room onwards, the compliance rate appears to plateau with a slight incline in compliance, possibly due to a buildup of trust (Formosa, 2021).

4.5 Correlation between Social Responses

To resolve the third objective pertaining to benchmarking the correlation between the participant's social responses after interacting with the social robot, a Pearson correlation analysis was conducted. Using the Pearson correlation tool on the SPSS software, the following data depicted in Table 4.10 was produced.

Table 4.10: Pearson correlation statistics of the responses

Response		Ease	Attitude	Intentions	Enjoy	Liking	Beliefs
Ease	Pearson Correlation	--					
	Sig. (2-tailed)						
Attitude	Pearson Correlation	.513**	--				
	Sig. (2-tailed)	<0.001					
Intentions	Pearson Correlation	.378**	.680**	--			
	Sig. (2-tailed)	0.003	<0.001				
Enjoy	Pearson Correlation	.264*	.452**	.751**	--		
	Sig. (2-tailed)	0.042	<0.001	<0.001			
Liking	Pearson Correlation	.474**	.515**	.525**	.621**	--	
	Sig. (2-tailed)	<0.001	<0.001	<0.001	<0.001		
Beliefs	Pearson Correlation	.590**	.606**	.685**	.652**	.778**	--
	Sig. (2-tailed)	<0.001	<0.001	<0.001	<0.001	<0.001	
Reactance	Pearson Correlation	-.438**	-0.208	-.325*	-0.247	-.332**	-.444**
	Sig. (2-tailed)	<0.001	0.111	0.011	0.057	0.01	<0.001

Some observations can be deduced from the visualization of Figure 4.3 as visualized by lines of different thickness to represent the level of correlations. Additionally, solid lines designate positive correlations whereas dotted lines designate negative correlations. Most notably, there is a strong correlation between the intention and enjoyment of using the robot. Namely, those that enjoyed their experience with the robot would have intentions to use the robot again in the future, $r(58) = .075$, $p = .001$. Other positive correlations were observed in most of the other responses which are in line with the findings of Ghazali et. al. (2020). Correlations on the remaining responses; ease and enjoyment, ease and attitude, and attitude and intentions could also be observed based on the technology acceptance models by Roubroeks et. al., (2009) and Heerink (2007).

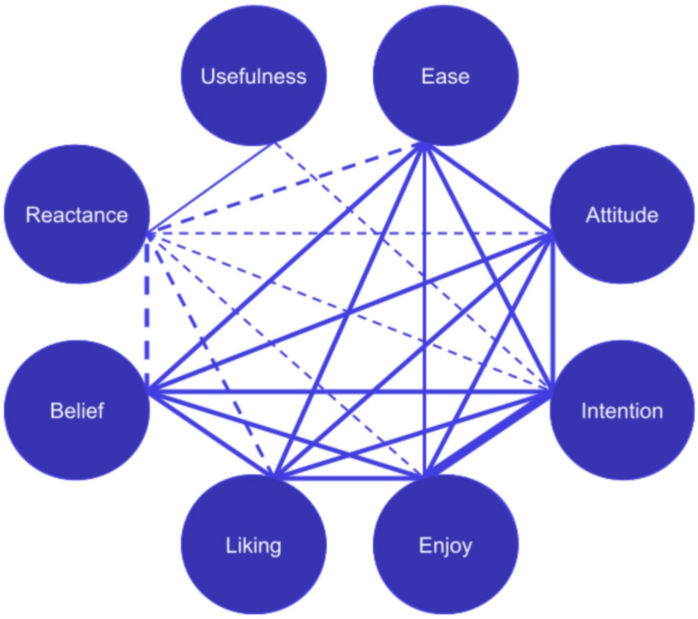

Figure 4.3: Graphical correlations between the dependent variables

Furthermore, there are only two statistically significant correlations of intent $r(58) = -0.19$, $p = 0.08$ and reactance $r(58) = 0.18$, $p = 0.09$ to usefulness with the prior being negatively correlated. Overall, except for usefulness, it can be concluded that there are positive correlations between most of the dependent variables except for reactance which is negatively correlated with others which mostly confirms H4.

4.6 Exploratory Analysis

For individual item inspection, some items for each response had a statistically significant main or interaction effect. To reiterate, the prior measures utilized the means of the items in each respective social response group. For the following, ANOVA tests were conducted on each questionnaire item and the following are individual items sorted according to the social responses, if significant. Main effects separated the statistically significant findings in each application of social cues, irrespective of the presence of the other. Interaction effects on the other hand draws results from the significant responses when both social cues were accounted for. Among the four items present in the ease-of-use social response, none were statistically significant when contrasted among the four groups.

4.6.1 Usefulness

There is a notable variance between the perceived usefulness of social robots which is typically dependent on the robot's functional capabilities, aesthetic, and applications (Letheren et. al., 2021). Under our parameters, the following are statistically significant effects on the participant's perception of the robot's usefulness. There is a significant interaction effect of controlling language and social praise on the participants' capability to better decide if they would like to choose the suggested option $F(1,56) = 4.89$, $p = 0.03$, partial $\eta^2 = 0.08$. Participants think that they can better decide whether they want to choose the suggested option or not when it exhibits low controlling language without the presence of social praise ($M = 5.93$, $SD = 0.884$). Conversely, the participants do not think that they can better decide whether if they want to choose the suggested option or not when it utilizes high controlling language with the inclusion of social praise ($M = 5.19$, $SD = 1.642$).

The participants' capability to decide quickly and easily if they would choose the suggested option $F(1,56) = 5.63$, p = 0.02, partial $\eta^2 = 0.09$. Participants consider themselves to be able to decide more quickly and easily among the options they would choose than without using the robotic advisor when the robot uses high controlling language (*M* = 4,87, *SD* = 1.43) as opposed to when the robot is using low controlling language (*M* = 4.24, *SD* = 1.56).

There is a significant interaction effect of controlling language and social praise on the participant's understanding of the suggested options $F(1,56) = 3.72$, p = 0.06, partial η^2 = 0.06. Participants think that they are better informed about the suggested options when it exhibits low controlling language with the presence of social praise (*M* = 6.000, *SD* = 0.906). Conversely, the participants perceive the social robot to not be better informed about the suggested options when it utilizes high-controlling language with the inclusion of social praise (*M* = 4.4, *SD* = 1.5).

There is also a significant main effect of controlling language on the participant's understanding of the suggested options $F(1,56) = 8.3$, p = 0.006, partial $\eta^2 = 0.13$. Participants think that they are better informed about the suggested options when the robot uses low-controlling language (*M* = 5.83, *SD* = 1.1) as opposed to when the robot is using high-controlling language (*M* = 4.87, *SD* = 1.43).

