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Short-term effects of an action video game on attention

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Abstract

This study was carried out to examine whether an action video game had short-term effects on selective attention and temporal attention, as measured by the Attentional blink, Simon task and Stroop task. The design was experimental in which the participants (N = 20) completed 1 hour of action video game playing or reading in a book on two occasions, separated by 7 days. All participants completed both conditions. The design was randomized, counterbalanced and with cross-over trials. A Kolmogorov-Smirnov test and a non-parametric Friedman test of differences among repeated measures were conducted. Furthermore, data was analyzed with the Mann-Whitney U Test, with no significant results. These results are discussed from the perspective of two attentional theories; Broadbents filter theory and Kahnemans capacity theory, in addition to studies of action video games related to attention. The non-significant results might depend on several methodological factors regarding the chosen action video game, the amount of video game playing and the attentional measures. The study contributes to the research field of action video games.

Keywords: Attention, Selective attention, Temporal attention, Action Video Games, Stroop, Simon, Attentional Blink, Tablet.

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1 Introduction

Every day we are bombarded with a massive amount of information from the environment in which we have to relate. Irrelevant information has to be ignored while relevant information is selected and processed. To select information in the environment we use our skills in selective attention. These skills are also in play when reading a text and suddenly overhearing a conversation that you want to follow and then switching your attention towards this conversation. However, reading a text while following a conversation concurrently is difficult. Trying to pay attention to two things at the same time involves divided attention. Paying attention to two sources of stimuli imply the likelihood of one stimulus' properties not to be fully processed, and in some cases, to be lost. When focusing your attention on a task for a period of time, sustained attention is engaged (Sarter, Givens & Bruno, 2001). There has been some discussion as to whether attention is a unitary construct or consists of several processes. According to Mirsky (1987) attention consists of several elements which are interrelated in a system.

"Attention can be likened to a spotlight that enhances efficiency of detection of events within its beam" (Posner, Snyder & Davidson, 1980, p. 172). Whether we direct our attention toward something depends among other things on the novelty, complexity and incongruity of the stimulus (Berlyne, 1970; Kahneman, 1973). Incongruity and novelty can be defined as a discrepancy between stimulation and expectations (Kahneman, 1973). According to Berlyne (1970), complex stimuli is perceived as more pleasing and interesting when their novelty decreases, while for simple stimuli it is the opposite way around. Berlyne (1960) proposed that the intensity of attention is related to the level of arousal.

William James (1890) suggested that attention was either a) immediate, b) derived, c) passive, reflex, non-voluntary, effortless; or d) active and voluntary. The aspect of active and passive attention is in modern terms known as bottom-up or top-down, thus stimulus-driven or goal-directed (Egeth & Yantis, 1997). A bottom-up or stimulus-driven approach involves the deployment of attention being depended almost completely on the properties of stimuli, thus the stimuli control attention. The top-down and goal-directed approach involves the deployment of attention according to the goals and intentions of that person (Egeth & Yantis, 1997). The attending to stimuli because of their relevance to a task at hand is referred to as voluntary attention. Novel and surprising stimuli that attract attention, thus involuntary attention, require more effort of processing than do more familiar stimuli (Kahneman, 1973).

In the nineteenth century attention was perceived as a focus within the field of consciousness. It was believed that attention could be focused on a limited number of related concepts or percepts and that between three and eight objects could be processed simultaneously (Cohen, 2014).

As the information age arrived in the 1970's, concepts from information-processing theory were increasingly used by cognitive scientists. These concepts were used to explain among other things the act of selectively attending to certain information in the surroundings.
Information-processing theory has produced concepts that are in use today, including the concept of attentional capacity (Cohen, 2014).

As mentioned earlier, there is a belief that the concept of attention consists of several elements (Mirsky, 1987; Mirsky, Anthony, Duncan, Ahearn & Kellam, 1991). According to multiple studies, attention is susceptible to alteration by means of training (MacLeod, Mathews & Tata, 1986; Wass, Porayska-Pomsta & Johnson, 2011). In this context, training implies an activity that has the ability of modifying something. In this thesis, emphasize is on the fact that training modifies attentional aspects. One of these activities that can train attention is video games, especially in the action genre (Green & Bavelier, 2003; 2006a; 2006b; Franceschini et al., 2013).

In 2012, 41 % boys and 21 % girls in Norway reported to play computer and video games several times a day. These numbers have increased to 45 % and 30 % respectively, from 2012 to 2014. In 2014, 94 % of children between the ages of 9-16 reported that they played computer- and video games as leisure activities (Mediatilsynet, 2014). When the majority of children and teenagers engage in video games, this is obviously an important research field in order to gain knowledge as to whether this is a positive or negative leisure activity to engage in for this age group. It is also reason to believe that knowledge in this field is of importance in other age groups as well, as it is of interest to be aware of the possible positive and negative effects for all age groups.

There is little knowledge about the mechanisms underlying the impact that action video games have on cognitive skills. However, it has been suggested that a general improvement in speed of processing, thus how fast stimuli are processed (Belchior, 2013), is a result of the demands of frequent and fast decisions in action video games (Green, Pouget & Bavelier, 2010), and that changes in visual short-term memory (VSTM) skills (Green & Bavelier, 2006b) is a result of requirements of allocating attention to several items over time in action video games. This enhances a serial process of counting which in turn increases the number of objects perceived in the visual array (Green & Bavelier, 2006b). Speed of information processing has been viewed as a general or task-independent construct (Fry & Hale, 2000). The faster the processing, the greater amount of information can be processed in one unit of time (Conway, Cowan, Bunting, Therriault & Minkoff,

2002). Short-term memory or working memory has been defined as "the system for the temporary maintenance and manipulation of information, necessary for the performance of such complex cognitive activities as comprehension, learning, and reasoning" (Baddeley, 1992, p. 556). Thus, VSTM is only a temporary "sensory store" where image-like representation is held (Sperling, 1960). It has also been suggested that early sensory processing, such as the sensory encoding of a stimulus event, is modulated by action video games, leading to increased sensitivity to salient visual events that capture attention (West, Stevens, Pun & Pratt, 2008). Thus, it is theoretically expected that playing action video games influences attention beneficially.

The study presented here is inspired by the work of Tahiroglu et al. (2010). They examined whether 1 hour of video game playing had short-term effects on performance in a TBAG (Turkish Scientific and Technical Research Council of Turkey) version of the Stroop task, as a function of daily computer use and what the purpose of computer use was. This task, which mainly measures selective attention, was completed before and immediately after video game playing as a pre-posttest design. Some participants showed an improvement from their pre-video-game score while others worsened their pre to posttest-score. The 1 hour of computer game playing was not a training session in itself. The results were affected by daily computer use with those who used a computer daily for more than 1 hour having the worst scores. In addition, the purpose of computer use was a contributing factor to the results. The results support the hypothesis of computer game playing having an effect on cognition, but it is not clear what this effect is. Inspiration from this work is specifically the pretest-posttest design and using 1 hour as duration for video game playing. Earlier research has applied training dosages ranging from 5 (Greenfield, DeWinstanley, Kilpatrick & Kaye, 1994), 10 (Green & Bavelier, 2003; 2006b; Feng, Spence & Pratt, 2007) to as much as 50 hours of training (Li, Potal, Makous & Bavelier, 2009; Green et al., 2010). No studies known to the author have been implemented with as little as 1 hour of playing an action video game and examining the possible short-term effects on attention, as is the case of the study in this thesis. Presumably, 1 hour of video game playing is not sufficient to classify as training. Thus, in this study, the goal is to examine possible short-term effects of video game playing. As enhancements of different attentional and visual skills have been found for the various training dosages, it is of interest to examine whether as little as 1 hour is a sufficient dosage of playing an action video game in order to observe enhancement in attentional skills. It is interesting because this can offer knowledge about how much or how little action video game playing is sufficient for influencing, modifying and training attention. This might say something about a possible limit as to when the modifying of attention starts.

There are a multitude of theories and models developed to understand attention, deriving from different traditions of thinking including information-processing and two strategies of information

processing; bottom-up and top-down. There are also theories and models within cognitive neuroscience. In this thesis, the focus will be on two attentional theories.

2 Theories of attention

As aforementioned, several theories and models of attention have been developed in order to understand this cognitive phenomenon (e.g. Broadbent, 1958; Kahneman, 1973; Posner & Peterson, 1990). The focus here will be on two approaches to understanding attention; the bottleneck – filter approach and the capacity theory approach. The emphasis will be on two attentional theories developed by two pioneers within attentional research; Broadbent's filter theory and Kahnemans capacity theory. The first mentioned theory is emphasized here because it offers a basic understanding of selective attention and in relation to action video games. The reason for focusing on the latter theory is because it offers an explanation of how action video games possibly influence attention which is the focus of this thesis.

2.1 Bottleneck - filter approach to attention

Broadbent (1957), which is referred to as one of the pioneers within the research field of attention, suggested a model of attention including a Y-shaped tube.

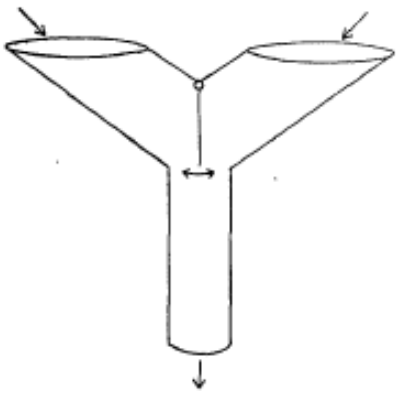

FIG. 1. The simple model for attention.

Figure 1 – The simple model for attention (Broadbent, 1957).

This figure illustrates how information enters two sensory channels which may represent each ear, or one may be an ear and the other an eye. However, sensory channels are not exactly the same as sensory organs. Sounds localized in different places are treated as being on different channels. Moving the flap prevents information from the other channel to pass. Consequently, information from the two channels is processed serially (Broadbent, 1957).

During selective listening experiments, Broadbent found that multi-channel listening is difficult because of the limited capacity of the human perceptual system. The limited capacity of the listener results in speech tasks interfering with one another, and it is therefore necessary to select which information that arrives the sensory organs. Thus, the need to presume a filter mechanism was

implied (Broadbent, 1958). A sequence of three elements is considered, in which information arrives a short-term store (S-system) with limited time span. From the short-time store (S-system) it may be passed by a selective filter through mechanisms of limited capacity (P-system) and then returned to the short-term store (Broadbent, 1958). Stimuli arrives the S-system at the same time as their physical feature (e.g. location) is analyzed. Thus, stimuli enters the selective filter if arriving in the correct channel and then into the P-system. The latter handles the most complex perceptual analyses (Kahneman, 1973). The theory can be illustrated by a model which consists of a first stage with sensory registration and storage where the stimuli enters, perceptual analysis as the second stage and response selection as the third stage. This is a model of perceptual analysis and information processing in which a bottleneck is placed prior to the perceptual analysis stage. This is illustrated in the following information-flow diagram adapted from Kahneman (1973), in which model A illustrates Broadbent's filter theory and model B is a similar model proposed by Deutsch and Deutsch (1963), with the bottleneck located prior to response selection.

