Report Title

- Subtitle -

Project Report

Group Name/Number

Aalborg University
Electronics and IT

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AALBORG UNIVERSITY
STUDENT REPORT

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Aalborg University
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Contents

Todo list

Preface

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Aalborg University, December 15, 2016

Author 1
<username1@XX.aau.dk>

Author 2
<username2@XX.aau.dk>

Author 3
<username3@XX.aau.dk>

Chapter 1

Problem statement

While designing any technological artefact that will be utilised by an individual, it is important to take into consideration the user's needs. This is no less significant if the artefact in question is a game — in this case, the user needs in question may be related to how enjoyable the game is for the user to play, and how engaging it is. Engagement is described by Charlton and Danford (2010) [2] as "a high degree of positive involvement in computer usage".

To measure engagement and define certain factors that influence it, flow theory can be utilised. As stated by Hamari and Koivisto, "The flow state has been widely used to describe an optimal experience characterized as a state of being fully focused and engaged in an activity" [3]. There are several ways to describe the state of flow, but nine dimensions of flow theory described by Hamari and Koivivisto, and specifically the fifth dimention which is "focusing on the task at hand", might be especially interesting when developing a game on a platform that utilises two screens at once, such as *AirConsole*.

AirConsole is a browser-based local multiplayer game platform — "local" in this case meaning that all players are in the same room. A computer serves as the main screen which is accessible to all players. In addition, each player uses their personal smartphone as the means to interact with the game, and as an individual interface. This presents some unique options for gamemakers, since this platform provides two screens for each player to work with instead of the one screen most platforms provide. However, it can also pose specific challenges, since the user is required to pay attention not only to the shared computer screen, but also to their personal smartphone screen. Usually, when a person shifts their attention between two things, the eyes move accordingly in order to have the object of interest portrayed on the forea. As a result of this, constantly moving the eyes from one screen to another might, for example, make a player miss some important information on one of the screens, which may lead to confusion during gameplay. Since AirConsole is a local multiplayer platform, the attention span of a player may be even shorter due to the distractions from other players. Therefore, if the game developer fails to consider the imposed challenges, the overall impression from the gameplay might be ruined. This leads to a problem formulation:

> **How can the player's attention be directed between a shared screen and a personal hand-held screen when there is a need to change their visual focus between the two in a local multiplayer game?**

This problem formulation caused some additional questions to arise. These questions will be addressed throughout the project, and seek to ultimately answer the problem formulation:

- What effect does different types of sensory feedback have on the players' attention on a two-screen platform such as the AirConsole?
- If given no indication of where to look, which of the two screens will the players most likely look at?

Before an experiment addressing the problem formulation can be conducted, it is essential to have some knowledge about attention. Therefore, the next chapter will examine attention, the terms used to describe it, and methods which can be used to measure it.

From Kibsgaard: Remember to introduce the entire report in your introduction (similarly to how you just introduced the next chapter in this paragraph). Of course this is easier to do at the end.

Chapter 2

Directing and Measuring Attention

Attention is a subject which has been discussed across various disciplines, which naturally leads to several definitions. Attention can be considered the allocation of cognitive resources to a certain task or stimulus; it can be the acquisition of information through senses such as sight; or it can be the passing of information to a person's memory. In order to make the discussion of attention more comprehensible, one may distinguish between various different types of attention. As described by Mancas et al. (2016) [7], when addressing visual attention, one may distinguish between *overt* and *covert* attention. Examples of how overt attention manifests are changes in posture, eye and head movements, and changes in pupil size. It deals with things that are fixated upon by the eyes. Covert attention is not as easily observed, but deals with information about a scene gathered with the peripheral vision rather than information which has been fixated on. Another way to describe different types of attention is to divide it into the following five categories:

1. *Focused* attention: a specific task or stimulus is focused on.
2. *Sustained* attention: one stays attentive for an extended period of time.
3. *Selective* attention: a specific task or stimulus is focused on, while ignoring distracting factors.
4. *Alternating* attention: multiple tasks are switched between.
5. *Divided* attention: multiple tasks are dealt with simultaneously.

When describing how a subject deals with multiple tasks or stimuli, one may distinguish between *serial* and *parallel* attention. Serial attention deals with the given stimuli one after another, whereas parallel attention deals with simultaneous processing of several tasks.

The terms presented here can be used to describe specific types of attention, and may be useful when analysing the results from the final experiment.

2.1 Directing Attention

In order to have a better understanding of how the final design of a game should look, there is a need to explore different ways of directing a player's attention. It is therefore important to understand how the attentional mechanisms operate in the human mind.

In general, two distinct forms of attention are recognized. The first is described as *exogenous* attention, which is driven by stimulus and, as described by Lee et al. (2011), "captured reflexively by events in a bottom-up manner" [5]. It is also referred to as the pre-attentive stage of attention [14]. The second, *endogenous* attention, is dependant on the goals of an individual, and as Lee et al. (2011) describes it, "is directed voluntarily in a top-down manner" [5]. It is also known as the attentive stage of attention [14]. It is worth noting that, as stated by Melloni et al. (2012), "hardly any search is purely bottom-up or purely top-down driven" [8]. In the following sections, those two forms of attention are explained in greater detail.

2.1.1 Bottom-up attention

Bottom-up attention means that an object is immediately and involuntarily noticed by an individual because of its salient features [8]. Those kinds of features include intensity, size, depth, colour, orientation, and movement [14]. For example, in Figure 2.1 it is easy to spot the black line no matter the amount of white ones present. Figure 2.1 also shows typical results from an experiment in which the participants are asked to detect an odd item in a picture similar to the one seen in the figure. The full line represents the reaction time to notice the target, whereas the dashed line represents the reaction time to notice that no target is present. It is clear that the results are not influenced by the amount of non-target items (the white lines) in the picture [11].

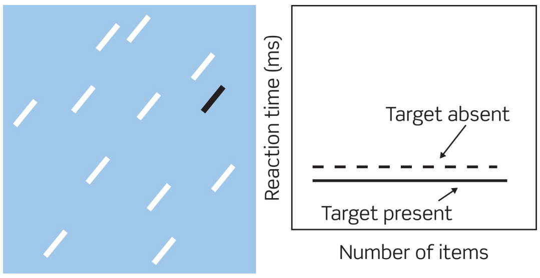

Figure 2.1: Example graphic for feature map testing (L) with corresponding results (R) [11].