4.6.2 Attitude

There is a significant interaction effect of controlling language and social praise on the participants' belief in the benefits of improving their decision $F(1,56) = 2.35$, p = 0.13, partial $\eta^2 = 0.04$. Participants found that the social robot is most beneficial in improving their decisions when it exhibits highly controlling language without the presence of social praise (M = 6.25, SD = 0.78). Conversely, the participants found that the social robot is less beneficial in improving their decisions when it utilizes highly controlling language with the inclusion of social praise (M = 5.87, SD = 0.64). This finding suggests that use of social praise diminishes the perceived benefits of using the robot.

4.6.3 Belief

A significant main effect of controlling language on the participants' perception of the robot behaving in an ethical manner was observed $F(1,56) = 2.93$, $p = 0.09$, partial $\eta^2 = 0.05$. Participants think the robotic advisor behaves in a more ethical manner when the robot uses high-controlling language (M = 6.14, SD = 1.09) as opposed to when the robot uses low-controlling language (M = 5.61, SD = 1.23.

There is also a significant interaction effect on the participants' likelihood to comply to the advice given by the robot $F(1,56) = 2.33$, $p = 0.13$, partial $\eta^2 = 0.04$. Participants feel like they are more likely to follow the advice given by the robot when the robot uses high controlling language with social praise (M = 4.88, SD = 1.2) and would feel least likely to comply when the robot uses high controlling language without social praise (M = 4.2, SD = 1.21) supporting the findings of Rossi et. al., (2020) in a study employing a perfunctory social cue modality. These findings also match the results of Ghazali et. al. (2019) with regard to the social cue's effects on trusting beliefs.

4.6.4 Enjoyment

There is a significant main effect on social praise on the participants' experience for the utilization of using the robot to be fun $F(1,56) = 3.02$, $p = 0.09$, partial $\eta^2 = 0.05$. Participants think using the robotic advisor was more fun when the robot used social praise ($M = 6.48$, $SD = 0.74$) than when the robot is not using social praise language ($M = 6.06$, $SD = 1.24$). The presence of social praise social cues solidifies the particular response of finding the use of the robot to be entertaining (Jimenez et. al., 2020).

4.6.5 Intention

There is a significant main effect of controlling language on the participants' likelihood to say something favorable about the robot $F(1,56) = 2.39$, $p = 0.13$, partial $\eta^2 = 0.041$. Participants would say something favorable when the robot uses high controlling language ($M = 5.74$, $SD = 9.10$) as than when the robot is using low controlling language ($M = 5.34$, $SD = 1.08$).

There is a significant main effect on social praise on the participants' certainty on using the robot $F(1,56) = 3.3$, $p = 0.08$, partial $\eta^2 = 0.06$. Participants think they would be more likely to use when the robot uses social praise ($M = 5.26$, $SD = 1.31$) as than when the robot is not using social praise language ($M = 4.59$, $SD = 1.43$). The impression of intimacy through the use of social praise supports the findings of Chien, Lin, & Chang (2022).

4.6.6 Liking

There is a significant main effect of controlling language on the participant's perception of the robot being honest *F*(1,56) = 2.23, p = 0.15, partial η^2 = 0.098. Participants think the robotic advisor was more honest when the robot used high controlling language (*M* = 6.32, *SD* = 0.83) than when the robot used low controlling language (*M* = 5.9, *SD* = 1.32) The participants also generally share the perception of the robot being sincere *F*(1,56) = 6.325, p = 0.0.15, partial η^2 = 0.101. Participants think the robotic advisor was more sincere when the robot used high controlling language (*M* = 5.97, *SD* = 1.048) than when the robot used low controlling language (*M* = 4.97, *SD* = 1.88). This observation is further supported by the findings of Daniel, Sebastian, and Takayuki (2021) in which the robot is perceived to be more competent.

There is a significant main effect on social praise on the participants' perception of the robot being friendly *F*(1,56) = 2.294, p = 0.136, partial η^2 = 0.0.36. Participants think the robotic advisor was more friendly when the robot gave out social praises (*M* = 5.9, *SD* = 1.3) than when the robot did not use social praise (*M* = 5.48, *SD* = 1.77). Liu, Shen and Hancock (2021) support this finding as the properties exhibited by the social cues is perceived to be pleasant.

There is also a significant main effect on social praise on the participant's perception of the robot being confident *F*(1,56) = 2.45, p = 0.12, partial η^2 = 0.04. Participants think the robotic advisor was more confident when the robot does not use social praise (*M* = 6.48, *SD* = 0.74) than when the robot is using social praise language (*M* = 6.06, *SD* = 1.24).

4.6.7 Reactance

Reactance is described by negative cognitions experienced by the participants typically associated by aversion towards the social robot. There is a significant main effect on social praise on the participants' emotion of anger towards the robot $F(1,56) = 3.4$, $p = 0.06$, partial $\eta^2 = 0.07$. Participants feel angry at the robotic advisor when the robot uses high controlling language ($M = 1.79$, $SD = 1.05$) as than when the robot is using low controlling language ($M = 1.39$, $SD = 0.56$) which has been similarly observed in a study on reactance by Roubroeks et. al. (2009) despite a discrepancy in the medium of robot expression.

Participants also experience irritation towards the robot $F(1,56) = 6$, $p = 0.02$, partial η^2 0.107. Participants felt irritated at the robotic advisor when the robot uses high controlling language ($M = 2.48$, $SD = 1.27$) as than when the robot is using low controlling language ($M = 1.87$, $SD = 0.85$). These results suggest that the use of static expressions and stiff verbal communication elicited a dislike towards the robot (Markopuolos, 2005). These findings partially confirm H2.

Based on the frequency of which the use of social praise is observed to have a considerable effect as both a main effect and an element of interaction effect on the participants. The results previously described are condensed in Table 4.11 and Table 4.12 for the controlling language and presence of social praise as the main effect respectively. Table 4.13 summarizes the interaction effects of the controlling language and presence of social cues.

Table 4.11: Mean values of controlling language as the main effect. Underlined values to highlight referred social response means.

Variable	Question	Independent variable means	
		High	Low
Usefulness	Participants can decide more quickly and easily the options I want to choose than without using this robotic advisor	<u>4.87</u>	4.24
	Participants are better informed about the suggested options	4.87	<u>5.83</u>
Intentions	Participants would say something favourable about this robotic advisor	<u>5.74</u>	5.34
Liking	Participants believe that this robotic advisor was sincere	<u>5.97</u>	4.97
	Participants believe that this robotic advisor was honest	<u>6.32</u>	5.9
Belief	Participants believe that this robotic advisor behaves in an ethical manner	5.61	<u>6.14</u>

Table 4.12: Mean values of the presence of social praise as the main effect. Underlined values to highlight referred social response means.