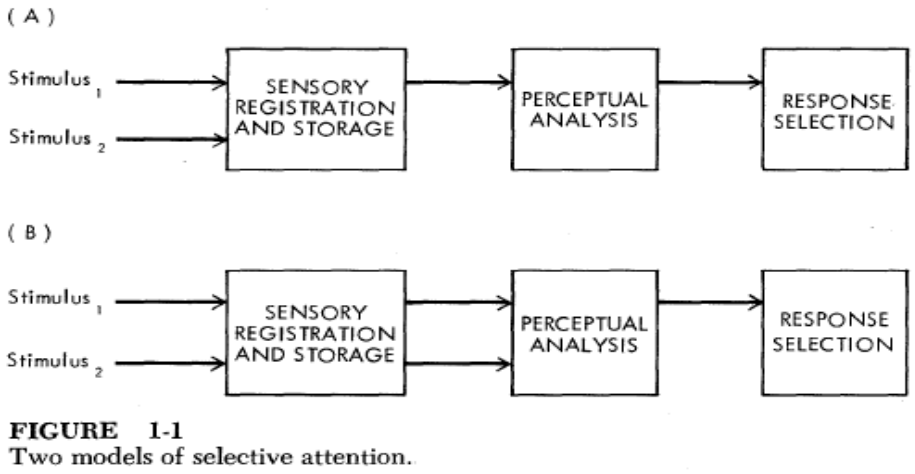

FIGURE 1-1
Two models of selective attention.

Figure 2 – Two models of selective attention (Kahneman, 1973).

It is more likely for novel and intense stimuli to be perceived (Broadbent, 1958). In Broadbent's theory the placing of the bottleneck preceding the perceptual analysis stage contributes to the perception of only one stimulus at a time. When two stimuli are presented at once, one of them is perceived immediately while the other one becomes something like an echo. The message which is not attended to is never heard because it is not interpreted and analyzed perceptually. Filter theory suggests that talk presented on a channel which is not relevant is not perceptually analyzed and therefore not perceived as speech (Kahneman, 1973).

However, Moray (1959) discovered that it was more likely that a subject noticed a message on the ignored ear when their name preceded the message. He carried out an experiment which

established how the meaningfulness of the content in the ignored message is of big importance. By mentioning the participant's name, the participant started switching from the shadowed message to the ignored message. Thus, if a subject is listening selectively to one channel and ignoring the other, calling his name on the rejected channel can cause him to switch his attention to this channel.

Deutsch and Deutsch (1963) proposed a model in which the bottleneck is located prior to the response selection stage, as shown in the previous figure. In this model concurrent stimuli are processed at the same time without interference, opposite of what Broadbent thought. In Deutsch and Deutsch's (1963) model, all messages are heard, but only one message is responded to. According to this model, attention can be divided between two messages simultaneously.

Although Broadbent's filter theory was replaced by other developments, it still offers insight into the "system" of selective attention, and served as a starting point for understanding this system. In addition to explaining how we filter information from the environment, this knowledge can also be implemented in the context of playing video games and processing of information in the video game environment. In the following, an alternative theory, that offers a different view of attention: Kahneman's capacity theory.

2.2 Capacity theory

The capacity theory is an alternative to the view of a bottleneck, and can be considered as "a theory of how one pays attention to objects and to acts" (Kahneman, 1973, p. 8). The total amount of attention which can be used at any time is limited, explaining the limited capacity to perform multiple activities concurrently. Thus this theory can be considered a theory of divided attention. If the available capacity is exceeded by two activities, an interference occurs which is non-specific. A central capacity theory was suggested, including arousal as a factor affecting the available capacity and the allocation policy which channels capacity to different tasks. However, the acceptance of such a theory depends on several questions needing to be dealt with. These questions include what it is that contributes to the demands of an activity, what affects the amount of capacity available and what the rules of the allocation policy comprise **(**Kahneman, 1973**)**.

An activity's difficultness determines how much demand is put on the limited capacity. Easy tasks demand less capacity than hard ones do. Tasks typically involving time pressure are considered as hard. Tasks of the same type can be ranked after level of difficulty by considering how fast the task is performed, its complexity and the likeliness of failure. Reading in a book or listening to music are considered as easy tasks. When demands of current activities change, the arousal level and capacity increase or decrease as a result of this, suggesting that the limited capacity and the arousal

system is related. Physiological arousal accompanies variations of effort. With arousal being moderately high more capacity is available compared to when arousal is low (Kahneman, 1973).

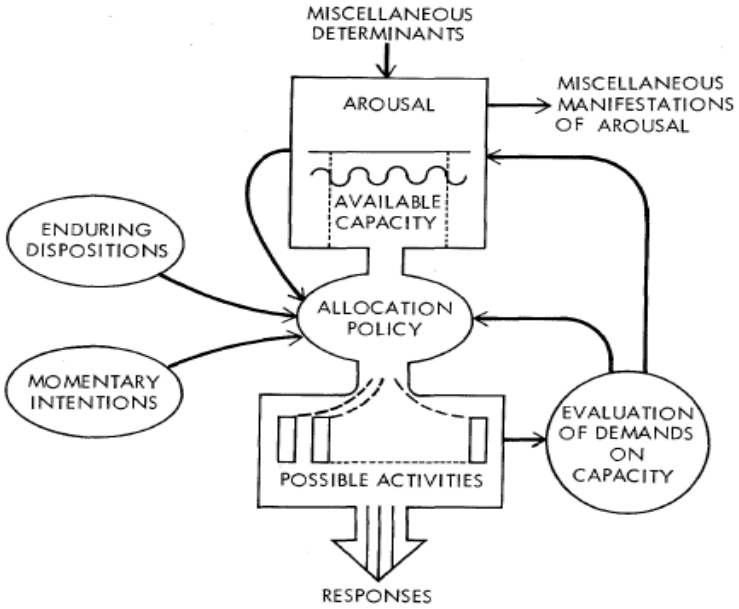

FIGURE 1-2
A capacity model for attention.

Figure 3 – A capacity model of attention (Kahneman, 1973).

How much capacity is available at any time depends on what is known as structural or energetic limitations, which can be observed in figure 3 as enduring dispositions and momentary intentions. Structural limitations reflect inherent characteristics of the individual, including their cognitive resources, memory and processing speed. Energetic limitations reflect temporary states of the person, including drowsiness, motivation and level of arousal (Cohen, 2014). Based on the theory of capacity it is expected that an action video game would expend capacity, leading to worsened performance on attentional measures completed after the video game playing.

3 Types of attention

Attention is involved in several different tasks and can be divided into components according to what the main function of that component is; whether it is to select certain information, keep focus over a prolonged period of time or divide processing resources among several tasks. Here attention will be divided into three components; selective, divided and sustained attention, as proposed in earlier research. These attentional components are considered as essential in the regulation of information processing (Mirsky et al., 1991). The component of selective attention is of main interest in this thesis based on the established relation between video games and selective attention, and will be examined first.

3.1 Selective attention

The environment is full of input and stimuli in which some are relevant to an action being carried out and others are not. Since humans are not capable of processing the complete array of stimuli available, it is essential that only the stimuli of importance are selected and processed further. Otherwise we would probably be overloaded with stimuli and incapable of acting. Relevant stimuli are differentiated from irrelevant stimuli by physical distinctions, so that only the relevant stimuli are responded to, yet, irrelevant stimuli are not fully excluded (Lavie, 1995). The selection of relevant stimuli depends on attention being directed towards them. Directing of attention towards a specific sensory feature (e.g. spatial location, color or frequency) causes more efficient processing of stimuli in which these features are inherent, than if attention is not directed (Posner & Presti, 1987). Different sources of visual input are competing to be analyzed, and the information which is currently relevant to behavior is more likely to be analyzed (Desimone & Duncan, 1995). When distractions are resisted and focus is directed to the relevant stimuli, thus, when certain stimuli or aspects of stimulation are selectively attended to in preference to others, this is known as selective attention (Kahneman, 1973). How efficiently irrelevant distractors are rejected depends on the perceptual load involved in the relevant processing (Lavie & Cox, 1997). Selective attention is controlled in both a bottom-up and top-down fashion (Desimone & Duncan, 1995), thus both depend on the properties of the stimuli and on the goals and intentions of that person (Egeth & Yantis, 1997).

Selective attention is considered to be “the selective allocation of effort to some mental activities, chosen over others” (Kahneman, 1973, p. 12). This aspect is profoundly related to focus. The selection part is characterized by the action of prioritizing some informational elements over others (Cohen, 2014).

Treisman (1969) suggested four types of selection: 1) selection of outputs; 2) selection of inputs; 3) analyzer selection and 4) selection of targets. The selection of outputs involves the thought

of a limit as to the responses we can make and information we can store. Consequently, there is a competition between concurrent outputs of perceptual analysis for the limited capacity of the motor systems and memory. In selection of inputs, the selection of which sensory data to analyze puts a restriction on perception. Selection of analyzers involves that one or more properties of stimuli are selected to analyze while others are ignored. The last type of selection; selection of targets, involves that specific goals or targets of perceptual analysis are selected for identification. One or a specified set of critical features defines these items.

There has been a debate of whether it is more correct to adopt an early selection approach or a late selection approach when understanding selective attention (Lavie, 1995). In the early selection approach, perception is a limited process depending on selective attention. Therefore, early after physical features have been analyzed, the attentional selection takes place (Broadbent 1958; Treisman & Geffen, 1967). The late selection approach claims that perception is a boundless process. In this approach, selection occurs after complete perception, thus late in the process (Deutsch & Deutsch, 1963).

Selective attention can be demonstrated in both the auditory and visual sensory modality. Visual attention has been defined as "the ability to monitor a part of the visual field for a change in stimulation" (Shapiro, 1994, p. 86). Research indicates that the control of visual selective attention involves working memory (de Fockert, Rees, Frith & Lavie, 2001). In de Fockert et al's. (2001) study, participants completed one task requiring visual selective attention and one task requiring working memory. It was hypothesized that the increasing of load in the working memory task would increase the processing of visual distractors in the selective attention task. This was exactly what they found and their hypothesis was confirmed. Thus, working memory and attention are two separate, but related concepts.

The uncovering of principles underlying the distribution of selective attention can be done by identifying the neural response to preparatory cues signaling what spatial location of stimulus feature should be attended prior to the appearance of the actual target display (Stevens & Bavelier, 2012). Functional magnetic resonance imaging (fMRI) studies have found that a fronto-parietal network in the brain is engaged by preparatory cues (Corbetta & Shulman, 2002). During the Stroop task, the neural network of the anterior cingulate cortex (ACC) and the left dorsolateral prefrontal cortex (DLPFC) is activated. More activation was seen in the ACC during color naming than word reading, and the responding to incongruent stimuli showed most profound activation in the DLPFC (MacDonald, Cohen, Stenger & Carter, 2000).