The feature integration theory suggests that during the pre-attentive phase there is a mental system of modules, each of which is designed to identify a feature. A module, in turn, has several feature maps, for instance a colour module can have maps for green, red and purple. All of the features are then combined through focal attention, where the brain combines the input from the feature maps. When an item stands out due to its feature (for example a green stripe amongst purple stripes), it is identified easily by its exclusivity in a feature map, as seen in Figure 2.2. The theory explains why finding a circle in a field of lollipops is harder than the inverse, as demonstrated in Figure 2.3, as the lollipop in the field of circles covers two feature maps and one of the feature maps, the one with lines, only have one object. However, when it comes to the circle in the field of lollipops, both feature maps, lines and circles, have multiple objects, so the process of finding the lone circle is not as fast. This is the same concept as the "Where's Wally?" books, where the images contain large amounts of features with multiple objects in each feature map, and ask the reader to find one specific combination of them (glasses, striped blouse and hat, cane, etc.).

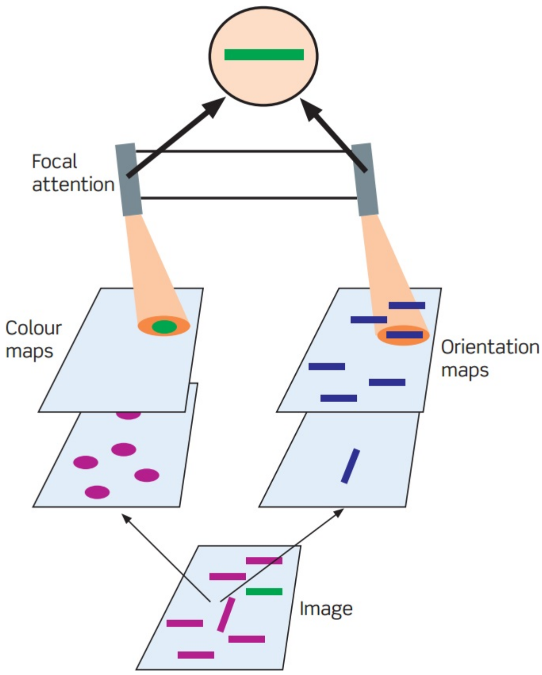

Figure 2.2: Feature Integration Theory illustrated [11].

It is also worth noting that a certain size of an object may attract more attention: in general, larger areas receive more attention than smaller ones, but after a certain saturation point, the importance of size diminishes. Besides that, regions with long and thin edge-like shapes attract more attention compared to rounder regions. In addition, motion is considered to have one of the strongest influences on visual attention. As Osberger and Maeder (1998) state: "Our peripheral vision is highly tuned to detecting changes in motion, and our attention is involuntarily drawn to peripheral areas undergoing motion distinct from its surrounds" [9].

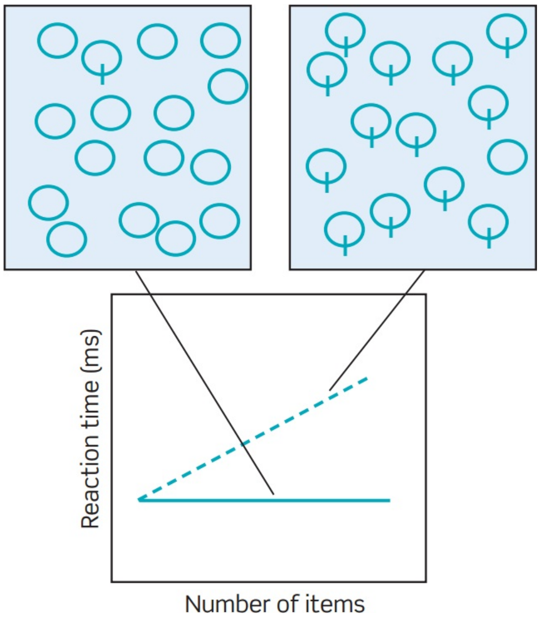

Figure 2.3: Circle target vs. lollipop target example [11].

Auditory stimuli also play an important role in directing attention. As stated by Lee et al.: "In exogenous spatial attention, it has been proved that a spatially non-predictive cue in one modality can attract covert attention toward the location of the cue in the other modality, which is called the "cross-modal facilitatory effect."" [6]. An example of such an effect could be when an unexpected sound source attracts immediate visual attention. Furthermore, moving objects that emit sound are generally paid more attention to than others, according to Lee et al. [5].

2.1.2 Top-down attention

As mentioned before, *top-down* attention is highly dependant on the task at hand. In a study conducted by Yarbus (1967), a person was asked to perform several different tasks while looking at a picture. The movements of the eye were recorded. Figure 2.4 shows the scan paths that were recorded during the fulfilment of seven tasks: (1) free examination of the picture, (2) estimate the material circumstances of the family, (3) give the ages of the people, (4) guess what the family had been doing before arrival of the unexpected visitor, (5) remember the clothes worn by the people, (6) remember the position of the people and the objects in the room, and (7) estimate how long the unexpected visitor had been away. The study clearly indicates that the movements of the eyes are dependant on the goals of an individual. [13]

In Yarbus' study, when participants were asked to view the scene freely, the results showed that people tend to focus on the objects of the image, rather than

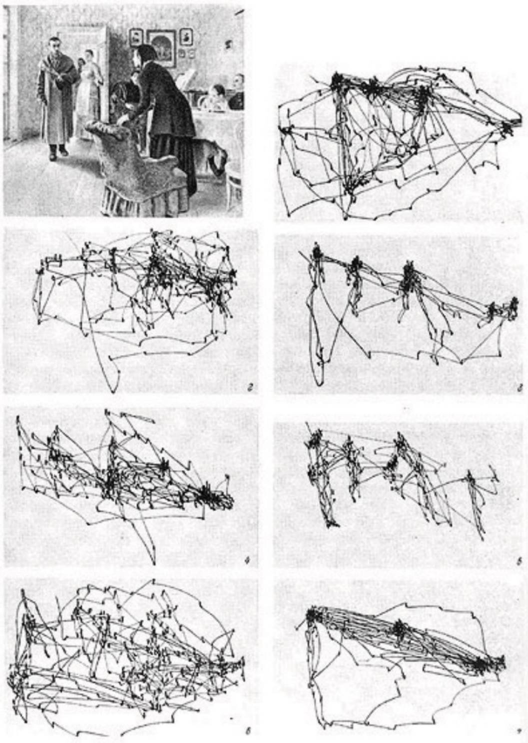

Figure 2.4: Recordings of eye tracking in response to different tasks [12]

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on uniform surfaces like walls or floors. Furthermore, all participants showed similar scan paths when viewing the image freely. Another study, conducted by Land et al. (1999), also showed that when participants were asked to perform a specific assignment, most of the focus was on objects related to the task at hand [4]. In addition to that, people usually tend to look at the centre of a screen for most of the time and are more likely to focus on the foreground of a scene, as stated by Osberger and Maeder (1998) [9].

To summarise, the main factors to manipulate when directing attention are sound, movement and differences in colours. Tactile feedback is not referenced in these papers since they do not deal with mediums which make tactile feedback relevant. For this project, tactile feedback is also a factor which can be manipulated when directing attention.