Variable	Question	Independent variable means	
		Present	Absent
Usefulness	Participants believe that they would certainly use it	<u>5.26</u>	4.59
Enjoy	Participants would find using this robotic advisor to be fun	<u>5.94</u>	5.31
Liking	Participants believe that this robotic advisor was confident	6.06	<u>6.48</u>
	Participants believe that this robotic advisor was friendly	<u>5.90</u>	5.34
Reactance	Participants feel irritated towards this robotic advisor	<u>1.87</u>	2.48
	Participants feel angry towards this robotic advisor	<u>1.39</u>	1.79

Table 4.13: Mean values of the interaction effect of high or low controlling language with the presence of social praise. Underlined values to highlight referred social response means. Higher emphasis on preference on double underlined values.

Variable	Question	Means			
		High controlling language		Low controlling language	
		Value	Social praise presence	Value	Social praise presence
Usefulness	Participants are better informed about the suggested options	5.33 vs 4.44	Absent	6.00 vs 5.64	Present
	Participants can decide more quickly and more easily whether they want to choose the suggested option or not	5.60 vs 4.81	Absent	5.40 vs 4.64	Present
	Participants can better decide whether I want to choose the suggested option or not	5.93 vs 5.19	Absent	5.93 vs 5.29	Present
Attitude	Participants believe that this robotic advisor is beneficial in improving their decision	6.25 vs 5.87	Present	6.14 vs 5.93	Absent
Belief	Participants will follow the advice that this robotic advisor gives them	4.88 vs 4.2	Present	4.57 vs 4.33	Absent

Based on the frequency, the presence of social praise was observed to have a considerable effect as both a main and interaction effect on the participants. In each instance, positive responses were mostly present, thus confirming H3. The use of high controlling language was also observed to be present in most instances where positive social responses were perceived. Specifically, when the robot uses high controlling language, the participants can decide more quickly and easily the options they want to choose than without using this robotic advisor and the participant would say something favourable about this robotic advisor. They also believe that this robotic advisor was sincere and honest. Conversely, when the robot uses low controlling language, the participants are better informed about the suggested options, and they believe that the robot behaves in an ethical manner.

Regarding the use of social praise by the robot, the participants believe that they would certainly use the robot and find using the robotic advisor to be fun when the robot uses social praise. The participants also believe that the robotic advisor was friendly when social praise was present. However, the participants believe that the robotic advisor was confident at the absence of social praise. The use of social praise by the robot also causes the participants to not feel irritated and angry towards the robotic advisor. Taking these findings into account, as each response was individual components of each representative responses, H5 is partially confirmed.

Based on average results of the responses, further observations could be deduced based on the response of all the participants as seen in Figure 4.4 and Figure 4.5. Each response represents the average of the total dataset. To reiterate, higher values for all responses constitute that the participants' experience was positively perceived, except for reactance, in which case the opposite applies. Perusing the midpoint as reference in Figure 4.4, it is fairly clear that the interaction with the robot was generally well perceived. In Figure 4.5, it shown that the average reactance towards the encounter with the robot had caused a relatively low effect of aversion towards the robot. While there are some variations between the responses, they are all well above the midpoint which suggests that the perusal of the applied social cues of any combination would still result in the participants perceiving the experience of interacting with the robot as pleasant and without much disdain.

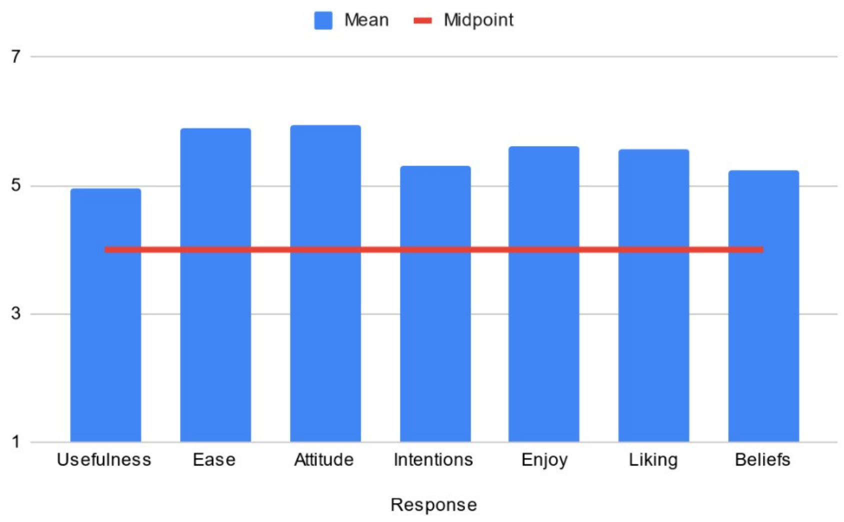

Figure 4.4: Overall mean of participant responses

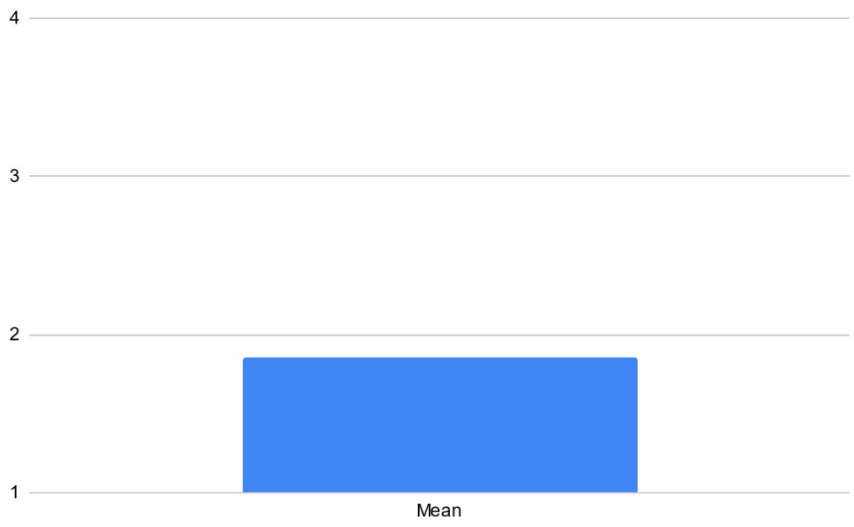

Figure 4.5: Mean reactance among all participants

4.7 Chapter summary

As a summary of this chapter, the outline for each topic discussed is as follows. A serious game was developed and tested to account for the establishment of a simulated environment that by itself applies minimal stress on the participants. Ascertaining the most appropriate social cues modality of a positively perceived social robot entailed the collection of responses of questionnaires from a total of 60 participants that were randomly assigned to four separate groups. Participants individually interacted with the social robot perusing a specific social cues modality in accordance with the assigned groups. According to the STAI assessment conducted based on the readings prior to and after the experiment, the reduction in n anxiety scores suggests that the intervention evokes a positive effect on the participant's well-being. Based on the data obtained, statistically significant responses were observed for the robot's usefulness as perceived by the participants. Other notable findings include statistically significant main and interaction effect of individual items presented in the questionnaire.