A relevant concept related to selective attention is the distinction between stimulus set and response set proposed by Broadbent (1970, 1971 as cited in Kahneman, 1973). Stimulus set allows

the analyzing of relevant stimuli in a more precise manner than other stimuli as a result of the relevant stimuli being defined by a physical characteristic. Response set reduces the possible responses. When instructed to read words printed in blue and ignore other words the stimulus set is used. When instructed to read digits and ignore other words, the response set is used (Kahneman, 1973). Two explanations have been suggested for the response set effect; it may be a result of attention being selectively allocated to acceptable responses at the level of response selection, or to a bigger inhibition of distractors which are not acceptable responses (Lamers, Roelofs & Rabeling-Keus, 2010).

Elements of selective attention include orienting (e.g. moving the head towards the location of a sound), filtering (e.g. processing certain characteristics of an object over others), searching (e.g. scanning the bookshelf for a specific book), and expecting (e.g. when holding information about where and when an event will occur) (Plude, Enns & Brodeur, 1994).

3.2 Divided attention

It is possible to divide attention between two activities at the same time, however, how much of the two stimuli are actually processed can be discussed. The switching between multiple tasks causes behavioral performance to be directly reduced (Kiesel et al., 2010). Multi-tasking is an excellent example of an activity which demands divided attention. As mentioned earlier, the successfulness in performing two tasks concurrently depends on how demanding the tasks are (Kahneman, 1973). The effort devoted to a task determines how well you can do another thing at the same time. You might have no problem driving a car and having a conversation with a passenger in an environment with little or nothing challenging the driving skills. However, when driving in an unknown environment with many pedestrians, crossing roads and heavy traffic, you might have to stop the conversation in order to fully concentrate on driving. This is a situation of dual tasks which engages divided attention. The studying of dual-task interference can offer insight about the system in the brain that appraises some tasks as too demanding to be processed at the same time (Pashler, 1994). The increased activity in a cortical field located within the right inferior frontal gyrus is associated with dual task interference (Herath, Klingberg, Young, Amunts & Roland, 2001). Several explanations have been suggested as to why performing two tasks concurrently may be perceived as a challenge. According to Pashler (1994) there are three widely accepted explanations, including what is known as cross talk, bottlenecks (task switching) and capacity sharing. The first-mentioned is the assumption that interference is not dependent on the type of operation, but what the information being processed contains. The bottlenecks (task switching) explanation involves a bottleneck resulting from two or more tasks demanding the same mechanism at the same time which cause

impairment for one or both tasks. This explanation is different from what Deutsch and Deutsch (1963) proposed, but corresponds to the initial belief of Broadbent (1958) of a bottleneck in attention. When two sources of stimuli arrive the perceptual system concurrently only one of the stimuli sources is processed or at least is processed to a higher degree than the other. Capacity sharing is the belief that processing capacity is shared among tasks. When performing more than one task, the capacity available for the individual task is limited, and this again affects performance. The allocation of resources between tasks can however be controlled reasonably well (Pashler, 1994). This explanation corresponds well with the capacity theory of Kahneman (1973).

3.3 Sustained attention

When reading in a book or scanning a bookshelf for a specific book you sustain attention for more than a few seconds, and consequently engage sustained attention (Langner & Eickhoff, 2013). Sustained attention has been defined as "a subject's readiness to detect rarely and unpredictably occurring signals over prolonged periods of time" (Sarter et al., 2001, p. 146). This component of attention has also been called vigilance (Oken, Salinsky & Elsas, 2006). During tasks requiring sustained attention, the right hemispheric prefrontal and parietal regions of the brain are active (Sarter et al., 2001). Over time the quality of sustained attention deteriorates (Mirsky et al., 1991).

Sustained attention determines the efficacy of "higher" components of attention; selective attention and divided attention, in addition to cognitive capacity, and sustained attention has been considered as a limited resource (Sarter et al., 2001). Cohen (1988, as cited in Coull, Frith, Frackowiak & Grasby, 1996), employed three vigilance tasks in which activation of the prefrontal cortex was observed in all three tasks. This suggests that sustained attention is mediated by this brain area.

4 Methodological approach to attention

Multiple paradigms and tests have been developed with the purpose of measuring attention. Since aattention is not directly measurable (Spikman & van Zomeren, 2010), and not a unified construct (Mirsky, 1987), the application of tasks engaging different attentional processes are necessary.

As aforementioned, humans do not allocate attention in one specific sensory modality only, e.g. selective attention has been studied in both the visual (Stroop, 1935) and the auditory domain (Cherry, 1953; Moray, 1959). Some experiments examine selective attention by studying the processing of information which occurs simultaneously by two separate sound sources (Deutsch & Deutsch, 1963). This includes the work by Cherry (1953) who developed a method called ”shadowing” where the participant listens to two messages presented to both ears simultaneously, known as dichotic listening. The task is to shadow one of the messages, thus, listen to a message and repeating it out loud concurrently. Shadowing one message causes the inability to report the content of the ignored message.

The Stroop task is a computerized test which mainly measures selective attention, but also cognitive flexibility, inhibition (Basak, Boot, Voss & Kramer, 2008) and cognitive control. Cognitive flexibility has been defined as “the readiness with which the person's concept system changes selectively in response to appropriate environmental stimuli” (Scott, 1962, p. 405), thus the ability to switch between two different mind sets. This concept is an aspect of executive functions (Miyake et al., 2000). Botvinick, Braver, Barch, Carter and Cohen (2001, p. 624) referred to cognitive control as “the cognitive system’s ability to configure itself for the performance of specific tasks with the help of appropriate adjustments in perceptual selection, response biasing, and the maintenance of contextual information”. The Stroop task includes the indication of the color of different color-words, in which some trials are congruent (e.g. the word RED written in red), and some are incongruent (e.g. the word RED written in blue). More details of this procedure will be given in the method section. The test assesses how well a person can maintain a goal in mind and suppress a habitual response in favor of one that is less natural (Strauss, Sherman & Spreen, 2006). The Stroop effect is the most extensively used paradigm to study interference and conflict (Cohen, 2014), and demonstrates the importance of response set, a concept mentioned earlier (Lamers et al., 2010).

The Simon task measures selective attention in addition to response switching and inhibition (Bialystok, 2006). The task is to indicate whether a square is green or red with the right or left index finger. More detail will be offered in the method section. In this kind of choice reaction task (CRT), performance is more efficient when stimuli and responses are ipsilateral, in other words on the same side, than when they are contralateral, on the opposite side (Lugli, Iani, Nicoletti & Rubichi, 2013).

Response times are faster when visual targets are presented in a spatial location that corresponds to the location of the correct response; this is known as the Simon effect. If red stimuli imply the responding on the left side, then responses to red stimuli are faster when they are presented on the left side of space (Klein & Ivanoff, 2011). Simon (1990, as cited in Melara, Wang, Vu & Proctor, 2008) believed that the location of a stimulus evoke an unlearned tendency to respond in its direction. He suggested that the interference involved in the Simon effect occurs in the stage of response-selection in information-processing.

There are several experimental paradigms developed to study the different components and aspects of attention, including the dual-task paradigm which measures divided attention. In this paradigm, stimuli are presented concurrently and responding to both is demanded (Bonnel & Hafter, 1998). To measure sustained attention one may carry out a task which demands the focus of attention for an extended period of time (Sarter et al., 2001), including the Continuous Performance Test (CPT) paradigm (Rosvold, Mirsky, Sarason, Bransome & Beck, 1956). Another measure of sustained attention is the multiple object tracking task (MOT). The original MOT involves tracking a number of targets varied from one to five, amongst distractors (Pylyshyn & Storm, 1988). This task requires the allocation of attention to several items over time and sustained attention for several seconds (Green & Bavelier, 2006b).

Attention is not limited to the three components mentioned in the last sections; other aspects of attention include attentional control and attentional capacity. These aspects can be measured by the flanker compatibility effect (Eriksen & Eriksen, 1974) which involves a distractor flanker among targets and measures the effect of this distractor on processing. This is a measure of stimulus-response interference and the executive function of attentional control (Eriksen & Eriksen, 1974; Oei & Patterson, 2014). The flanker compatibility effect has been applied in relation to video-game playing, with results indicating that video-game playing enhances attentional capacity. Thus, as attention consists of several elements, different experimental paradigms and attentional measures are applied to examine these different elements.

As to measuring attention in time, one frequently used paradigm is the rapid serial visual presentation paradigm (RSVP). In this paradigm, stimuli such as letters, words, pictures or digits replace the previous stimuli at the same spatial location in a rapid progression. RSVP-tasks can be considered as visual search tasks operating in the temporal rather than the spatial domain (Raymond, Shapiro & Arnell, 1992). The word temporal is perhaps not immediately comprehended, but it has been defined as “related to time” (SNL, 2009). The related term temporal processing has been applied to the processing of stimuli including the duration of a flashed bar of light or the interval between two tones (Mauk & Buonomano, 2004). Thus, the RSVP-procedure makes it possible to

examine attention across time (Shapiro, 1994), in addition to the examination of temporal characteristics of attentional and perceptual processes (Raymond et al., 1992). When two targets appear in close temporal proximity (200-500 ms), thus close to each other in time, the second target becomes difficult for the observer to identify. This effect is known as the *attentional blink* (AB) (Vul, Hanus & Kanwisher, 2008), and has been applied in research of action video games' ability to enhance temporal resolution (Green & Bavelier, 2003). The metaphor of an eye blink where vision is disrupted for a brief period when the eye lid is closed underlies the name of this effect (Cohen, 2014). An explanation for the AB-effect has been suggested by the early selection approach to attention saying that attentional resources get "tied up" to the task at hand until it is resolved (Shapiro, 1994). The depletion of a limited resource is a common theme of different explanations. Thus, the first target exhausts the limited resource which leads to a deficit in the second target (Di Lollo, 2004). This is related to the capacity theory of attention. Di Lollo (2004) suggested that the perceptual control is temporarily lost during target identification. The time it takes for a visual stimulus to be consciously identified and consolidated in VSTM is a processing limitation shown in the attention blink paradigm (Marois & Ivanoff, 2005). In the research field of information processing, the AB has been highlighted as one of three major processing limitations, including VSTM and the psychological refractory period (PRP). The limitations of the VSTM regards how long it takes to consciously identify and consolidate a visual stimulus in VSTM, in addition to the number of stimuli that can be held in VSTM being restricted. When selecting a proper response to one stimulus, this delays the ability to select a response for a second stimulus*;* this is called the PRP (Marois & Ivanoff, 2005).

In addition to the tests and paradigms just mentioned, approaches within cognitive neuroscience have used methods including fMRI to examine, among other things, the principles underlying the distribution of selective attention (Corbetta & Shulman, 2002). In one study, the Stroop and Simon tasks were carried out during an fMRI to examine the potential differences in interference effects. Similar brain regions were active over a similar time course during the two tasks. Consequently, the neural systems underlying successful task performance are expected to be similar (Peterson et al., 2002).