This project will not direct attention in a single person setup as the research papers referenced have. There will be multiple people during these tests, and the goal is to direct attention individually without distracting the other participants. Sound, depending on the volume, might be a distraction to the other participants. Dramatic movement of the playable characters might also be a distraction. This means that other ways of directing attention have to be modulated to fit a multi-person setup. For this purpose, the tactile feedback provided by the smartphones can be a useful replacement for the sound, i.e. the phone vibrates when the participant's character collects a map piece. If players engage in combat their smartphones could play a loud sound to direct their attention there. Alternatively, a player's smartphone could vibrate when it is their turn, and when they engage in combat. Another possibility is to provide visual on where the player should look, either with a focus on colour (i.e. a given player's colour may take up a certain amount of the screen when it is their turn) or movement (i.e. a moving icon may pop up on the screen when players are engaged in combat). The position of the visual feedback may have an effect on where a player directs their attention. All of these are factors which can be isolated and tested in the experiment of this project.

To conclude on the assumptions made on multi-person setups based on the research found on single person setups, the same principles can be applied. However, one must take into consideration how they can distract the other participants. The solution in this project might be to take advantage of all participants having their own smartphone in addition to the main screen, and therefore have a direct device to direct their attention without distracting the other participants.

2.2 Methods of measuring attention

As this paper seeks to investigate the effect various factors will have on a player's attention, it is necessary to consider some methods with which attention can be measured. One possibility is to measure a test subject's Secondary Task Response Time (STRT). As Lang et al. (2009) [1] describes it, this method involves a test subject who is given two tasks: a primary task, such as viewing a video, which is presented as the most important of the two; and a secondary task, such as pressing a button when a certain sound is heard. In this case, the time that elapses between the moment the sound is played and the moment the subject presses the button is referred to as the STRT. In theory, this method indicates the amount of attention allocated for the primary task by measuring the amount available for the secondary task — these should be in inverse proportion to one another. However, the data gathered by Lang et al.[1] indicates that this is not the case, and the entire methodology may be flawed.

Margarita: maybe avoid describing the STRT alltogether, since we already mention that this method might be flawed.

Another method for measuring a subject's attention is through eye tracking. More specifically, this method is a way to map a subject's overt attention. This can be done by using a video camera and image processing software to detect the edge of the pupil. For more precise results, one may stabilise the position of the subject's head, i.e. by using a chin rest. However, stabilising the player's head is not suitable for the Airconsole platform, since the player needs to alternate between facing the computer screen and the smartphone screen. The quality of the results from such a test is limited by the resolution and frame rate of the camera used, as well as the speed of the image processing algorithm. Results may also be obscured by changes in lighting, dark eye colours which have little contrast to the pupils, and subjects wearing glasses which may cause stray reflections. In order to alleviate some of these issues, hardware specific to eye tracking, such as the *Tobii EyeX eye tracker* [10], can be used instead of a regular video camera. This eye tracking hardware, consisting of cameras and near-infrared illuminators, is placed in front of the subject, just beneath the screen which they are viewing, as is seen in figure 2.5. Near-infrared light illuminates the subject, casting a pattern of non-visible light on their eyes, of which high-resolution images are taken. An algorithm uses information about the infrared light reflected from the pupil and the cornea to produce a 3D model of the eye, which is then used to calculate the gaze direction relative to the screen. All of this is summarised in figure 2.5.

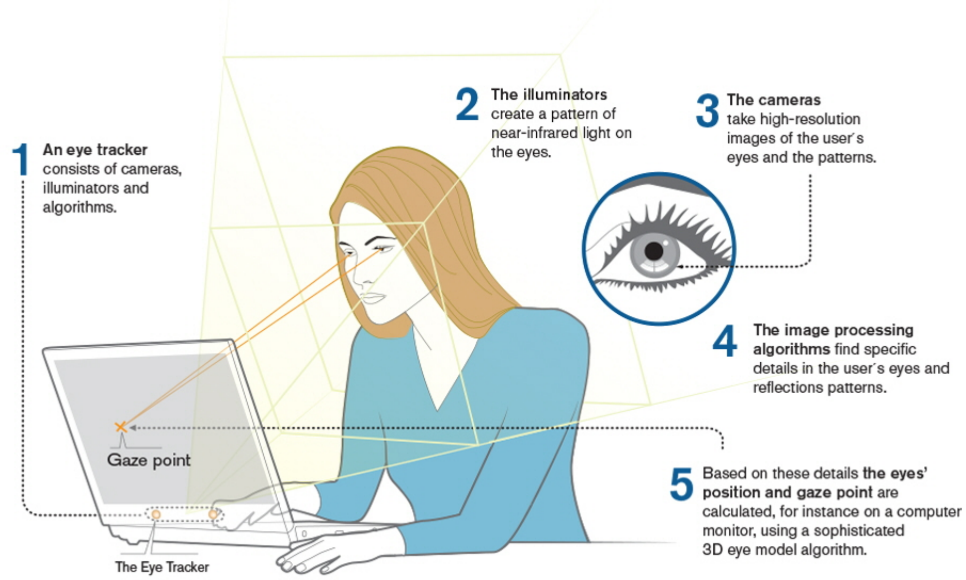

Figure 2.5: Overview of how the Tobii eye tracker works [10].

When analysing data gathered from an eye tracking test, it is important to distinguish between different types of eye movements, as described by Mancas et al.:

- *Fixations*: the gaze stays on approximately the same area for a period of time. One should note that the gaze is never completely still; even when a subject focuses on a certain location, small saccades can still be detected.

- *Saccades*: the gaze shifts from one fixation to another. Between these two fixations, no visual information is gathered.
- *Smooth pursuit*: the gaze fixates on a moving object, following its movements. As with fixation, microsaccades are done to correct position errors.

Results from an eye tracking test can be presented in several ways. They can simply display the path travelled by the gaze, referred to as a *scan path*, or they can show *heat maps* of the scan path, typically accumulating scan paths from ten or more test subjects. However when using the Tobii Eye Tracker, these scan paths must be gathered from single-person tests, as the hardware can only keep track of one subject at a time.

To alleviate this issue, a Kinect 2 is used. While not specifically eye tracking equipment, a Kinect 2 can via infra-red light and computer algorithms detect the position and orientation of faces. This means that the Kinect 2 can see if a face is facing towards or away from it. Additionally, the hardware is not limited to only one face at a time, but can instead detect multiple people at once. When placing the Kinect 2 under a screen, this results in a platform that can detect multiple individual people at once, and see if they are looking at or away from what is shown on the screen. While it cannot detect where a person is looking specifically on a screen and is therefore less accurate for eye tracking, it is still useful because of its capability to be used in a local multiplayer environment.