There was no statistically significant effect from the use of the social cues on compliance. Correlations were also established between the recorded responses, signifying the effect of how each response affected another. Lastly, an assessment was made based on the overall results of the experiment shows that the use of high controlling language paired with the use of social praise as social cues had produced an outcome in which the participants perceived the robot as pleasant.

CHAPTER FIVE

CONCLUSION

Ultimately, the end target of this research was to design and develop a system perusing a social robot programmed to exhibit specific social cues in a simulated scenario so that information detailing on which social cues modality would elicit the least amount of stress and establish the correlation of the perceived impression towards the robot. Essentially, the result of this study may potentially be point of reference in the future for a more fully thought-out and comprehensive design for a mental health support robot.

Throughout the development process, the Ren'Py development platform has presented itself as a robust yet lightweight system for the development of serious games. Performance-wise, effectively zero issues stemmed from the use of the Ren'Py platform during the study. An integrated system between the participants, game and robot were developed and the system reliably collected data throughout the data collection sessions. For relatively basic serious games designs, the systems present within the platform fulfil several critical criteria. While a serious game can be replicated by anyone using the supplied sample projects, python proficiency is valuable addition to the development using the Ren'Py platform as it offers more venues of more complex game mechanics that can be introduced. The developed game has shown to not induce stress solely through the use of game elements when contrasted with the group interacting with the robot. While there is room for improvements during the game development process, the final game has effectively served its purpose.

Statistically significant findings were observed regarding the robot's increased perceived usefulness when the robot converses using high controlling language without social praise. Stress impact was generally absent across various social cues. Significant correlations were identified between participants' social responses, particularly in enjoyment and intention. The influence of responses towards one other suggests that there were associations observed between the responses that are shared among the participants. Overall, people perceive the robot to yield the most positive social response (with the lease amount of reactance) when the robot uses high controlling language with the use of social praise. The research suggests exploring additional social cues modalities for implementing social robots in mental health support. While current cues were validated, the study encourages considering alternative cues and examining interaction effects for a more comprehensive understanding and robust implementation of social robots in mental health contexts.

There are some significant correlations of the social responses of the participants from interacting with the robot despite the lack of effect on participant compliance. A deeper on the underlying mechanisms can provide valuable insights on the dynamics of human-robot interaction. While some social responses of enjoyment and intention have shown to have stronger correlation than others, most conveyed a strong correlation as whole. The resulting output of the research offers further avenues towards identifying other potential cues modalities that could be used to design an effective social robot for mental health support. However, several limitations have been observed during the study, as discussed in the following section.

5.1 Limitations

Some points of consideration were noted throughout the process of conducting the research. Several concerns arose as some factors posed more of a challenge than initially expected. As advertised, the Alphamini robot is equipped with several advanced features. In some regards, the Alphamini robot surpasses its peers despite its small stature. However, throughout the development process, a series of issues surfaced regarding the technical restrictions present on the robot. Specifically, while comprehensive, the supplied physical and online documentation leaves a lot to be desired. Much effort is expected by the consumer that plans to develop using the robot within a system. Troubleshooting the Alphamini robot has occasionally become an issue that delay the experimentation process. A critical issue to note is the robot is prone to having connection issues. The connection issue specifically plagues the TTS program, occasionally ignored commands when the network becomes slightly unstable. The issue is also exacerbated with the consistent delays between the execution of commands as most of the processing power done by the robot is done through the cloud. With the TTS functionality is of main dependence during the study, this was a persistent issue that had to be resolved through many unconventional methods.

As previously stated, game development is a multidisciplinary field. There are several aspects that need to be considered when designing a game without including aspects of serious game principles. The creative drive necessary to design the assets, programming the game, introducing game mechanics among others is an intensive process. Game development is a process that typically requires a considerable amount of time and effort. However, with the completion of this research and the accomplishment of the full game design, better insight and experience towards game development has been attained. Additionally, should there need be a design of a serious game perusing mechanics and systems similar to this developed game, a platform is ready for an accelerated start for game development.

5.2 Recommendations

Taking a retrospective stance on the understating of the topics discussed a potential approach that could be considered for future improvements or applications of the system are as follows. While the social cues selected for the study were justified due to the result effectiveness, there are multiple possible approaches that this study alludes to. Primarily, the applications of other social cues with the same platform and system may yield differing outcomes. Additionally, as presented within this thesis, the interactive effects with combinations of social cues can be further analyzed and isolated invoke further discussion and understanding of the applications in a more robust system.

As demonstrated by the complete system, Python integration of the Alphamini robot is mostly functional, save for a few technical concerns. This level of integration allows for a variety of other concepts that can be utilized, potentially different from the computer-based system used in the study. As supported by prior research, this level of versatility is invaluable to adopt other methodologies that aim to study another relevant research. Thus, this matter should be of note when considering the design of an HRI system.

In sum, the current research has defined prominent constructive effects on the use of high-controlling language and use of social praise by a robot on the social responses perceived by those engaging with it.

APPENDIX

This informed consent form is for a healthy subject.

Name of Principle Investigator: Dr. Aimi Shazwani Binti Ghazali
Name of Organization: Department of Mechatronics Engineering, International Islamic University Malaysia
Name of Project and Version: Explication of Social Cues on Persuasive Robots for Mental Health Support Among Malaysian Youth

This Informed Consent Form has two parts:

- **Information Sheet (to share information about the study with you)**
- **Certificate of Consent (for signatures if you choose to participate)**

You will be given a copy of the full Informed Consent Form

This Informed Consent Form has two parts:

Part I Information Sheet (to share information about the study with you)
Part II Certificate of Consent (for signatures if you agree to participate in the study)

You will be given a copy of the full Informed Consent Form.

PART I: INFORMATION SHEET

Introduction

I am Dr. Aimi Shazwani Binti Ghazali, working for the International Islamic University Malaysia (IIUM). This research is conducted to investigate how the presence of certain social cues as communicated by a robot could affect its persuasiveness and resulting change in the mental state if any as measured by biological reactance with Galvanic Skin Response (GSR). I am going to give you information and invite you to be part of this research. You do not have to decide today whether or not you will participate in the research. Before you decide, you can talk to anyone you feel comfortable with about the research. This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask me or other researchers relevant to the study.

Purpose

Social robots have been shown to be capable of influencing people to behave or make alternative decisions when equipped with properties that builds trust and connection with the individual, particularly using social cues. This research aims to further study the effectiveness of specific social cues that could persuade people to do certain actions, ideally for use of encouraging the receiving party to conduct smarter and or healthier decisions.

Type of Research Intervention

Your participation in this research will produce a quantitive measure of your reactance and biological response towards a robotic agent as an accompaniment when prompted with activities complemented with the collaboration of the two engaged parties. The degree of compliance will also be analyzed across all groups.