5 Psychological effects on attention

Attention is dynamic and susceptible to alteration by means of different sorts of training and experiences, and there is a multitude of research in this area. Attention training has shown to be effective in training depressed individuals to shift their attention away from negative images (MacLeod et al., 1986), and improve cognitive flexibility and sustained attention in 11-months old children (Was et al., 2011). Furthermore, a high-intensity aerobic interval exercise has been shown to improve selective attention as measured by the Stroop task (Alves et al., 2014). Other experiences in the environment that have been said to affect our brain and cognitive processes are media and technology, including video games, TV and internet use (Cohen, 2014; Carr, 2011; Green & Bavelier, 2003; 2006a; 2006b).

5.1 Media and Technology

There has been suggested that our attention span is shorter now than it was some years ago, however no empirical research known to the author has been carried out on this topic. The possible shorter attention span can perhaps be a consequence of the media and technology that we have become so addicted to. The shorter attention span is likely to be a consequence of many different types and not just one particular source of media and technology. Media is a synonym for mass media and includes TV and internet (SNL, 2013). In the US, an increase in problems with attention has been seen, partly due to the increased complexity and the pace of modern living (Cohen, 2014). This might include modern technology.

Computers, smartphones and tablets have today become a big part of many peoples' daily lives, functioning as tools for different purposes. There is some knowledge about how some of the media and technological developments affect humans, including television, but little is known about others, like the relatively "new" gadget: tablets. The understanding of how television viewing influence human behavior and cognition is still under development (Foster & Watkins, 2010). Wright et al. (2001) found that the content of the television viewing matters. Educational television was associated with higher language skills and school readiness in children, while general programming was associated with poor performance. Thus, it is not possible to draw conclusions on the influence of technology and media based on the device alone, the purpose also needs to be addressed. As is the case with video games, specific examination of the genre and content of the video game is necessary. Examination of screen use will be carried out in the following section followed by the specific knowledge we have about video games.

5.2 Screen use

Daily use of TV, computers, smart phones and tablets stimulate the alteration of brain cells and releasing of neurotransmitters which strengthen new nerve pathways in the brain while others are weakened (Carr, 2011). These findings state that activities including playing video games actually have the power of altering our biology, this emphasize the importance of thorough scientific research. It also support the research on video games which states that attentional processes can be influenced by playing action video games (e.g. Greenfield et al., 1994; West et al., 2008; Belchior et al., 2013). Whether the type of screen (e.g. television-, smart phone-, computer-, tablet screen) and size of screen influence cognitive processes when playing video games differently, or even at all, is yet to be examined.

5.3 Action video games

It seems that the most frequently encountered media headlines regarding video games focus on their negative effects. Video games have been perceived as a big bad wolf that perhaps especially developing children and teenagers should avoid. Obviously, as with a huge amount of other activities, the excessive use and engaging in video games is not advised (Colzato, van Leeuwen, van der Wildenberg & Hommel, 2010). When an activity influences important aspects of life negatively, then it might become a problem as Gentile, Lynch, Linder and Walsh (2004) found in their studies. They found a relation between playing a huge amount of video games and poor school performance. This relation might be explainable by the displacement hypothesis which states that time spent playing video games reduces the time spent on homework or reading (Huston, Wright, Marquis, & Green, 1999). When searching Google Scholar with the search term “negative effects of video games” the result is that almost exclusively, the relevant articles discuss violent video games and aggression. A meta-analytical review comprising 35 research reports found that high video-game violence was strongly related to heightened aggression in males and females, children and adults. A temporary increase in aggression was shown by the short-term exposure to violent video games (Anderson & Bushman, 2001). The research on other possible negative effects of video game playing is lacking.

On the other hand, the research field of positive effects of video games is seldom encountered in the media headlines, despite the fact that this field is extensive and offers another view of video games than exclusively negative. A multitude of studies on how video games affect attention and other cognitive processes have been carried out with positive results, the majority with action video games (Green & Bavelier, 2003; 2006a; 2006b; Franceschini et al., 2013). Action video games have been characterized by the simultaneous tracking of multiple targets, fast motion and vigilant

monitoring of the visual periphery (Green & Bavelier, 2006). According to these characteristics the game series Grand Theft Auto (GTA) belongs to this genre. Video games in this genre require that sensory information is rapidly processed and that action is immediate. Speeded decision making is of the essence (Dye, Green & Bavelier, 2009). This is some of the demands of action video games that have been suggested to train different attentional aspects. Research on action video games includes correlational studies in which one group is defined as video-game players (VGP) and the other group as non-video-game players (NVGP) by different criteria. Exactly what the criteria are, have varied throughout the literature. The criterion for being defined as a VGP has been to play action video games (e.g. GTA 3) for a minimum of 1 h per day the previous 6 months (Green & Bavelier, 2003), a minimum of 3-4 days a week for at least 2 hours of playing time on each day the previous 6 months (West et al., 2008), or a minimum of 1 hour per day the last 6 months (Castel, Pratt & Drummond, 2005). The criteria for being defined as a NVPG has been little or no video game usage in the past 6 months (Green & Bavelier, 2003; West et al., 2008) and little to no video game usage in general (Castel et al., 2005).

Correlational studies have found that playing video games is positively correlated with enhanced VSTM (McDermott, Bavelier & Green, 2014), speeding up reaction time (Castel et al., 2005; Bialystok, 2006), improved spatial attention (West et al., 2008) improved cognitive flexibility and cognitive control (Colzato, et al., 2010).

Another approach to the studying of video games are training studies, which have established that training with an action video game enhances spatial attention (Feng et al., 2007), probabilistic inference (Green et al., 2010), contrast sensitivity (Li, Polat, Markous & Bavelier, 2009), spatial resolution of vision (Green & Bavelier, 2007), attentional capacity (Green & Bavelier, 2003) and had a positive effect on reading in children with dyslexia (Franceschini et al., 2013). Thus, playing action video games enhances several aspects of attention and other cognitive processes.

Training effects have been established with 5 (Greenfield et al., 1994), 10 (Green & Bavelier, 2003; 2006b; Feng et al., 2007), 12 (Franceschini et al., 2013), 30 (Green & Bavelier, 2007) and 50 hours of training (Li et al., 2009; Green et al., 2010), and never with as little as 1 hour which is the case in the study in this thesis.

Of specific importance and relevance in this thesis is research on selective and temporal attention in relation to action video games. Studies have established an enhancement in different aspects of selective attention for video-game players, including benefits in selective attention to objects (Dye & Bavelier, 2010) and selective visual attention (Belchior et al., 2013). Green and Bavelier (2003) assessed visual attention in time with the AB-task. This task includes an attentional bottleneck; the AB, where the second target is difficult to process when it appears 200-500 ms after

the onset of the first target, as aforementioned. Video-game players performed better than non-video-game players in detecting the second targets indicating that the ability to process information in time is enhanced in this group. The superior skills in allocating attention over time in video game players have also been established in the multiple object tracking task (Green & Bavelier, 2006b). Thus, based on this research, participants in the study included in this thesis were expected to improve their scores on the selective and temporal measures of attention from pre to post - action video game playing. In addition to studies on selective and temporal attention, the aspect of divided attention has also been examined in relation to video games. Video game expertise was found to be related to superior skills in divided attention in a study by Greenfield et al., (1994).

Thus, the research field of action video games involves both correlational and experimental studies, examining how action video-game playing influences several different cognitive processes in addition to the attentional components of selective and divided attention. There has been some discussion as to whether action video games improve general attentional ability or whether this enhancement can be ascribed to the training of underlying mechanisms (Belchior, 2013).

As can be seen in the research presented in this section, theoretical findings in the area of video games point mostly in the same direction of improving different attentional aspects.

The purpose of the study presented in this thesis is to examine whether playing an action video game has any effects on attention as measured by the Attentional blink, Simon and Stroop tasks. It is expected that playing an action video game for 1 hour will influence the performance on the attentional measures in the study presented in this thesis.

6 The present study

The theoretical expectation from the video-game literature and theories of attention, points in two directions. The majority of theoretical findings on action video games describe different benefits for cognition, including processes involved in attention. However, the theory of attention being restricted by a certain amount of capacity (Kahneman, 1973) offers a hypothesis of action video games expending attentional resources, thus a disadvantage for attention, contrary to the action video game literature.

The main goal of the present study was to examine whether playing an action video game had a short-term effect on attention. The participants completed the AB, the Simon task and the Stroop task to measure attention in time and selective attention.

The activity for the control condition was to read in a book because books and action video games engage attention differently. The book was a crime novel chosen for the reason of being a popular book which hopefully was enjoyable for the majority of participants contributing to sustained focus and attention throughout the whole reading session. The enjoyment of the book contributes to the reader's motivation throughout the hour of reading.

Grand Theft Auto - Vice City (Rockstar North) was chosen as the action video game as it has been categorized as an action game in earlier studies (Green & Bavelier, 2006), and was age appropriate for the participants. The choice of 1 hour as the duration of game playing was based on this being the shortest session found to study computer games and attention earlier, although not as a session with the aim of modifying or training attention (Tahiroglu et al., 2010). This choice relates to the wish of examining whether the short session of action video game playing had the effect of enhancing the components of selective and temporal attention. The choice of a counterbalanced design was made in order to rule out possible effects of which order the conditions were completed. By using the same group we avoid that differences between groups including game experience, sex and age affect the results.

In this thesis the main focus will be on selective attention and action video games, as earlier research has shown a relation between the two (Green & Bavelier, 2003; Feng, Spence & Pratt, 2007). The secondary focus is on how temporal attention, thus attention in time, is associated with action video games as this relation also has been established in earlier work (Green & Bavelier, 2003; Green & Bavelier, 2006b). Thus action video games engage both selective and temporal attention, and these aspects of attention are the focus of the study in this thesis. Green and Bavelier (2003) studied temporal characteristics of visual attention and examined whether the demand for acting rapidly to several visual items, which is evident in action video games, influences how a person processes items over time and how they prevent attentional bottlenecks often occurring in

temporal processing. The same will be examined in this thesis, but with a smaller dosage of playing an action video game; they employed 10 h of training; the study presented here consisted of 1 hour of action video game playing alone. The rationale for this study is to examine whether an action video game played on a tablet has short-term effects on attention. As there is little research on tablets, the choice of using a tablet in this study is to offer a contribution to this relatively new field.

The hypothesis of this study is that playing an action video game has short-term effects on attention, as the majority of research with action video games suggests (e.g. Green & Bavelier, 2003; Colzato et al., 2010). In this context, effect means to enhance or weaken attention. The concept effect in this context means consequence or influence. Thus, the goal of the present study is to examine whether playing an action video game influence attention in terms of enhancing, decreasing or not having an effect on temporal and selective aspects of attention. The research question is:

"Does playing an action video game have short-term effects on attention?".

7 Method

7.1 Participants

The participants in this study were 20 university students, mainly psychology students (60 % females) in Norway. Participants were primarily Norwegian, between the ages of 20 and 31 years (*M* = 24.65 years, *SD* = 2.08). By means of randomization, participants were divided into two groups. The two groups were either assigned to first complete the action video game condition (4 males, and 5 females), and then the control condition, or the opposite order (4 males and 7 females). The criteria for being a frequent video game player was playing video games >9 hours per week, and <9 hours per week for being categorized as an infrequent video game player as adopted by Kühn et al. (2011). According to these criteria only one participant was categorized as a video game player. When including participants just below the limit of 9 hours (e.g. 7.5 h, 8.7 h and 8.2 h), the number of video game players were four.