Although results from such a test may provide an indication of where the subject's attention is directed, the eye tracking method may not be sufficient in and of itself; as it is mentioned by Snowden et al.[11]: “merely having our eyes pointing in the right direction is not enough to ensure that we will process or appreciate the information". Therefore, it would be sensible to combine eye tracking with other methods, such as a questionnaire, to acquire a more detailed and reliable feedback from the participants.

In addition to methods of measuring attention, an artefact to which test participants can direct their attention is needed. For this purpose, an AirConsole game has been created, which will be described in the following chapter.

Chapter 3

Treasure Hunt: a Dual-Screen Testing Tool

As the focus of this paper lies on directing attention between two screens, a game has been developed for purpose of testing the problem formulation. The game is an AirConsole game, which means that players will need to direct their attention at the main screen in certain situations, and at their phone screen in others. Therefore, the game serves as a tool to test the best way to direct a player's attention towards a certain screen.

It's just a working title, do not panic

The game is a turn-based treasure hunting game for four players. Each player controls a pirate character which they use to walk around on a treasure island, to look for map pieces or steal them from the other players. When a player has found all nine map pieces, they win the game.

It was decided to create a multiplayer game because AirConsole lends itself to this type of game, as players can easily use their own phone as an individual controller. The game is designed in a way so that players will have too look at the main screen in certain situations, and on their phone screen in others. This decision was made so that the game works as a testing tool to investigate how to direct players' attention between two screens. Furthermore, the game is turn-based, rather than real-time, as the AirConsole format has an inherent latency issue. Making the game turn-based reduces the consequences of a delay between player input and game reaction time.

3.1 Gameplay

Each player has a turn in a random order — once all players have had their turn, this order is scrambled. On a player's turn, they must plan two actions, which will be executed. They have 10 seconds to do this . The possible actions are: Moving in a direction and interacting with an object. The actions are planned by clicking on

what happens if the timer runs out?

the corresponding button in the order you would like them to execute in. There is a movement option for each of the four directions. The interact action makes the players pirate interact with an object on the tile it is on. This is one way to find map pieces.

If a player actively moves onto a tile another player already occupies then an attack will be initiated. A minigame will start on the two players smartphone. Which player won the fight is shown the fighting players' smartphones with a "YOU WON" or YOU LOST" text message displayed on screen. Whoever wins the fight will then copy a map piece from the loser, if the loser is in possession of a map piece that the winner does not already has. If the winner has all the map pieces that the loser also has, then no new map pieces are gained. This was implemented to avoid players from copying the same map pieces over and over in order to win, and also requiring all map pieces to be found from the objects by someone.

The random turn-order was decided upon based on the problem statement regarding directing attention. This would be a way to test different ways to direct the players attention without them growing accustomed to the turn-order. The time limit is to increase the pace of the game. However, if a player is last in a turn order, then they cannot become first player. This was included so that a player could not effectively get two turns in a row.

The way the movement and actions work was decided due to the platform having issues with latency on some networks and also the lack of the tactile feedback buttons on a screen provide. This means that moving in a real-time system is less accurate, so a turn-based structure is used instead.

The attack action works like described based again on testing the problem statement. The way it works forces the players to redirect attention when it is not necessarily their turn. The minigame was implemented so as not to make the winning side be the one who initiated the attack or chosen at random.

3.2 Interfaces

The game has two different type of screens. A shared main screen and a personal smartphone screen for each player. This is a feature of the AirConsole platform.

On the main screen is the game arena which is a tropical island. This island has a visible grid pattern on it to indicate to the players where they can walk and where the boundaries of the arena are. Interactable objects such as palm trees, ferns and skulls are placed inside of the corners of these grids and they can be interacted with if a player character is on the same grid space. The island is square and it is viewed from an isometric perspective.

The grid based arena was chosen to make it easier for the player to navigate the map. The placement of the objects are also placed where the players find it most intuitive to be able to interact with them when on the same tile, according to

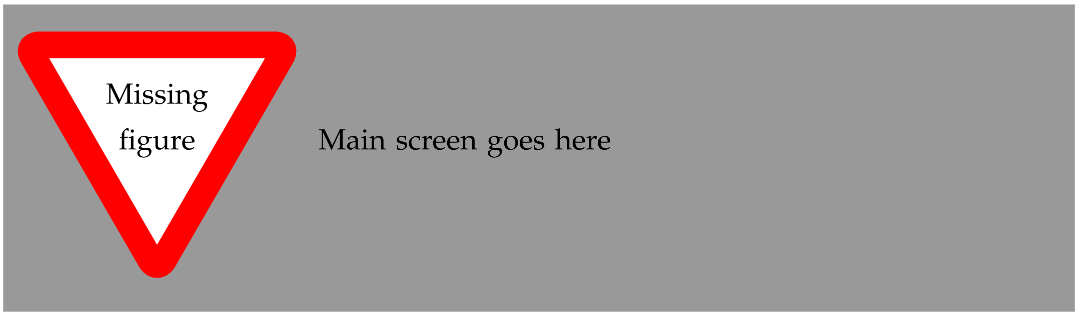

Figure 3.1: The main screen

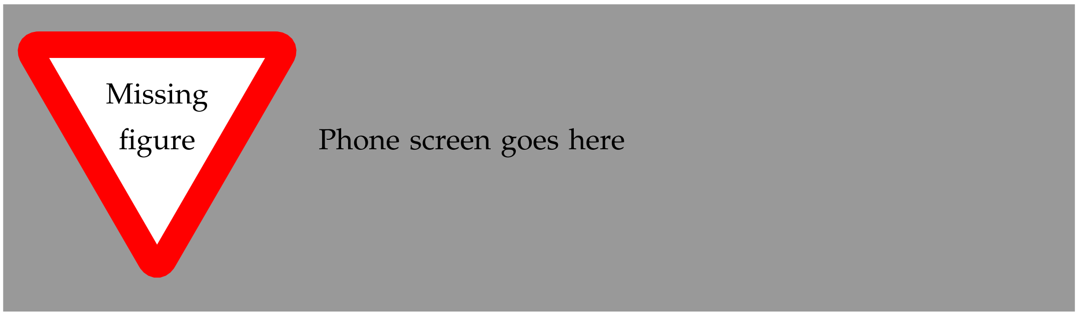

Figure 3.2: The phone screen

the paper test. Therefore, skulls and ferns populate the middle and lower border of the island, as these do not cover much area of the screen. The palm trees cover a lot more of the screen, and are placed around the upper border, so they do not cover any of the other tiles.

The island's shape is to fit the cartoon-ish style and the grid pattern. The scoreboard it there for strategic purposes, so that the players can keep track on how far the other player are, and how close they are to being able to find the treasure.