Participant Selection

We are asking you to consider participating in this study because you do not suffer from any severe mental critical health issues and skin issues on your fingertip that may inhibit proper readings for the GSR sensor. We are inviting a total of 60 people.

Voluntary Participation

You can choose to decline and any services that you and your family receive at this centre will not change. You can ask as many questions as you like and we will take the time to answer them. You don't have to decide today. You can think about it and tell us your decision later.

Procedure

A. Once you have decided to take part in this research, our research team will discuss the study with you and answer any questions you may have. If you are still happy to take part, we will ask you to sign the consent form. You will be asked to attend one session, lasting approximately one hour. We need 10 minutes to prepare the experiment.

B. You will be seated facing a monitor and a robot on a table. On the table will be a general flowchart to guide you through the experiment. The flowchart begins with the instructions on attaching a GSR sensor. A video describing the steps to attach the GSR sensor to your fingertips will be shown. Follow the instructions mentioned in the video. The supervising researcher will confirm when the sensor is attached properly.

C. You will be instructed to complete a questionnaire on the computer. Completion of the questionnaire will be followed by closing the browser which will immediately bring up the game window. The game will begin when you click on the game window.

D. The game will begin with a simple and brief self introduction of the robot. Direct progression will be prompted with a suggestion by the robot. Throughout the game, you will be prompted to make several decisions on solving a given challenge. The robot will offer arguments to other options and the prior options are subsequently presented again. The second choice for each option is decided by your discretion.

E. This process will be repeated until all the challenges are completed. Upon completion, the game will automatically close and two questionnaires will be opened in another window. Complete the questionnaires. You may exit the experiment and collect the honorarium.

Duration
Time for a session to complete will take about one hour per participant. Each session may be done at different times depending on the participant's willingness and readiness.

Risks and Discomforts
The experiment may induce a slight level of anxiety from imposed social pressure by the robot. The GSR sensor will be attached to the fingertips and would limit the allowed motions of the connected hand.

Benefits
There are no clear benefits to you of taking part. However, the information we get from this research will enable us to better understand how robots applying socials cues may affect the decisions people make, the psychological results and the level at which it impacts the outcomes.

Reimbursements
An honorarium will be given as a token of appreciation to the participants at the end of the session.

Confidentiality:
Any information you give us will be kept confidential. If the study is published in a book or scientific journal, no individual will be identified in any way.

Sharing of Research Findings
The results of the study will be analysed by the research team and presented at conferences and published in scientific journals. No individual subject will be identified in any report or presentation arising from the research. We are unable to provide you with your

individual results; however, you can be provided with a summary report of our findings at the end of the study, upon your request.

Right to refuse or withdraw

You do not have to take part in this research if you do not wish to do so, and choosing to participate will not affect your job or job-related evaluations in any way. You may stop participating in the experiment at any time that you wish without your job being affected. I will give you an opportunity at the end of the experiment to review your remarks, and you can ask to modify or remove portions of those, if you do not agree with my notes or if I did not understand you correctly.

Who to Contact

If you have any questions you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact:

Dr. Aimi Shazwani Binti Ghazali

0132229406
aimighazali@iium.edu.my

Muhammad Hariz bin Hafizalshah

0173370167
hariz.hafizalshah@live.iium.edu.my

This proposal has been reviewed and approved by the IIUM Research Ethics committee (IREC), which is a committee whose task is to make sure that research participants are protected from harm. If you wish to find out more about the IREC, you may visit to this web http:iium.edu.my/irec

You can ask me any more questions about any part of the research study if you wish to.
Do you have any questions?

Part II: Certificate of Consent

I have been invited to participate in this research study which will gather my graded perception of the robotic agent and the overall experience in addition to the State-Trait Anxiety Inventory with the collection of measurements of my biological signals through my Galvanic Skin Response. I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have been asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

Print Name of Participant__________________
I/C No of Participant ______________________

Signature of Participant ___________________
Date ___________________________
Day/month/year

If illiterate

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness________________
I/C No of witness ___________________

Signature of witness ________________
Date ________________________
Day/month/year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands the research procedures.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

Print Name of Researcher/person taking the consent: __________________________
I/C No of Researcher/person taking the consent: ______________________________
Signature of Researcher /person taking the consent__________________________
Date ___________________________
Day/month/year

REFERENCES

A. Yessad, J. -M. Labat and F. Kermorvant. (2010). SeGAE: A Serious Game Authoring Environment presented at the 10th IEEE International Conference on Advanced Learning Technologies, pp. 538-540.

Adams, R. B., Albohn, D. N., & Kveraga, K. (2017). Social Vision: Applying a Social-Functional Approach to Face and Expression Perception. Current Directions in Psychological Science, 26(3), 243–248.

Aimee van Wynsberghe & Shuhong Li. (2019). A paradigm shift for robot ethics: from HRI to human–robot–system interaction (HRSI), Medicolegal and Bioethics, 11-21.

Abdullah Ajmal, Hamza Aldabbas, Rashid Amin, Sundas Ibrar, Bader Alouffi, Mehdi Gheisari. (2022). Stress-Relieving Veo Game and Its Effects: A POMS Case Study. *Computational Intelligence and Neuroscience*, vol. 2022, Article ID 4239536, 11 pages.

Aldenaini N, Alqahtani F, Orji R and Sampalli S (2020) Trends in Persuasive Technologies for Physical Activity and Sedentary Behavior: A Systematic Review. Front. Artif. Intell. 3:7.

Aliyari, Hamed et. al. (2018). The Beneficial or Harmful Effects of Computer Game Stress on Cognitive Functions of Players. Basic and clinical neuroscience vol. 9, 3. 177-186.

Amirova A, Rakhymbayeva N, Yadollahi E, Sandygulova A and Johal W (2021) 10 Years of Human-NAO Interaction Research: A Scoping Review. Front. Robot. AI 8:744526. doi: 10.3389/frobt.2021.744526

Ben Rebah, H., & Ben slama, R. (2019). The educational effectiveness of serious games in the Médiations et médiatisations.

Bendel, O., Allemann, A. (2024). Alpha Mini as a Learning Partner in the Classroom. In: Ali, A.A., et al. Social Robotics. ICSR 2023. Lecture Notes in Computer Science(), vol 14453 . Springer, Singapore. https://doi.org/10.1007/978-981-99-8715-3_33

Berger, B. G., & Owen, D. R. (1988). Stress reduction and mood enhancement in four exercise modes: Swimming, body conditioning, hatha yoga, and fencing. Research quarterly for exercise and sport, 59(2), 148-159.

Bischoff, R. J., Springer, P. R., & Taylor, N. (2016). Global Mental Health in Action: Reducing Disparities One Community at a Time. Journal of Marital and Family Therapy, 43(2), 276–290.

Björling, E. A., Rose, E., Davidson, A., Ren, R., & Wong, D. (2019). Can we keep him forever? Teens' engagement and desire for emotional connection with a social robot. International Journal of Social Robotics, 1-13.