The decision to test students is based on the fact that the effects of action video games for attention are established with this group and in the age span of 18-33 years old in earlier studies (Greenfield et al., 1994; Green & Bavelier, 2003; Feng et al., 2007).

Participants were recruited by social media and from a circle of acquaintances. The consent forms were given personally. Participants had normal or corrected vision as reported by the participants or known to the experimenter. Conducting the experiment required allowances from NSD which were obtained.

7.2 Materials

Testing of attention was carried out on a stationary computer. The video game was played on different editions of the Apple iPad. Two iPads were the *iPad 2* with 9.7-inch (diagonal) screen and one was an *iPad Mini* with 7.9-inch (diagonal) screen. All screens were LED-backlit with multi-touch display (Apple Inc, 2014). The book for the control activity was the crime novel *"Kakerlakkene"* by the Norwegian author Jo Nesbø, one hardback and two paperbacks. The story of the book centers on the main character the police officer Harry Hole, and how he contributes to the solving of a murder case.

7.3 Design

The study design is a randomized, counterbalanced, and cross-over trial. The participants randomly performed two experimental sessions on separate occasions seven days apart. This design is adapted from Alves et al. (2014). Counterbalanced means that participants are tested both in condition A then B, and condition B then A. This controls for the order in which conditions are completed and that

this order does not have an effect on the behavior of the participant. Thus, whether the participant first read or played the action video game should not have any effects on the results. A benefit of using a cross-over trial is that the requirement of a big sample size is not essential as each participant is their own control. Furthermore, the cross-over trial controls for possible group effects having an influence on the results. These group effects include sex, age, experience with video games and the tablet. The design also controlled for a high or low score being caused by chance.

7.4 The action video game

Grand Theft Auto – Vice City (Rockstar North) is played from a third-person perspective in an open world environment. The person who plays is navigating a man around the environment of the fictional city Vice City by the use of a map. This map contains symbols of where a certain store or person is. The general goals are to complete missions which make you advance in the game by completing a storyline and unlocking new parts of the city. The map always indicates where to go to complete a mission. Some missions require a certain amount of money which can be obtained by robbing people or completing other missions. The game has violent content and has an age limit. Progression in the game was measured by missions completed or started as reported by the participants. Also, a follow-up question following the game playing was asked. The question was whether the participants were chased by the police, as this also is an indicator of engaging in the game in addition to missions completed.

7.5 The reading

Whereas the action video game requires the distribution of attention and/or the switching of attention around the field (Green & Bavelier, 2003), reading in a book demands the sustained focus of attention directed at words and sentences. Reading engages sustained attention as reading demands the focus of attention over a prolonged period of time (Sarter et al., 2001). Reading in a book is a good control task because it does not contain any stressors of suddenly appearing objects that need attention. There is no need for rapid switching of attention or rapid decision-making. Reading is generally not expected to train attention the same way as action video games do as the two activities contain very different attentional demands. Reading is thus believed to be a beneficial choice of activity for the control condition.

7.6 Procedure

A letter of introduction of the project (See Appendix B) was written and handed out to the participants who indicated interest. Twenty students were given an informed consent form (See Appendix B) to sign and a short questionnaire (See appendix A) to fill out. Students were informed

about the purpose of the study in the informed consent form. All participants chose the preferred time of testing, and were informed that the testing was completed at the same time both days. All participants completed a questionnaire prior to completing the experiment. The questionnaire established experience with video games, video game genres and gaming consoles. The reason for adding the questionnaire was to examine if experience with the game and tablet, amount of video game playing and game genre had an effect on the results. A short version of the questionnaire was completed on the second day of the experiment. Questions in this questionnaire regarded circumstances that might affect attention, including whether the participants' food and drink intake and hours of sleep were sufficient at the time of the experiment and if the participant had consumed caffeine 4 hours prior to the experiment.

The participants randomly performed two experimental sessions on separate occasions seven days apart. The experimental sessions were: (1) action video game playing and (2) a control session that involved reading in a book. Attention was assessed before (PRE) and immediately after (POST) each experimental session. Prior to the first assessment of attention the participants were asked whether they had completed the tests or played the game before, the answer was written down by the experimenter. The testing and video game playing was completed during the hours of 08:45-16:55 at the Norwegian University of Science and Technology (NTNU). The testing was conducted in a computer room, and all students were tested 1-3 at a time with a space between them of one or two desks. All participants started each test at the same time. The raise of a hand was the signal of being finished with each test after which the experimenter saved their results and prepared the new test. The video game playing was completed in a laboratory. During the experimental session the participants were separated by dividing walls implemented to prevent the interference of other participants. The duration of the video game playing was 1 hour. Prior to video game playing, the participants were instructed how to play and the experimenter demonstrated how to navigate around the environment, how to complete missions and how to know if a mission actually was completed, in addition to how the light of screen and volume was adjusted. Participants were instructed to write down the accomplished missions on a piece of paper, and call the name of the experimenter in case they encountered any challenges. The experimenter was seated in the neighboring room and the door between the rooms was open. Active playing and not watching videos in the game was insisted to assure that the attentional demands were in place. The control condition did not require the same scale instructions. A bookmark was placed at the page in the book where it was desirable for the reading to start. The participants were told to finish reading when the experimenter entered the room and put the book mark at the page they got to. Instructions endured for approximately 5-15 minutes,

depending on the condition. The experimental design was pretest-posttest. The equipment used was computers, tablets and books.

A gift card of 100,-NOK was awarded a randomly chosen participant and a gift card of 200,-NOK was awarded the participant who progressed the furthest in the action video game. Each experimental session took approximately 2 hours.

7.7 Measures

7.7.1 Temporal attention measure – the Attentional Blink

A Coglab 2.0 CD-ROM (Francis, Neath & VanHorn, 2007) was utilized as a resource to gain access to psychometric measures, the AB being one of them. The participants read instructions which told them to report whether a J or K or both letters were observed in a stream of 19 letters in a high rate of speed. The participants were instructed to use their index finger and the middle finger of the preferred hand to report observations, holding the two fingers on the keyboard the whole duration of the test. A reminder was given of which fingers to use, that speed was of the essence and that there was no competition between participants. As a measure of performance on the AB-task, the percentage of times targets (J and K) were detected as a function of separation (0, 2, 4, 6, 8 letters between targets) was registered (Raymond et al., 1992; Chun & Potter, 1995). The duration of the AB-test was approximately 5:30 minutes.

7.7.2 The selective attention measures – the Simon and Stroop tasks

Versions of the Simon task and the Stroop task from a Coglab 2.0 CD-ROM (Francis et al., 2007) were applied. The Simon task consisted of 100 trials and took approximately 3:30 minutes to complete. The participants read the instructions which told them to indicate whether they observed a green or red square which appeared either on the left or the right side of the computer screen. They were reminded about which fingers to use, to respond fast, and that they only competed with themselves as with the two other tests. To indicate the colors of the squares the participants pressed the V-key with their left index finger to indicate the observation of a green square, and the M-key with their right index finger to report a red square. Fingers were touching the keys during the testing period. The Simon task consists of congruent and incongruent trials. A red square presented on the right side of the computer screen is considered to be congruent because the response key is on the corresponding right side, and a red square presented on the left side is considered incongruent because the corresponding key is on the opposite side. Generally, performance is better when the stimulus and response are on the same side. Performance was obtained in mean reaction time scores for both incongruent and congruent trials (Simon, 1969; Peterson et al., 2002).

The Stroop task was based on the original test and consisted of 45 trials, with duration of approximately 1:50 minutes. The participants read instructions which told them to indicate whether the ink of a color-word (red, green or blue) was red, green or blue by pressing the H, J or K-key on the keyboard. The index finger (H-key/K-key), middle finger (J-key) and ring finger (K-key/H-key) of the preferred hand were used to respond, and were touching the keyboard during the whole test session. Both congruent and incongruent trials were presented. Congruent trials contained color-words printed in the color of the color-word (e.g. the color-word red printed in red). Incongruent trials contained color-words printed in a different color than the color-word (e.g. the color-word red printed in blue). As with the Simon task, mean reaction time scores were obtained as a measure of performance (Stroop, 1935; Peterson et al., 2002).

7.7.3 Questionnaire

The questionnaire contained questions regarding experience with playing video games on tablets, Microsoft Xbox, computers, or other game consoles. Which games they played most frequently, how much time they spent playing during a month and the last week, which consoles/platforms they played on in addition to their sex and age. Participants were asked to evaluate whether they ate, drank and slept sufficiently before completing the experiment together with a question about whether they had consumed caffeine 4 hours prior to the experiment. These questions were asked for the purpose of examining possible effects on performance, thus to examine if good or bad scores were related to a lack of sleep, food, drink, caffeine intake or absence of caffeine that particular day. The questionnaire served several purposes, including the examination of whether experience with video games, the genre and amount of playing had any effects on the results. As mentioned earlier only one participant was categorized as a video game player. Making these criteria less stringent the number of video game players was four.

8 Data analysis

IBM SPSS statistics 22 was used for all statistical analyses, and $p<.05$ was used as a statistical significance criterion. A Kolmogorov-Smirnov test was carried out to examine whether the distribution of scores deviated from a comparable normal distribution. Furthermore, a Friedman test was carried out to examine possible differences in effects of reading and action video game playing on performance on the three measures of attention. A Mann-Whitney U test was used to compare the distributions in the two conditions.

8.1 Results

All 20 participants completed the three attention tasks. The means, standard deviation and P-values for both conditions of reading and action video game playing are shown in table 1 and table 2.

8.1.1 Temporal attention

No significant results were found for the Kolmogorov-Smirnov test meaning that *the distribution of the sample is not significantly different from a normal distribution.* A non-parametric Friedman test of differences among repeated measures was conducted and rendered Chi-square values as with the selective attention measures. None of the conditions of the AB showed significant effect on the video game and reading conditions as shown in table 2. No significant results were found for the Mann-Whitney U Test, thus the distributions in the two conditions did not differ significantly.

Table 1. Descriptive statistics of performance on the Attentional blink shown by percentage of times targets were detected.

Reading

Separation of targets	T1		T2	
	PRE	POST	PRE	POST
0	66,25 (14,31)	71,25 (18,27)	8,25 (13,10)	5,80 (6,50)
2	61,00 (22,86)	69,25 (13,88)	39,50 (23,05)	39,50 (23,05)
4	64,50 (17,68)	62,25 (23,31)	51,00 (23,54)	49,50 (19,59)
6	61,50 (18,92)	64,75 (18,09)	68,25 (21,96)	67,50 (27,79)
8	63,00 (19,89)	64,00 (17,81)	74,25 (18,44)	68,75 (21,08)

Action video game

Separation of targets	T1		T2	
	PRE	POST	PRE	POST
0	62,75 (21,913)	66,00 (17,290)	6,85 (11,67)	5,25 (9,24)
2	67,75 (18,53)	63,00 (20,41)	32,00 (19,49)	36,25 (19,66)
4	64,50 (15,63)	67,75 (16,97)	49,25 (21,72)	53,25 (22,55)
6	65,50 (23,83)	63,00 (19,89)	69,50 (20,05)	60,45 (21,82)
8	64,25 (21,10)	64,10 (20,96)	71,75 (22,14)	74,75 (20,61)

T1 = Target 1, T2 = Target 2

Table 2. Chi-square and P-values for the attentional blink.