The smartphone screens display the colour of the player, the amount of map pieces the player has, the slot for the planned actions, five action buttons you can tab during your turn to plan the turn, and the button to execute your turn. This is shown in Figure 3.2.

The movement buttons are arranged in a two-by-two pattern, with the interact button placed outside of them to the right. Two empty spaces at the top is where the planned actions are shown. The button with a check mark is at the right side and is the button that needs to be tapped to implement the actions the player planned. The last thing on the smartphone screen is an icon with a little grid-map on it and a number underneath it. The left number is the number of map pieces the player is in possession of and the right number is the number of pieces needed.

When designing the smartphone interface it was incredibly important that it did not become overcrowded with buttons and other features. Initially the treasure map was an actual map and shown next to the controls. However, this was revised since if a player is using a small smartphone, then the button would not be very large to make room for the map. This in turn would lead to difficulties tapping the correct button. Since the map pieces was not necessary for the experiment of attention, their aesthetic representation was ultimately scrapped and abstracted with a simple icon and number.

3.3 Attention-Directing Cues

Four versions are made of this game. Three of them implement different methods to direct attention, while the fourth one has no attention-directing cues.

These four versions are described in the Subsections 3.3.1, 3.3.2, 3.3.3, and 3.3.4. The implemented methods are:

- Tactile feedback through vibrations in the smartphone
- Visual feedback through splash screens on the main screen
- Visual feedback through splash screens on the smartphones

The feedback is given to individual players when their turn starts and when a fight in which they participate begins.

3.3.1 No feedback

Labelled *A* in the experiment, it is used as a control vercion to analyse how people will distribute their attention when the system does not give any cues on where users are supposed to look. With this version, it is possible to investigate if certain attention cues work at all, by comparing the results of the version with said attention cues to the data from this version.

3.3.2 Tactile feedback

Labelled *B* in the experiment, this version of the game uses vibrations in the smartphones. The phone of a player always vibrates at the start of the player's turn and of a fight that said player is part of. This vibration is one continuous pulse lasting for 200 milliseconds.

3.3.3 Visual feedback - The main screen

Labelled *C* in the experiment, this version of the game displays splash screens on the main screen as attention cues. A splash screen is shown every time a player begins their turn, which corresponds to the colour of that player's controller and pirate. An example of this can be seen in Figure 3.3.

A splash screen is also shown on the main screen every time a fight begins between any two players. This splash screen can be seen in Figure 3.4.

Figure 3.3: Splash screen for red player's turn

Figure 3.4: Splash screen for a beginning fight

3.3.4 Visual feedback - The smartphones

Labelled *D* in the experiment, this version of the game uses the same splash screens as in version *C*. However, the splash screens are used only for switching a player's turn. These splash screens are shown on the smartphones, and a splash screen is only shown to the player that is currently starting their turn. This means that in case it is the red player's turn, only said player will have a splash screen displayed on the smartphone.

Chapter 4

The experiment

The game described in Chapter 3 serves as a tool to test the problem formulation:

> **How can the player's attention be directed between a shared screen and a personal hand-held screen when there is a need to change their visual focus between the two in a local multiplayer game?**

Since the focus of this problem formulation is on directing attention between two screens in a setup such as that of the AirConsole, the experiment described in this chapter sought to discover which method is best fit for directing the players' attention. To do this, test participants were subjected to the four different iterations of the game, which, as mentioned in Chapter 3, utilise four different methods of directing attention. The effect on the player's attention were measured through a combination of self-report questions and gaze tracking. This chapter describes the experiment in further detail.

4.1 Metrics

In order to test the problem formulation, a combination of several metrics were measured. These metrics may be split into two categories: performance and user experience metrics.

4.1.1 User experience metrics

After playing an iteration of the game, test participants were asked to fill out a questionnaire. The answers from this questionnaire serve as user experience metrics. As this is self-reported data from the participants, it is fit for measuring the users' own perception, but less so for measuring their concrete performance. However, as the users' own experience is still relevant to the problem formulation, this experiment made use of self-report questionnaires. The questions in the questionnaire were as follows:

1. To which degree do you agree with the following statements?
   (a) It was clear when it was my turn to act
   (b) It was clear when I was in combat
   (c) It was clear when I was supposed to look at the phone screen
   (d) It was clear when I should look at the main screen
   (e) It was easy for me to switch my attention between the two screens
   (f) It was easy to find what I was looking for when switching my gaze between the screens
   (g) I was distracted by the other players' phones
2. What did you think of the dual-screen setup? What did you enjoy about it? What did you find confusing?
3. Do you have any additional notes?

The rating scale statements (that is, the statements presented under question 1) provide seven possible answers: Strongly disagree, disagree, somewhat disagree, neutral, somewhat agree, agree, and strongly agree. The inclusion of the *neutral* option allows participants who neither agree nor disagree with a statement to pick a fitting option, rather than being forced to decide whether they agree or disagree, which may damage the validity of the test. The inclusion of the *slightly agree* and *slightly disagree* options allow participants who feel that they only partially agree with a statement to pick a side without sounding too opinionated, which may dissuade some from picking the completely neutral option in these cases.

4.1.2 Performance metrics

Performance metrics measure concrete results observed throughout the experiment. While playing the game, players were recorded both with a video camera and a Kinect 2 which logged when the players looked at the main screen, and when they looked away. The game logged when it was a new player's turn. By comparing these time stamps, it was possible to measure how much time passed from the moment it became a player's turn, to the moment they looked at their smart phone. The time stamps logged by the game also allowed for the measurement of performance time, namely the time it takes for a participant to complete their turn. In addition to this, error rates were also measured; for each turn, it was noted whether a participant looked at their screen at all, and whether they completed their turn before the given time ran out.

4.2 Setup

Each test included four participants. Apart from these, three people were present to facilitate the test:

- A **test conductor**, who instructed the participants in the terms of the test
- A **note taker**, who wrote down anything of note
- A **technician**, who made sure that both the Kinect 2 and the game were running smoothly, and that the camera was on.

Apart from the test conductor, the people facilitating the test remained as silent as possible throughout the test in order to not interfere with its results. The following materials were used for the purpose of this test:

- A television screen
- A computer that runs the game, connected to the TV screen through an HDMI cable
- A Kinect 2
- A computer that runs the Kinect, connected to it through a USB 3.0 cable
- 4 smartphones
- A video camera
- One consent form for each participant
- Four questionnaires for each participant
- Four different builds of the game

These materials were set up as shown in Figure 4.1. The four participants were seated in front of a large television screen, to which a computer running the game was connected through an HDMI cable. This way, the main screen for all four participants was the television screen. Underneath this screen was a Kinect 2 which was aimed at the participants while connected to another computer through a USB 3.0 cable. In front of each participant was a smartphone, which was connected to the game.