Braad, E., Žavcer, G., & Sandovar, A. (2016). Processes and Models for Serious Game Design and Development in Lecture Notes in Computer Science, 92–118.

Brådvik L. (2018). Suicide Risk and Mental Disorders. Int J Environ Res Public Health. Sep 17;15(9):2028.

Caplin, A., Chen, F. S., Beauchamp, M. R., & Puterman, E. (2021). The effects of exercise intensity on the cortisol response to a subsequent acute psychosocial stressor. Psychoneuroendocrinology, 131, 105336.

Caserman P, Hoffmann K, Müller P, Schaub M, Straßburg K, Wiemeyer J, Bruder R, Göbel S. (2020). Quality Criteria for Serious Games: Serious Part, Game Part, and Balance. in the JMIR Serious Games;8(3):e19037. URL: https://games.jmir.org/2020/3/e19037.

Checa, D., Bustillo, A. (2020). A review of immersive virtual reality serious games to enhance learning and training. Multimed Tools Appl 79, 5501–5527.

Chien, Shih-Yi & Lin, Yi-Ling & Chang, Bu-Fang. (2022). The Effects of Intimacy and Proactivity on Trust in Human-Humanoid Robot Interaction. Information Systems Frontiers.

Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. Psychometrika 16, 297–334.

Crossman, M. K., Kazdin, A. E., & Kitt, E. R. (2018). The influence of a socially assistive robot on mood, anxiety, and arousal in children. Professional Psychology: Research and Practice, 49(1), 48.

Dallas, O. and Gogoulou, A. (2022, February). Learning Programming Using Python: The Case of the DigiWorld Educational Game," in the European Journal of Engineering and Technology Research. CIE, 1–8.

Damon Daylamani-Zad, Fotios Spyridonis, Kamal Al-Khafaaji. (2022). A framework and serious game for decision making in stressful situations; a fire evacuation scenario in the International Journal of Human-Computer Studies, Volume 162, 102790, ISSN 1071-5819.

Daniel J. Rea, Sebastian Schneider, and Takayuki Kanda. (2021). "Is this all you can do? Harder!": The Effects of (Im)Polite Robot Encouragement on Exercise Effort. In Proceedings of the 2021 ACM/IEEE International Conference on Human-Robot Interaction (HRI '21). Association for Computing Machinery, New York, NY, USA, 225–233. https://doi.org/10.1145/3434073.3444660

Dillard, J. P., & Shen, L. (2005). On the nature of reactance and its role in persuasive health communication. Communication Monographs, 72(2), 144-168.

Dosovitsky G, Pineda BS, Jacobson NC, Chang C, Bunge EL Artificial Intelligence Chatbot for Depression: Descriptive Study of Usage JMIR Form Res 2020;4(11):e17065.

Elprama, Shirley & El Makrini, Ilias & Vanderborght, Bram & Jacobs, An. (2016). Acceptance of collaborative robots by factory workers: a pilot study on the role of social cues of anthropomorphic robots.

Fellmeth, G., Harrison, S., Opondo, C. et. al. (2021). Validated screening tools to identify common mental disorders in perinatal and postpartum women in India: a systematic review and meta-analysis. BMC Psychiatry 21, 200.

Fischer, K., & Niebuhr, O. (2020). Studying Language Attitudes Using Robots. Paper presented at the Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction.

Fisher, R. (1919). XV.—The Correlation between Relatives on the Supposition of Mendelian Inheritance. Earth and Environmental Science Transactions of The Royal Society of Edinburgh, 52(2), 399-433.

Flogie A, Aberšek B, Kordigel Aberšek M, Sik Lanyi C, Pesek I. (2020 Apr 16). Development and Evaluation of Intelligent Serious Games for Children With Learning Difficulties: Observational Study in the JMIR Serious Games. 8(2):e13190.

Fogg, B. J. (2002). Persuasive technology: using computers to change what we think and do. Ubiquity, 2002(December), 2.

Formosa, Paul (2021). Robot Autonomy vs. Human Autonomy: Social Robots, Artificial Intelligence (AI), and the Nature of Autonomy. Minds and Machines 31 (4):595-616.

F. Jimenez, M. Kanoh, T. Yoshikawa, and T. Nakamura. (2020). Learning Effect of Collaborative Learning with Robots Speaking a Compliment. J. Adv. Comput. Intell. Intell. Inform., Vol.24 No.3, pp. 396-403.

Gammanpila, A. C., Wijesinghe, A., Wanniarachchi, T., Amarajeewa, V., Jayasinghe, D., & de Silva, R. (2020). The Sorting Hat, a Mediator Social Robot with a Fictional Character Appearance for Autistic Children. Paper presented at the Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction.

Ghazali, A. S., Ham, J., Barakova, E. I., & Markopoulos, P. (2017). Pardon the rude robot: Social cues diminish reactance to high controlling language. Paper presented at the 2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN).

Ghazali, A. S., Ham, J., Barakova, E. I., & Markopoulos, P. (2018). Effects of robot facial characteristics and gender in persuasive human-robot interaction. Frontiers in Robotics and AI, 5, 73.

Ghazali, A. S., Ham, J., Barakova, E., & Markopoulos, P. (2018). The influence of social cues in persuasive social robots on psychological reactance and compliance. Computers in Human Behavior, 87, 58- 65.

Ghazali, A. S., Ham, J., Markopoulos, P., & Barakova, E. I. (2019). Investigating the Effect of Social Cues on Social Agency Judgement. Paper presented at the HRI.

Ghazali, A.S., Ham, J., Barakova, E. et al. Persuasive Robots Acceptance Model (PRAM): Roles of Social Responses Within the Acceptance Model of Persuasive Robots. Int J of Soc Robotics 12, 1075–1092 (2020). https://doi.org/10.1007/s12369-019-00611-1

Guadagno, R. E., & Cialdini, R. B. (2002). Online persuasion: An examination of gender differences in computer-mediated interpersonal influence. Group dynamics: Theory, research, and practice, 6(1), 38.

Guemghar I, Pires de Oliveira Padilha P, Abdel-Baki A, Jutras-Aswad D, Paquette J, Pomey MP. (2022 Apr 19). Social Robot Interventions in Mental Health Care and Their Outcomes, Barriers, and Facilitators: Scoping Review. JMIR Ment Health. 9(4):e36094.

Hachenberger J, Teuber Z, Li YM, Abkai L, Wild E, Lemola S. (2023 May 31). Investigating associations between physical activity, stress experience, and affective wellbeing during an examination period using experience sampling and accelerometry. Sci Rep. 13(1):8808.

Heerink, M., Krose, B., Evers, V., & Wielinga, B. (2009). Measuring acceptance of an assistive social robot: a suggested toolkit. Paper presented at the RO-MAN 2009-The 18th IEEE International Symposium on Robot and Human Interactive Communication.