		Chi-square	P-value
Sep	*Targets*		
0	1	3,782	.286
	2	1,76	.624
2	1	3.734	.292
	2	2,637	.451
4	1	2,304	.512
	2	.401	.940
6	1	3,111	.375
	2	2.657	.448
8	1	.914	.822
	2	7,751	.051

Sep = separation of targets

8.1.2 Selective attention

No significant results were found for the Kolmogorov-Smirnov or the Mann-Whitney U Test. Furthermore, a non-parametric Friedman test of differences among repeated measures was conducted. Neither the congruent nor the incongruent conditions of the Stroop and Simon tasks showed significant effects of playing an action video game or reading, as shown in table 3.

Table 3. Performance in the Stroop and Simon tasks as shown in mean reaction time in milliseconds. In addition to chi-square and p-value.

	Reading		Action video game			
	PRE	POST	PRE	POST	Chi square	P-value
Stroop C	650 (118)	626 (78)	632 (68)	610 (62)	1,500	.682
Stroop I	691 (103)	645 (95)	684 (85)	657 (71)	5,880	.118
Simon C	534 (60)	508 (36)	521 (58)	513 (44)	2,820	.420
Simon I	557 (61)	543 (41)	544 (55)	538 (52)	.420	.936

C = congruent I = incongruent

9 Discussion

The main purpose of this study was to investigate the potential short-term effects of playing an action video game on attention. Participants played an action video game or read in a book for the duration of 1 hour. Three attentional measures were completed immediately before and immediately after the experimental or control condition. The results were non-significant. The results may indicate that playing the action video game GTA for 1 hour simply do not have short-term effects on attention as measured by the three tasks applied. Since there were no significant difference between playing the video game and reading, the data collected with the questionnaire, including experience with the game and tablet, amount of video game playing and game genre, was not statistically tested further. The research question was whether an action video game would have short-term effects on attention as measured by the AB, Simon and Stroop tasks.

Performance on the AB, Simon and Stroop tasks may be affected by several methodological factors, including fatigue, earlier experience with the test, and knowledge of being tested and wishing to obtain good scores, however, as no significant results were obtained, these factors did not affect the results sufficiently to influence attention. A methodological concern to address regarding all three measures is the short duration of approximately 5:30, 3:40 and 1:50 minutes respectively. This briefness might affect the measurement of attention. If the tests were a little longer in duration this might have ensured a stronger measure of attention, consequently leading to the possible effect of the action video game being observed. However, tests with a longer duration could also lead to fatigue which in turn affects the measurement negatively, so perhaps the short duration was beneficial.

The AB was carried out to measure temporal attention, thus attention in time, with no effect of the action video game on the performance on the AB. Explanations for this might be that 1 hour of action video game playing is not sufficient to modify temporal attention, or that GTA did not contain sufficient demands of allocating attention in time. Earlier studies have, as mentioned before, assessed visual attention in time with the AB-task. Video-game players showed an enhanced ability to process information in time compared to non-video-game players (Green & Bavelier, 2003). Others have also established superior skills in allocation of attention over time in video game players with other tasks measuring temporal attention (Green & Bavelier, 2006b). These findings suggest an enhanced performance on the AB immediately after playing the action video game, although this was not the finding in the study in this thesis.

The Simon task measures selective attention in addition to response switching and inhibition (Bialystok, 2006). There are two explanations for the finding of no observed effect of the video game on the performance on the Simon task. This finding is the same as with temporal attention; perhaps 1 hour of video game playing was not sufficient to modify performance on the Simon task and the aspect of selective attention. There is a possibility that GTA do not contain sufficient demands for selective attention skills and thus does not enhance selective attention as measured by the Simon task. The Simon effect is perhaps explainable in terms of capacity limitations in which the task's demands increase when location of stimulus and color of square do not correspond. Thus, capacity is expended as a result of this interference causing a slower response. Based on earlier research on selective attention and action video games, the participants were expected to demonstrate benefits in selective visual attention (Belchior et al., 2013), and significantly better scores was expected after the video game playing, but this was not observed.

The Stroop task measures selective attention in addition to cognitive flexibility, inhibition (Basak et al., 2008) and cognitive control. As with the Simon and the AB-tasks, the same factors of GTA not containing sufficient selective attention demands in order to enhance selective attention, and 1 hour being inadequate for modifying selective attention. A concern in the Stroop task is the fact that the color-words in the applied Stroop task are written in English. The vast majority of participants were Norwegian and this version of the Stroop task might have been less challenging for participants with a first language other than English because of the smaller interference effect. Completing a Stroop task in the participants' native language leads to more interference and the incongruent condition will post more demands on the switching and inhibition skills possibly affecting the performance of the participant as the tasks' level of difficulty increase. The results did not deviate significantly from the Norwegian-speaking participants; however, as it is desirable with a reliable measure of attention, it is essential to make sure all participants are exposed to the same interference effect, which is something to consider in possible further research. No significant results were obtained for either of the tests. The Stroop effect is perhaps explainable in terms of attentional capacity and speed of processing. When color and words are incongruent this demands more attentional capacity and thus the processing is slower, which leads to a slower response during incongruent trials. Based on earlier research on selective attention and action video games, the participants were expected to score better on both of the selective attention measures. In addition, video game players have shown to have improved cognitive flexibility and cognitive control, which also supports that the performance on the Stroop task was expected to improve after the video game playing (Colzato et al. 2010).

The experimental design was a strong one, being randomized, counterbalanced and involving cross-over trials. This design controls for possible effects of the sequence of the control and experimental conditions, high or low scores being caused by chance and effects of group differences including age, sex and experience with video games. Participants were mainly psychology students. This group is knowledgeable about psychological testing which is a possible factor that affect the results, but not sufficient in this study to actually affect the results. This group is perhaps more prone to analyzing what is expected from the experimental tasks and trying to perform accordingly, or their knowledge of the attentional measures and what they are actually testing may cause an enhanced performance. A possible effect of test-retest should have led to consequently improved scores the second, third and fourth time tests were completed, which was not the case, ruling out test-retest as a confounding variable.

The tablets had varying screen size, but this should not be of any importance for the results as the difference was only 1.8 inches. In addition to tablets' possible ability of engaging the video game player slightly more than video games played on traditional game consoles (e.g. Sony Playstation and Microsoft Xbox) due to the shorter distance between the tablet and video game player, however, this is just speculations not rooted in empiricism. Being unfamiliar with tablets might have had a negative effect on the participants as this unfamiliarity may have led to challenges with playing the video game leading to frustration and a low level of motivation. A result of this may be that the action video game did not engage their attention fully, and did not train attention sufficiently to observe an effect on the attentional measures. The studies on action video games have been carried out on computers. These findings should be transferable to playing on a tablet as the video games are the same and the only things that differ between a computer and a tablet is mainly the size of the screen and how the hands and fingers are used to play the game.

As to the measures chosen, there is a possibility that the attentional measures were simply not good enough or did not offer a sufficient measure of attention. It may be that other tests would have offered a stronger measure of both selective and temporal attention. Perhaps an action video games' attention enhancing abilities is not observable in the short versions of the attentional measures applied. Adding several attentional measures could perhaps contribute to more influence of the action video game to be captured, as different attentional measures capture slightly different aspects of attentional processes.

As mentioned before, it may be that GTA does not have sufficient attentional demands, thus does not train attention sufficiently, and therefore it did not affect attention in the study in this thesis. A possible explanation for the chosen video game not having an effect on attention, other than factors innate to the game, could lie in the tests and that the game trains other aspects of attention

than the tests capture. However, as GTA is characterized as an action video game, based on the literature on action video games, it is expected to train selective and temporal attention which are captured by the chosen tests. It is also a possibility that the duration of game playing is too short for modifying attention sufficiently. The action game playing was completed in one session and lasted for 1 hour. In earlier research, participants trained on video games within the action genre, including first-person shooter (FPS) for 5 (Greenfield et al., 1994), 10 (Green & Bavelier, 2003; 2006b; Feng et al., 2007), 12 (Franceschini et al., 2013), 30 (Green & Bavelier, 2007) and 50 hours of training (Li, Potal, Makous & Bavelier, 2009; Green et al., 2010). 1 hour of video game playing may not be sufficient to have any observable effects on attention.

FPS-games are characterized by the player experiencing the action through the eyes of the player character. FPS-games require a flexible mindset which allows the switching between different subtasks and reacting to moving visual and sudden acoustic events fast (Colzato et al., 2010). The demands of fast decision-making, quick responses and switching between tasks are likely to be greater in a FPS-game compared with GTA. Thus, the choice of a FPS-game instead of a third person shooter game, such as GTA, might have offered more substantial modification of attention and stronger observable effects, as this has been established in earlier research with training with FPS-games. GTA has been used in earlier studies as one of the criteria games for being categorized as a video game player and further attentional enhancing effects were found for the experience with action games including GTA (Castel et al., 2005; Green & Bavelier, 2006b; Basak et al., 2008; Dye et al, 2009; Colzato et al., 2010; Dye & Bavelier, 2010). However, GTA has not been used as the game supposed to train attention in attentional training studies.

The reading session chosen as the control condition could have been replaced by a game in another genre than action since this have been done in earlier research with significant results. Attentional training studies have used strategic (Green & Bavelier, 2003), life simulation (Li et al., 2009; Green et al., 2010) or puzzle games (Feng et al., 2007; Green & Bavelier, 2007) in the control condition with participants in the experimental group showing a greater performance improvement than participants in the control group. When both groups play a video game this assures that the groups are engaged in a stimulating video game-related activity (Li et al., 2009).

With all these factors considered, the discussion of the attentional theories of Broadbent (1958) and Kahneman (1973) is in place. Broadbent's filter theory offers a basic understanding of selective attention and can be used to explain the selective processing of stimuli in a video game environment containing a huge amount of stimuli. The capacity theory of attention offers an explanation of how action video games influence attention. It states that the total amount of attention which can be used at any time is limited. This explains the limited capacity to perform multiple

activities concurrently (Kahneman, 1973). How difficult a task is perceived determines on the demands put on the limited capacity (Kahneman, 1973, p. 9). Reading is considered as an easy task, and playing a video game is considered a hard task partly because time pressure is present.