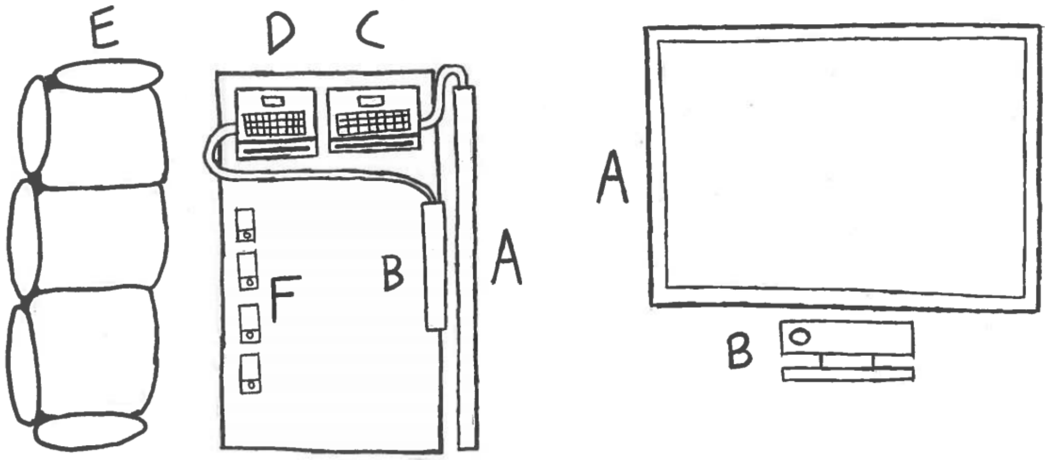

Figure 4.1: Test setup, showing the television screen (A), the Kinect 2 (B), a computer running the game (C), a computer running the Kinect 2 (D), seating for participants (E), and 4 smartphones (F)

4.3 Method

Once participants were seated, the test conductor explained the test procedure as well as the basics of the game. Once every participant was ready, the game began, and participants played freely until a the game ended or 10 minutes had passed, whichever came first. While the game was ongoing, the participants were filmed with the video camera, and data about their gaze was recorded with the Kinect 2. Each group of participants played through four iterations of the game, in a randomised order. The four iterations, as mentioned in Chapter 3, utilise four different methods for directing the player's attention to their phone screen when it becomes their turn, as well as when they are engaged in combat. These four methods are:

A) No feedback

B) Tactile feedback (phone vibration

C) Visual feedback (warning image on main screen)

D) Visual feedback (warning image on phone screen)

After a group of four participants had tried an iteration of the game, every participant was asked to fill out the questionnaire described in Section 4.1.1. While the game was ongoing, the Kinect logged whether players looked at or away from the main screen, and the game logged whose turn it was at any given time. The note taker noted down each player's error rates as described in Section 4.1.2.

4.4 Results

4.4.1 User experience results

After having played a version of the game, each participants as asked to fill out the questionnaire described in section 4.1.1. The rate at which participants agreed with the statements given in question 1 will be described in this section. The answers given in statement 1a are illustrated in Figure 4.2. From this figure, it is clear that participants most strongly agreed with the notion that it was clear when it was their turn to act when given tactile stimulus, or visual stimulus on the main screen. They found it most unclear when given nu stimulus at all.

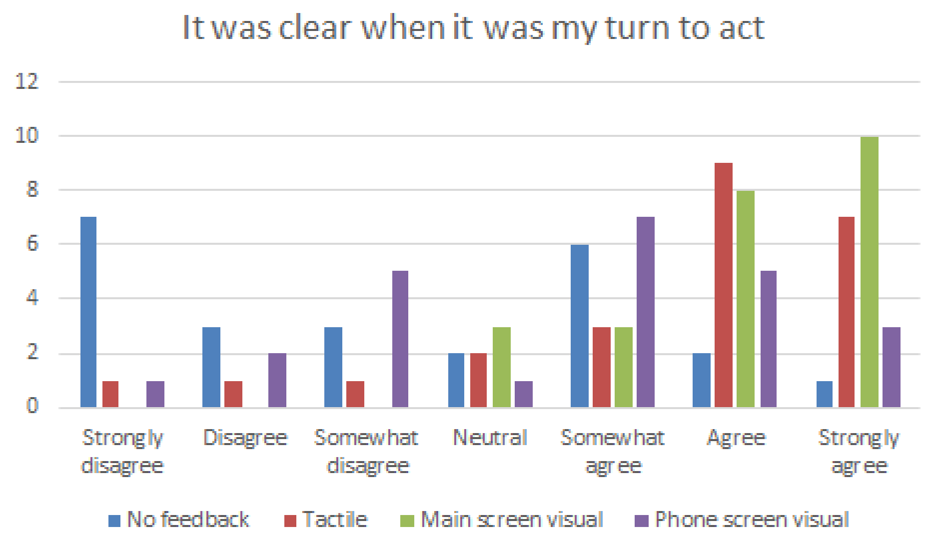

Figure 4.2: Answers for the question "it was clear when it was my turn to act" for each of the four versions

Figure 4.3 shows that it was somewhat clearer to participants when they were in combat when given no stimulus, but similarly to the previous question, participants mostly found it clear when given tactile stimulus or visual stimulus on the main screen.

Similar results are seen in Figure 4.4, where players were least in doubt regarding when they were supposed to look at the phone screen when given main screen or tactile stimuli. However, the answers seen in Figure 4.5, players were generally neutral regarding whether it was clear when they should be looking at the main screen. The version with tactile feedback stands out in this case as the version where most people found it clear when they should look at the main screen.

Figure 4.6 illustrates to which degree participants found it easy to switch their attention between the two screens in the four different versions of the game. The

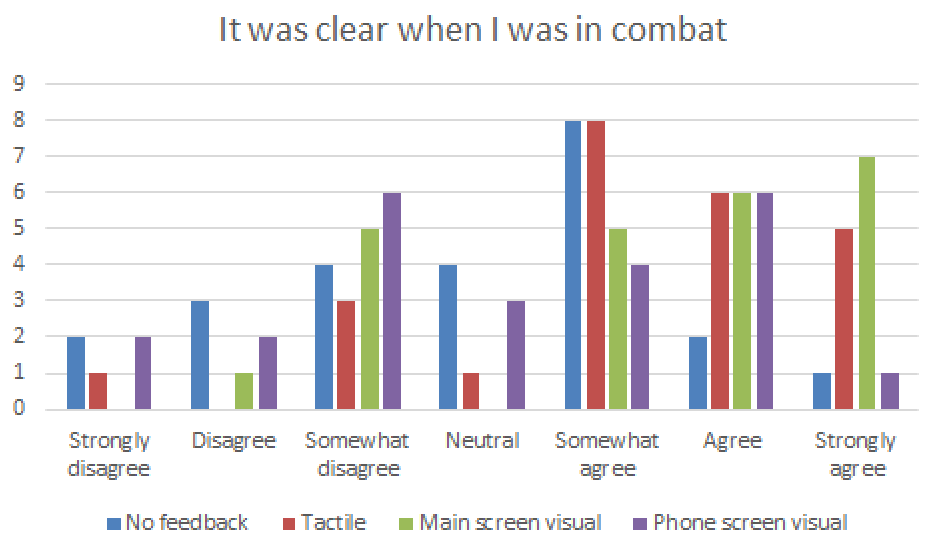

Figure 4.3: Answers for the question "it was clear when I was in combat" for each of the four versions