Hengen KM and Alpers GW. (2021). Stress Makes the Difference: Social Stress and Social Anxiety in Decision-Making Under Uncertainty in Front. Psychol., 12:578293.

I. J. Pérez-Colado, A. Calvo-Morata, C. Alonso-Fernández, M. Freire, I. Martínez-Ortiz and B. Fernández-Manjón. (2019). Simva: Simplifying the Scientific Validation of Serious Games presented at the IEEE 19th International Conference on Advanced Learning Technologies (ICALT), pp. 113-115.

Inoue, K., Wada, K., & Shibata, T. (2021). Exploring the applicability of the robotic seal PARO to support caring for older persons with dementia within the home context. Palliative Care and Social Practice.

Jackson RB and Williams T (2021) A Theory of Social Agency for Human-Robot Interaction. Front. Robot. AI 8:687726.

Jacquart, J., Papini, S., Freeman, Z., Bartholomew, J. B., & Smits, J. A. (2020). Using exercise to facilitate arousal reappraisal and reduce stress reactivity: A randomized controlled trial. Mental Health and Physical Activity, 18, 100324.

Janko, M. R., & Smeds, M. R. (2019). Burnout, depression, perceived stress, and self-efficacy in vascular surgery trainees. Journal of vascular surgery, 69(4), 1233-1242.

Jantke, Klaus & Knauf, Rainer. (2012). Taxonomic concepts for storyboarding digital games for learning in context presented at CSEDU 2012 - Proceedings of the 4th International Conference on Computer Supported Education. 2. 401-409.

Jussi Palomäki, Anton Kunnari, Marianna Drosinou, Mika Koverola, Noora Lehtonen, Juho Halonen, Marko Repo, Michael Laakasuo. (2018). Evaluating the replicability of the uncanny valley effect, Heliyon, Volume 4, Issue 11, e00939, ISSN 2405-8440.

K. H. Sharif and S. Yousif Ameen. (2021). Game Engines Evaluation for Serious Game Development in Education in the International Conference on Software, Telecommunications and Computer Networks (SoftCOM), pp. 1-6.

Kara, N. (2021). A Systematic Review of the Use of Serious Games in Science Education in Contemporary Educational Technology, 13(2), ep295.

Kilian Wenker. (2022). A systematic literature review on persuasive technology at the workplace, Patterns, Volume 3, Issue 8, 100545, ISSN 2666-3899.

LeMoult, J., & Gotlib, I. H. (2019). Depression: a cognitive perspective. Clinical Psychology Review, 69, 51-66.

Liaw, K., Driver, S., & Fraune, M. R. (2019). Robot Sociality in Human-Robot Team Interactions. Paper presented at the International Conference on Human-Computer Interaction.

Liu, S. X., Shen, Q., & Hancock, J. (2021). Can a social robot be too warm or too competent? Older Chinese adults' perceptions of social robots and vulnerabilities. Computers in Human Behavior, 125, 106942.

Lopresti, A. L., & Drummond, P. D. (2019). Lifestyle and neuroprogression: Diet, sleep, and exercise. Neuroprogression in Psychiatry, 207.

M. A. F. Rodrigues et. al. (2022). An Interactive Story Decision-Making Game for Mental Health Awareness. 2022 IEEE 10th International Conference on Serious Games and Applications for Health(SeGAH), Sydney, Australia, pp. 1-8.

Maheu-Cadotte, M.-A., Cossette, S., Dubé, V., Fontaine, G., Mailhot, T., Lavoie, P., Alexis Cournoyer, Fabio Balli, Mathieu-Dupuis, G. (2018). Effectiveness of serious games and impact of design elements on engagement and educational outcomes in healthcare professionals and students: a systematic review and meta-analysis protocol in the BMJ Open, 8(3), e019871.

Markopoulos, P., de Ruyter, B., Privender, S., & van Breemen, A. (2005). Case study. Interactions, 12(4), 37.

MHA. (n.d.). Mental Health Month (MHM). Mental Health America. https://www.mhanational.org/mental-health-month

MIASA. (n.d.). Mental illness awareness and support association (MIASA). Mental Illness Awareness and Support Association MIASA. https://www.miasa.org.my/index.html

Mikkelsen, K., Stojanovska, L., Polenakovic, M., Bosevski, M., & Apostolopoulos, V. (2017). Exercise and mental health. Maturitas, 106, 48-56.

Mori, M. (1970). The uncanny valley. Energy, 7(4), 33-35.

Navea, Roy & Buenvenida, Paul & Cruz, Christian. (2019). Stress Detection using Galvanic Skin Response: An Android Application. Journal of Physics: Conference Series. 1372. 012001.

Niemelä, M., & Melkas, H. (2019). Robots as social and physical assistants in elderly care Humancentered digitalization and services (pp. 177-197): Springer.

Nomura, T., Kanda, T., Suzuki, T., & Yamada, S. (2019). Do people with social anxiety feel anxious about interacting with a robot? Ai & Society, 1-10.

Nomura, T., Suzuki, T., Kanda, T., Han, J., Shin, N., Burke, J., & Kato, K. (2008). What people assume about humanoid and animal-type robots: cross-cultural analysis between Japan, Korea, and the United States. International Journal of Humanoid Robotics, 5(01), 25-46.

Nunnally, J. C. (1978). Psychometric theory: New York : McGraw-Hill, c1978. 2d ed.

Park S, Kook H, Seok H, Lee JH, Lim D, et. al. (2020) The negative impact of long working hours on mental health in young Korean workers. PLOS ONE 15(8): e0236931.

Perloff, R. M. (2020). The Dynamics of Persuasion: Communication and Attitudes in the Twenty-First Century. United Kingdom: Taylor & Francis.

Poku, C.A., Donkor, E. & Naab, F. (2020). Determinants of emotional exhaustion among nursing workforce in urban Ghana: a cross-sectional study. BMC Nurs 19, 116.

Puglisi A, Caprì T, Pignolo L, Gismondo S, Chilà P, Minutoli R, Marino F, Failla C, Arnao AA, Tartarisco G, Cerasa A, Pioggia G. (2022, June 25) Social Humanoid Robots for Children with Autism Spectrum Disorders: A Review of Modalities, Indications, and Pitfalls. Children (Basel). 9(7):953.

Quick, B. L., & Stephenson, M. T. (2007). The Reactance Restoration Scale (RRS): A measure of direct and indirect restoration. Communication Research Reports, 24(2), 131-138.

Rakhymbayeva N, Amirova A, Sandygulova A. (2021, Jun 16). A Long-Term Engagement with a Social Robot for Autism Therapy. Front Robot AI. 8:669972.

Rasouli, S., Gupta, G., Nilsen, E. et. al. (2022). Potential Applications of Social Robots in Robot-Assisted Interventions for Social Anxiety. Int J of Soc Robotics 14, 1–32.