The filter theory of Broadbent (1958) can be implemented in the context of playing video games and processing of information in the game environment. The theory offers an understanding of how stimuli in the game environment are selected and processed and why some stimuli go unnoticed. The thought of a bottleneck in attention illustrates how focus is important in action video games. If there is an excessive amount of stimuli in which the video game player has to respond, it is possible that a bottleneck in processing all this information is present. It is possible that some of the participants experienced a bottleneck in which stimuli that were actually important was lost. When relating the filter theory to the results presented here, there is a possibility that the action video game playing and the reading did not contain a huge amount of stimuli, maybe the amount of stimuli was suitable for the participants, and therefore did not affect performance on the attentional measures. On the other side a possibility is that there was a bottleneck present, but that it did not affect performance on the attentional measures. The participants apparently managed to filter the stimuli and information in the action video game sufficiently for 1 hour for this not to have an effect on the attentional measures immediately after playing the video game.

According to the capacity theory suggested by Kahneman (1973) the reading session is less demanding and leads to a lower level of arousal compared to playing the action video game which should lead to a higher level of arousal. Reading should expend less attentional capacity than the action video game as a result of the lower demands and arousal level. Thus, the action video game should lead to a poorer performance on the completion of attentional tasks immediately after playing as compared to reading because more of the attentional capacity has been expended during the action video game playing. The participants evidently had sufficient capacity available for playing the action video game for 1 hour, without this affecting the performance on the attentional measures, and this is expected to be a hard task. Clearly the video game playing needs to exceed 1 hour in order to possibly affecting performance on attentional measures after video game playing. As to individual differences of attentional capacity, it is likely that the participants have different amounts of attentional capacity available as a result of both structural and energetic limitations, leading to differential results. However, the individual differences were not sufficient to affect the attentional capacity available in the study presented here. Although the improved attentional capacity has been demonstrated in video game players (Green & Bavelier, 2003), the result in the study presented in this thesis did not succeed in establishing the same. Perhaps neither of the conditions expended

sufficient capacity to affect performance on the attentional measures. This might be due to lacking demands or absence of arousal increasing factors in the reading and video game playing activities.

The attentional capacity theory (Kahneman, 1973) and research within the field of action video games (Greenfield et al., 1994; Green & Bavelier, 2003; Green & Bavelier, 2006b; Feng et al., 2007; Colzato et al., 2010) offers contrary contributions to the expectation of how an action video game influences attention, in terms of a possible direction in effects. According to the research on video games, playing the action video game should theoretically have shown beneficial effects on attention. It was expected from research that participants would score higher on both the selective attention measures and the temporal attention measures (Green & Bavelier, 2003; Green & Bavelier, 2006b) after playing the action video game as compared with reading.

If changes were to be made with the video game, attentional measures and control condition and still no effects on attention were observed, it would be of interest to extend the game's duration as this perhaps offer more than just practicing and modifying attention and may offer training of attention, and an observed effect of the game which more likely leads to significant results. Earlier studies have implemented similar research with the sessions being both longer in duration and carried out in several sessions, demonstrating improved post-test-score on the attentional measures chosen (i.e. Attentional blink) (Green & Bavelier, 2003: Feng et al., 2007). Thus, several sessions of action video game playing could have been added for a higher probability of stronger effects on attention and significant results. To summarize, there is a possibility that other attentional measures, another action video game with more action components (e.g. a first person shooter game) which offers more attentional demands, and increased practice dosage in terms of both longer duration and several sessions, which might qualify as training, would contribute to an observed effect of an action video game on attention.

Future studies could examine if there is a limit in regards to modifying of attention; is there a certain limit at which enhancement in different attentional skills is observed? Examination of the smallest dosage of playing an action video game possible to modify attention is interesting for the reason of gaining knowledge about how much action video game playing is sufficient for influencing, modifying and training attention, and perhaps whether there is a upper limit as to where playing action video games no longer trains attentional skills, and where training possibly leads to a decrement in enhanced attentional skills. Earlier research with elderly have shown that training with a real-time strategy game can enhance skills in task switching, working memory, VSTM and reasoning (Basak et al., 2008). Implementing training with action video games for people with impaired attentional and visual skills may be especially advantageous.

10 Conclusion

This study sought out to investigate whether playing an action video game had short-term effects on temporal and selective attention as measured by the AB, Simon and Stroop tasks. None of the results were significant. The experimental design was a randomized, cross-over and counterbalanced one which is a design out ruling possible effects of the condition's order or a high or low score being caused by chance, in addition to effects of group differences including sex, age and video game experience. The data was analyzed with the Kolmogorov-Smirnov test, Friedman test and Mann-Whitney U test with the results being non-significant. From the capacity theory view, attention was expected to worsen from pre to posttest in the video game condition while the reading session was not expected to affect attention at all. However, no effects were found. Studies on action video games suggest that playing an action video game should enhance both selective and temporal attention. The non-significant results might depend on a variety of reasons including the inadequacy of dosage of video game playing including only one session, the video game not containing sufficient attentional demands and modifying attention, the attentional measures being too short in duration, not being strong enough, or not capturing the aspects of attention which the video game engage. Perhaps playing GTA for 1 hour simply does not have any effects on attention as measured by the AB, Simon and Stroop tasks.

Future studies with the same experimental design could increase the dosage of video game playing, including the extension of the duration and adding several sessions. Other attentional tests could have been utilized. The action video game chosen could have been one with more attentional demands, e.g. a first-person shooter game. The study presented offers a contribution to the field of video games, and their effects on attention. In addition to a contribution to the research involving tablets, as there is little to no research completed with tablets. Future studies could examine the possibility of a lower and upper limit in regards to attentional modification and training. Thus, examination of the smallest dosage of action video game playing possible to modify and train attention and a possible upper limit as to where playing action video games no longer trains attentional skills, but perhaps leads to a decrement in enhanced attentional skills, is something to investigate further. Implementing training with action video games for people with impaired attentional and visual skills can perhaps be especially advantageous, as has been seen with elderly and real-time strategy games.

References

Alves, C. R. R., Tessaro, V. H., Teixeira, L. A. C., Murakava, K., Roschel, M., Gualano, B. & Takito, M. Y. (2014). Influence of acute high-intensity aerobic interval excerise bout on selective attention and short-term memory tasks. *Perceptual & Motor Skills: Learning & Memory, 118*(1), 63-72.

Anderson, C. A. & Bushman, B. J. (2001). Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: a meta-analytic review of the scientific literature. *Psychological Science, 12*(5), 353-359.

Apple Inc. (2014). *iPad 2 – Technical Specifications.* Retrieved 02.12.2014 from http://support.apple.com/kb/SP622?viewlocale=en_US&locale=no_NO

Apple Inc. (2014). *iPad mini.* Retrieved 02.12.2014 from https://www.apple.com/ipadmini/specs/

Baddeley, A. (1992). Working memory. *Science, 255*(5044), 556-559.

Basak, C., Boot, W. R., Voss, M. W. & Kramer, A. F. (2008). Can training in a real-time strategy video game attenuate cognitive decline in older adults? *Psychology and Aging, 23*(4), 765-777.

Berlyne, D. E. (1960). *Conflict, arousal and curiosity*. New York: McGraw-Hill book company.

Berlyne, D. E. (1970). Novelty, complexity and hedonic value. *Perception & Psychophysics, 8*(5), 279-286.

Bialystok, E. (2006). Effect of bilingualism and computer video game experience on the Simon task. *Canadian Journal of Experimental Psychology, 60*(1), 68-79.

Bonnel, A-M. & Hafter, E. R. (1998). Divided attention between simultaneous auditory and visual signals. *Perception & Psychophysics, 60*(2), 179-190.

Boot, W. R., Blakely, D. P. & Simons, D. J. (2011). Do action video games improve perception and cognition? *Frontiers in Psychology, 2*, 1-6.

Botvinick, M. M., Braver, T. S., Barch, D. M., Carter, C. & Cohen, J. D. (2001). Conflict monitoring and cognitive control. *Psychological Review, 108*(3), 624-652.

Broadbent, D. (1958). *Perception and Communication*. London: Pergamon Press.

Castel, A. D., Pratt, J. & Drummond, E. (2005). The effects of action video game experience on the time course of inhibition of return and the efficiency of visual search. *Acta Psychological, 119*(2), 217-230.

Cherry, C. E. (1953). Some experiments on the recognition of speech, with one and with two ears. *The Journal of the Acoustical Society of America*, *25*(5), 975-979.

Chun, M. M. & Potter, M. C. (1995). A two-stage model for multiple target detection in rapid serial visual presentation. *Journal of Experimental Psychology: Human, Perception and Performance, 21*(1), 109-127.

Cohen, R. A. (2014). *The Neuropsychology of Attention* (3.rd ed.). New York: Springer.

Colzato, L. S., van Leeuwen, P. J. A., van den Wildenberg, W. P. M. & Hommel, B. DOOM'd to switch: Superior cognitive flexibility in players of first person shooter games. *Frontiers in Psychology, 1*, 1-5.

Conway, A. R. A., Cowan, N., Bunting, F. N., Therriault, D. J. & Minkoff, S. R. B. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence, 30*, 163-183.

Corbetta, M. & Shulman, G. L (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews, 3*(3), 201-215.

Coull, J. T., Frith, C. D., Frackowiak, R. S. J. & Grasby, P. M. (1996). A fronto-parietal network for rapid visual information processing: A PET study of sustained attention and working memory. *Neuropsychological, 34*(11), 1085-1095.

De Fockert, J. W., Rees, G., Frith, C. D & Lavie, N. (2001). The role of working memory in visual selective attention. *Science, 291*(5509), 1803-1806.

Desimone, R. & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience, 18*(1), 193-222.

Deutsch, J. A., & Deutsch, D. (1963). Attention: Some theoretical considerations. *Psychological Review, 70*, 80-90.

Dye, M. W. G., Green, C. S. & Bavelier, D. (2009). Increasing speed of processing with action video games. *Current Directions in Psychological Science, 18*(6), 1-9.

Dye, M. W. G., & Bavelier, D. (2010). Differential development of visual attention skills in school-age children. *Vision Research, 50*(4), 452–459.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics, 16*(1), 143-149.

Egeth, H. W., & Yantis, S. (1997). Visual attention: Control, representation, and time course. *Annual Review of Psychology, 48*, 269-297.

Feng, J., Spence, I. & Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science, 18*(10), 850-855.

Foster, E. M. & Watkins, S. (2010). The value of reanalysis: TV viewing and attention problems. *Child Development, 81*(1), 368-375

Franceschini, S., Gori, S., Ruffino, M., Viola, S., Molteni, M. & Facoetti, A. (2013). Action video games make dyslexic children read better. *Current Biology, 23*(6), 462-466.

Francis, G., Neath, I. & VanHorn, D. (2007). *CogLab on a CD, Version 2.0.* Belmont, California: Thomson Wadsworth.

Fry, A. F. & Hale, S. (2000). Relationships among processing speed, working memory, and fluid intelligence in children. *Biological Psychology, 54*, 1-34.

Gentile, D. A., Lynch, P. J., Linder, J. R., & Walsh, D. A. (2004). The effects of video game habits on adolescent hostility, aggressive behaviors, and school performance. *Journal of Adolescence, 27*(1), 5-22.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*, 534-537

Green, C. S., & Bavelier, D. (2006a). Effect of action video games on the spatial distribution of visuospatial attention. *Journal of Experimental Psychology: Human Perception and Performance, 32*(6), 1465-1478.