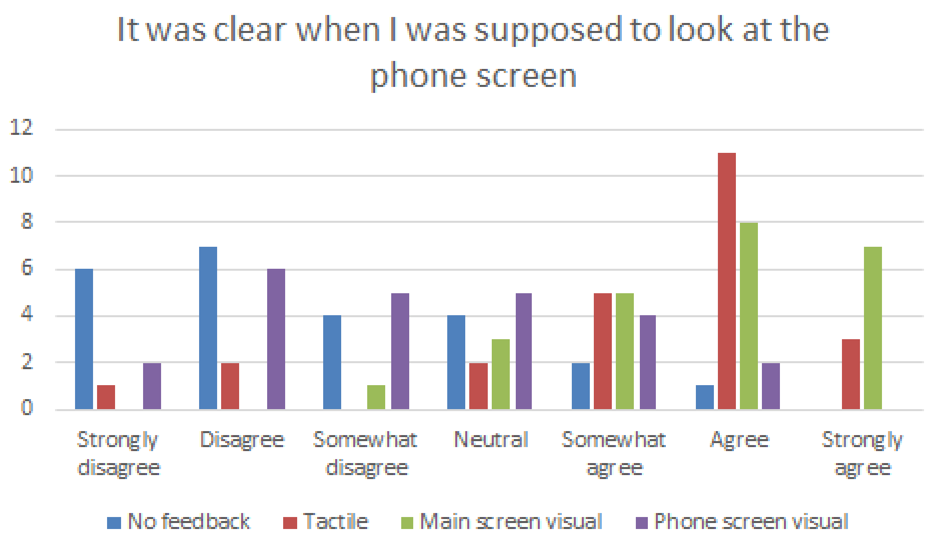

Figure 4.4: Answers for the question "it was clear when I was supposed to look at the phone screen" for each of the four versions

results here show that people especially found it easy in the versions with tactile and main screen stimuli.

Figure 4.7 shows that players generally found it easy to find what they were looking for when switching their gaze between the two screens. These results stand out compared to those of the previous questions, as they do not seem to be affected

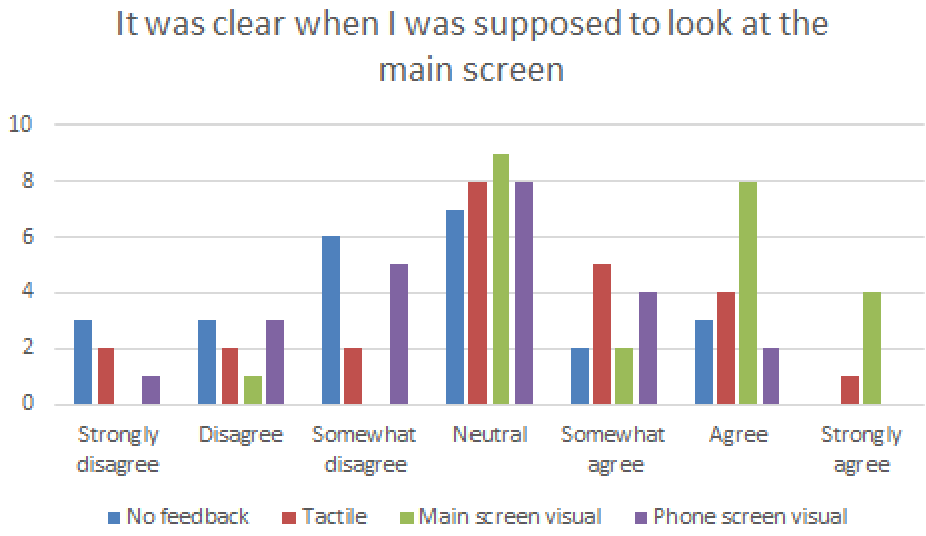

Figure 4.5

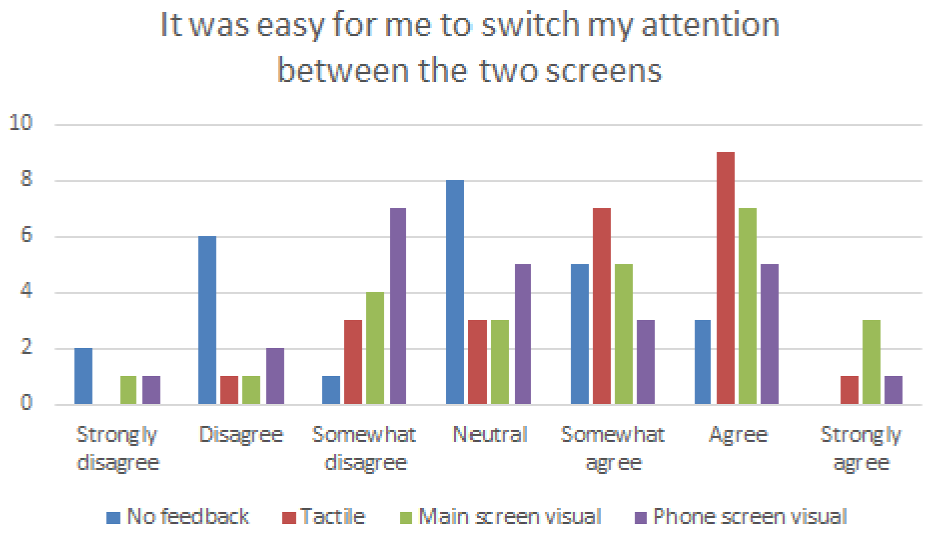

Figure 4.6

as much by the stimulus given to the participants when it was their turn, and when they are engaged in combat; even the versions with no stimulus, or visual stimulus on the phone screen, got more positive results on this question.