Raul Benites Paradeda, Carlos Martinho, and Ana Paiva. (2020). Persuasion Strategies Using a Social Robot in an Interactive Storytelling Scenario. In Proceedings of the

8th International Conference on Human-Agent Interaction (HAI '20). Association for Computing Machinery, New York, NY, USA, 69–77.

Reeves, B., & Nass, C. I. (1996). The media equation: How people treat computers, television, and new media like real people and places: Cambridge university press.

Reynaldo, Charles & Christian, Ryan & Hosea, Hansel & Gunawan, Alexander. (2021). Using Video Games to Improve Capabilities in Decision Making and Cognitive Skill: A Literature Review in the Procedia Computer Science. 179. 211-221.

Richard F Mollica, Gregory L Fricchione. (2021). Mental and physical exhaustion of health-care practitioners, The Lancet, Volume 398, Issue 10318, Pages 2243-2244, ISSN 0140-6736.

Roberts, N. L., Mountjoy-Venning, W. C., Anjomshoa, M., Banoub, J. A. M., & Yasin, Y. J. (2019). GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study (vol 392, pg 1789, 2018). Lancet, 393(10190), E44-E44.

Robinson OJ, Vytal K, Cornwell BR, Grillon C. (2013, May 17). The impact of anxiety upon cognition: perspectives from human threat of shock studies. Front Hum Neurosci. 7:203.

Rose, Emma & Björling, Elin & Cakmak, Maya. (2019). Participatory design with teens: A social robot design challenge. 604-609.

Roubroeks, M., Ham, J., & Midden, C. (2011). When artificial social agents try to persuade people: The role of social agency on the occurrence of psychological reactance. International Journal of Social Robotics, 3(2), 155-165.

S. Alam, B. Johnston, J. Vitale and M. -A. Williams. (2021). Would you trust a robot with your mental health? The interaction of emotion and logic in persuasive backfiring 2021 30th IEEE International Conference on Robot & Human Interactive Communication (RO-MAN), Vancouver, BC, Canada, pp. 384-391.

Sara Zarubica and Oliver Bendel. (2023) Pepper as a Learning Partner in a Children's Hospital. In Social Robotics: 15th International Conference, ICSR 2023, Doha, Qatar, December 3–7, 2023, Proceedings, Part II. Springer-Verlag, Berlin, Heidelberg, 15–26. https://doi.org/10.1007/978-981-99-8718-4_2

Schönbohm, A., & Zhang, T. (2021). *Evaluating the effectiveness of serious games in facilitating strategic decisions-making under COVID-19 crisis conditions.* Journal of Work-Applied Management.

Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation Coefficients. Anesthesia & Analgesia, 126(5), 1763–1768.

Scoglio A, Reilly E, Gorman J, Drebing C. (2019). Use of Social Robots in Mental Health and Well-Being Research: Systematic Review J Med Internet Res; 21(7):e13322 URL: https://www.jmir.org/2019/7/e13322.

Seiferth, C., Vogel, L., Aas, B. et. al. (2023). How to e-mental health: a guideline for researchers and practitioners using digital technology in the context of mental health. Nat. Mental Health 1, 542–554.

Shalaby R, Agyapong V. (2020). Peer Support in Mental Health: Literature Review JMIR Ment Health;7(6):e15572 URL: https://mental.jmir.org/2020/6/e15572.

Shamsuddin, S., Ahmad, I. F., Zulkifli, W. Z., Hwee, L. T., & Yussof, H. (2016). Preliminary study on the use of therapeutic seal robot for patients with depression. Paper presented at the 2016 IEEE International Symposium on Robotics and Intelligent Sensors (IRIS).

Sheridan, Thomas. (2016). Human-Robot Interaction: Status and Challenges. Human factors. 58.

Shibata, T., Hung, L., Petersen, S., Darling, K., Inoue, K., Martyn, K., Hori, Y., Lane, G., Park, D., Mizoguchi, R., Takano, C., Harper, S., Leeson, G. W., & Coughlin, J. F. (2021). PARO as a Biofeedback Medical Device for Mental Health in the COVID-19 Era. Sustainability, 13(20), 11502.

Smiderle, R., Rigo, S.J., Marques, L.B. et. al. (2020). *The impact of gamification on students' learning, engagement and behavior based on their personality traits*. The Smart Learn. Environ. 7, 31.

Stroessner, Steven. (2020). On the social perception of robots: measurement, moderation, and implications. 10.1016/B978-0-12-815367-3.00002-5.

Su, B., Jung, S., Lu, L., Wang, H., Qing, L., Xie, Z., & Xu, X. (2023). The effects of human-robot interaction modality on workers' mental stress. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 0(0).

Talebi, N. (2020). The Effectiveness of Aerobic Exercise Interventions and Stress Coping skills Training on the Reduction of Job Stress among Employees of the Organization.

Taufik, M., Rezali, M., Shahein, N., Sahril, N., Ying Ying, C., & Ab Wahab, N. (2022). Anxiety and Its Associated Factors among School-going Adolescents in Malaysia. International Journal of Public Health Research, 12(2). Retrieved from https://spaj.ukm.my/ijphr/index.php/ijphr/article/view/335

Valenti, E., Giacco, D. (2022). Persuasion or coercion? An empirical ethics analysis about the use of influence strategies in mental health community care. BMC Health Serv Res 22, 1273.

Vaidyam AN, Linggonegoro D, Torous J. (2021). Changes to the Psychiatric Chatbot Landscape: A Systematic Review of Conversational Agents in Serious Mental Illness: Changements du paysage psychiatrique des chatbots: une revue systématique des agents conversationnels dans la maladie mentale sérieuse. The Canadian Journal of Psychiatry.66(4):339-348.

Voorveld, H. A. M., & Araujo, T. (2020). How Social Cues in Virtual Assistants Influence Concerns and Persuasion: The Role of Voice and a Human Name. Cyberpsychology, Behavior, and Social Networking, 23(10), 689–696.

Wasala, K., Gomez, R., Donovan, J., & Chamorro-Koc, M. (2019). Emotion specific body movements: Studying humans to augment robots' bodily expressions. Paper presented at the Proceedings of the 31st Australian Conference on Human-Computer-Interaction.

Widyasari, Y.D.L., Nugroho, L.E. & Permanasari, A.E. Persuasive technology for enhanced learning behavior in higher education. Int J Educ Technol High Educ 16, 15 (2019).

Wu JH, Du JK, Lee CY. (2021). *Development and questionnaire-based evaluation of virtual dental clinic: a serious game for training dental students*. Med Educ Online.

Yang, Chi Lan & Wang, Haochuan. (2019). Understanding How Social Prompts Influence Expert's Sharing of How-to Knowledge. 433-437.

YIN, J.-j. (2019). A Compression-based BiLSTM for Treating Teenagers' Depression Chatbot. DEStech Transactions on Computer Science and Engineering(ammso).