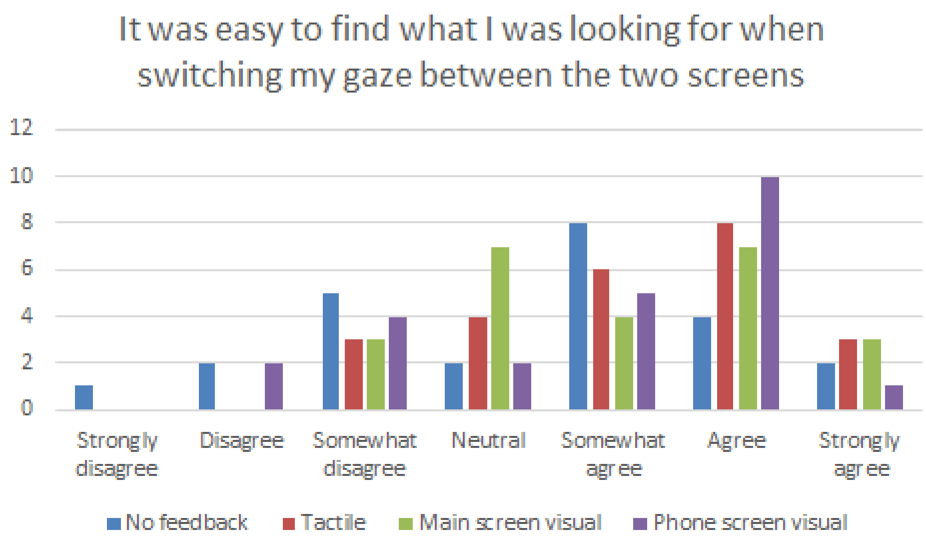

Figure 4.7

4.4.2 Performance results

As mentioned in section 4.1.2, two logs were generated throughout the test: one noting time stamps for different events on the game, and one noting data from the kinect regarding whether players looked at or away from the main screen. By comparing the two, it was possible to measure the amount of time it took for each player to look at their phone after it became their turn, as well as after they were engaged in combat. This reaction time was noted for each of these events, and an average reaction time was calculated for each of the four versions of the game. As can be seen in Figure 4.8, participants switched their visual attention fastest when given tactile stimulus, at an average of 0,78 seconds. Players switched their visual attention slowest when given visual stimulus on the main screen.

It is, however, significant to note that in some cases, test participants failed to look at the phone screen at all during their turn or a combat they were a part of, and in other cases, participants were already looking at their phone by the time it became their turn or they engaged in combat. In these cases, it was impossible to note a reaction time. Instead, Figure 4.9 illustrates the rate at which these two circumstances occur, for each of the four versions. As the figure shows, these cases occurred most frequently when players were given no indication of when it was their turn, and least so when they were given visual stimulus on the main screen.

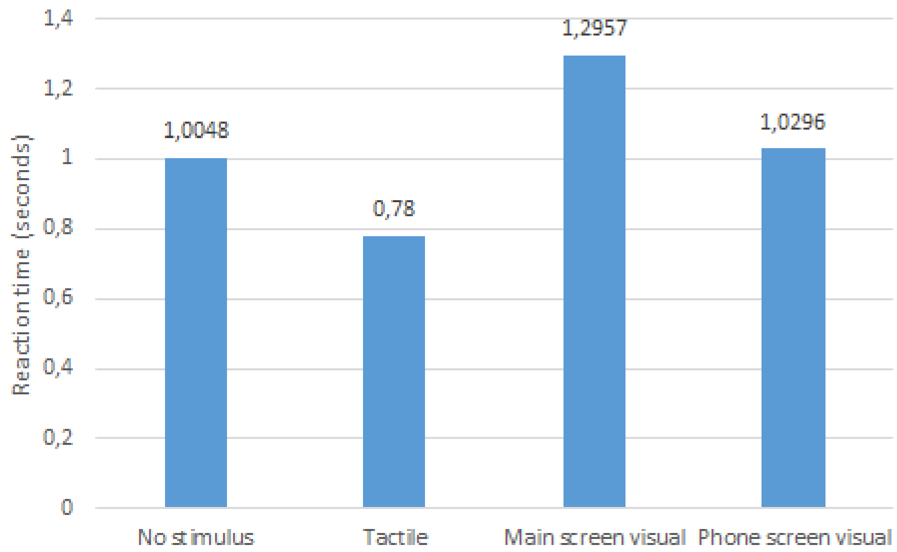

Figure 4.8: Average reaction time for the four versions of the game

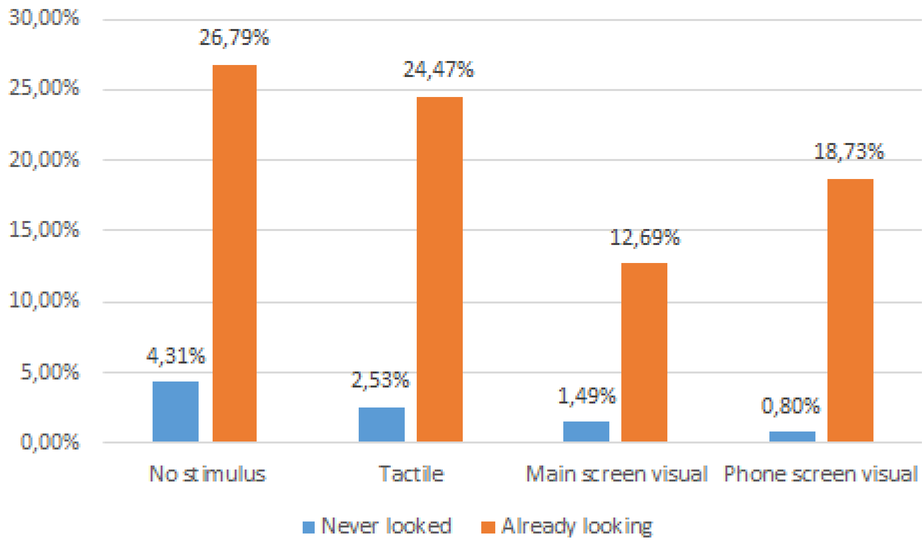

Figure 4.9: The rate at which participants failed to look at their phone screen, or were already looking at it, for each of the four versions

4.5 Analysis and Conclusion

When looking at the performance metric results, it is important to note that even though the game version with visual stimulus caused test participants to perform the worst with regards to reaction time, it is the version which caused fewest cases where participants were already looking at the screen to wait for their turn, whereas the version with no indication of whose turn it is caused faster reactions from participants, but many would constantly look at their phone screen, even if it was not their turn. This is possibly because they were anticipating their turn, but since they would be given no indication of when their turn would start, they had to check in with their phone screen more often.

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Chapter 5

Discussion

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5.1 Result validity

Describe the validity of the results

5.2 Future Research

Describe other areas that could be researched from these results.

5.3 Further Implementation

Describe what the results could be used for in other contexts. Discussable how important this chapter is.

Chapter 6

Conclusion

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Appendix A

Appendix A name

Here is the first appendix