Green, C. S., & Bavelier, D. (2006b). Enumeration versus multiple object tracking: the case of action video game players. *Cognition 101*(1), 217-245.

Green, C. S., Pouget, A. & Bavelier, D. (2010). Improved probabilistic inference as a general learning mechanism with action video games. *Current Biology 20*(17), 1573-1579.

Greenfield, P. M., deWinstanley, P., Kilpatrick, H. & Kaye, D. (1994). Action video games and informal education: effects on strategies for dividing visual attention. *Journal of Applied Developmental Psychology 15*, 105-123.

Huston, C. A., Wright, J. C., Marquis, J., & Green, S. B. (1999). How young children spend their time: Television and other activities. *Developmental Psychology, 35*(4), 912-925.

James, W. (1890). *The Principles of Psychology.* New York: Holt

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hal.

Kiesel, A., Wendt, M., Jost, K., Steinhauser, M., Falkenstein, M., Philipp, M. A., & Koch, I. (2010). Control and interference in task switching – A review. *Psychological Bulletin, 136*(5), 849 874.

Klein, R. M., & Ivanoff, J. (2011). The components of visual attention and the ubiquitous Simon effect. *Acta Psychologica, 136*(2), 225-234.

Kühn, S., Romanowski, A., Schilling, C., Lorenz, R., Mörsen, C., Seiferth, N., Banaschewski, T., Barbot, A., Barker, G. J., Büchel, C., Conrod, P. J., Dalley, J. W., Flor, H., Garavan, H., Ittermann, B., Mann, K., Martinot, J-L., Paus, T., Rietschel, M., Smolka, M., N., Ströhle, A., Walaszek, B., Schumann, G., Heinz, A. & Gallinat, J. (2011). The neural basis of video gaming. *Translational Psychiatry, 1,* 1-5.

Lamers, M. J. M., Roelofs, A. & Rabeling-Keus, I. M. (2010). Selective attention and response set in the Stroop task. *Memory & Cognition, 38*(7), 893-904.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology, 21*(3), 451-468.

Lavie, N. & Cox, S. (1997). On the efficiency of visual selective attention: Efficient visual search leads to inefficient distractor rejection. *Psychological Science, 8*(5), 395-398.

Li, R., Polat, U., Makous, W. & Bavelier, D. (2009). Enhancing the contrast sensitivity function through action video game training. *Nature Neuroscience, 12*(5), 549-551.

Lugli, L., Iani, C., Nicoletti, R., & Rubichi, S. (2013). Emergence of the go/no-go Simon effect by means of practice and mixing paradigms. *Acta Psychologica, 144*(1), 19-24.

MacDonald 3.rd, A. W., Cohen, J. D., Stenger, V. A. & Carter, C. S (2000). Dissociating the role of the dorsolateral prefrontal and anterior cingulate cortex in cognitive control. *Science, 288*(5472), 1835-1838.

MacLeod,C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*(1), 15-20.

Marois, R., & Ivanoff, J. (2005). Capacity limits of the information processing in the brain. *Trends in Cognitive Science, 9*(6), 296-304.

Mauk, M. D. & Buonomano, D. V. (2004). The neural basis of temporal processing. *Annual Review of Neuroscience, 27*, 307-340.

McDermott, A. F., Bavelier, D. & Green, C. S. (2014). Memory abilities in action video game players. *Computers in Human Behavior, 34*, 69-78.

Medietilsynet. (2014). *Barn og unges mediebruk* (Barn og medier-undersøkelsen 2014). Retrieved from: http://www.medietilsynet.no/PageFiles/8704/Barn_medier_2014_rev_13.10.14.pdf

Melara, R. D., Wang, H., Vu, K. P. L., & Proctor, R. W. (2008). Attention origins of the Simon effect: Behavioral and electrophysiological evidence. *Brain Research, 1215*, 147-159.

Mirsky, A. F. (1987). Behavioral and psychophysiological markers of disordered attention. *Environmental Health Perspectives, 74*, 191-199.

Mirsky, A. F., Anthony, B. J., Duncan, C. C., Ahearn, M. B. & Kellam, S. G. (1991). Analysis of the elements of attention: A neuropsychological approach. *Neuropsychology Review, 2*(2), 109 144.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H. & Howerter, A., Wager, T. D (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: a latent variable analysis. *Cognitive Psychology, 41*(1), 49-100.

Moray, N. (1959). Attention in dichotic listening: Affective cues and the influence of instructions. *Quarterly Journal of Experimental Psychology, 11*(1), 56-60.

Oei, A. C., & Patterson, M. D. (2014). Playing a puzzle video game with changing requirements improve executive functions. *Computers in Human Behavior, 37*, 216-228.

Oken, B. S., Salinsky, M. C., & Elsas, S. M. (2006). Vigilance, alertness, or sustained attention: Physiological basis and measurement. *Clinical Neurophysiology, 117*, 1885-1901.

Pashler, H. (1994). Dual-task interference in simple tasks: Data and theory. *Psychological Bulletin, 116*(2), 220-244.

Peterson, B. S., Kane, M. K., Alexander, G. M., Lacadie, C., Skudlarski, P., Leung, H-C., May, J. & Gore, J. C. (2002). An event-related functional MRI study comparing interference effects in the Simon and Stroop tasks. *Cognitive Brain Research, 13*(3), 427-440.

Plude, D. J., Enns, J. T. & Brodeur, D. (1994). The development of selective attention: A life-span overview. *Acta Psychological, 86*(2-3), 227-272.

Posner, M. I. & Presti, D. E. (1987). Selective attention and cognitive control. *Trends in Neuroscience, 10*(1), 13-17.

Posner, M. I., & Peterson, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13*, 25-42.

Posner, M. I., Snyder, C. R. R., & Davidson, B. J. (1980). Attention and the detection of signals. *Journal of Experimental Psychology: General, 109*(2), 160-174.

Pylyshyn, Z. M. & Storm, R. W. (1988). Tracking multiple independent targets: evidence for a parallel tracking mechanism. *Spatial vision, 3*(3), 179-197.

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception and Performance, 18*(3), 849-860.

Rosvold, H. E., Mirsky, A. F., Sarason, I., Jr., Bransome, E. D. & Beck, L. H. (1956). A continuous performance test of brain damage. *Journal of Consulting Psychology, 20*(5), 343-350.

Sarter, M., Givens, B., & Bruno, J. P. (2001). The cognitive neuroscience of sustained attention: where top-down meets bottom-up. *Brain Research Reviews, 35*(2), 146-160.

Scott, W. A. (1962). Cognitive complexity and cognitive flexibility. *Sociometry, 25*(4), 405-414.

Shapiro, K. L. (1994). The attentional blink: the brain's "eyeblink". *Current Directions in Psychological Science, 3*(3), 86-89.

Simon, J. R. (1969). Reactions toward the source of stimulation. *Journal of Experimental Psychology, 81*(1), 174-176.

SNL. (2009). *Temporal.* Downloaded 24.03.2015 from https://snl.no/temporal

SNL. (2013). *Massemedier*. Downloaded 08.04.2015 from https://snl.no/massemedier

Sperling, G. (1960). The information available in brief visual presentations. *Psychological Monographs: General and Applied, 74*(11), 1-29.

Spikman, J., & van Zomeren, E. (2010). Assessment of attention. In J. Gurd, U. Kischka & J. Marshall (Ed.), *The Handbook of Clinical Neuropsychology*. Oxford: Oxford University Press.

Strauss, E., Sherman, E. M. S., & Spreen, O. (2006). *A Compendium of Neuropsychological Tests* (3rd). Oxford: Oxford University Press.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*(6), 643-662.

Tahiroglu, A. Y., Celik, G. G., Avci, A., Seydaoglu, G., Uzel, M. & Altunbas, H. (2010). Short-term effects of playing computer games on attention. *Journal of Attention Disorders, 13*(6), 668 676.

Treisman, A. M. (1969). Strategies and models of selective attention. *Psychological Rreview, 76*(3), 282-299.

Treisman, A. & Geffen, G. (1967). Selective attention: Perception or response? *The Quarterly Journal of Experimental Psychology, 19*(1), 1-17.

Vul, E., Hanus, D. & Kanwisher, N. (2008). Delay of selective attention during the attentional blink. *Vision Research, 48*(18), 1902-1909.

Wass, S., Porayska-Pomsta, K. & Johnson, M. H. (2011). Training attentional control in infancy. *Current Biology, 21*(18), 1543-1547.

West, G. L., Stevens, S. A., Pun, C. & Pratt, J. (2008).Visuospatial experience modulates attentional capture: evidence from action video game players. *Journal of Vision, 8*(16), 1-9

Wright, J. C., Huston, A. C., Murphy, K. C., St. Peters, Piñon, M., Scantlin, R. & Kotler, J. (2001). The relations of early television viewing to school readiness and vocabulary of children from low-income families: The early window project. *Child Development,* 71*(5),* 1347-1366.

Appendix A: Questionnaire

Spilling på nettbrett og oppmerksomhet

Vinter 2015

Spørreskjema

Deltakerkode _____

Mobilnummer_____

Dato_____

Informasjonen som samles i dette spørreskjemaet vil behandles konfidensielt. Når prosjektet avsluttes våren 2015 vil all informasjonen fra spørreskjemaet bli makulert.

Alle spørsmål om spilling gjelder alle typer spillkonsoller som xbox, playstation, datamaskin, nettbrett, smarttelefoner etc.

For å svare på spørsmålene, vennligst kryss av/skriv tydelig.

1. Kjønn_____

2. Alder_____

3. Har du spist og drukket tilstrekkelig i dag, normalt for deg?

   Ja _____ Nei _____

4. Har du fått tilstrekkelig med søvn i natt, normalt for deg?

Ja _____ Nei _____

5. Har du inntatt koffein de siste 4 timene?

   Ja___

   Nei___

6. Tenk på forrige uke. Hvor mange dager spilte du? (*på xbox/playstation/datamaskin/nettbrett/smartphone etc.)*

   0 ___

   1 ___

   2-3 ___

   4-5 ___

   6-7 ___

7. Tenk på den dagen du spilte mest i forrige uke. Hvor mange timer spilte du den dagen?

   Ingenting ___

   Mindre enn 1 ___

   1-2 ___

   2-3 ___

   3-4 ___

   4-5 ___

   Mer enn 6 timer ___

8. Tenk på forrige uke. Hva slags type spill spilte du mest?

   Actionspill *(f. eks Tekken, Battlefield, Tomb Raider, Grand Theft Auto)* ___

Pedagogisk spill *(f. eks Dragon Box)* ___

Puslespill *(f. eks Bubble Trouble, Tetris)* ___

Rollespill *(f. eks Star Wars, World of Warcraft)* ____

Strategispill (*f. eks World of Warcraft)* ____

Plattformspill *(f. eks Super Mario, Ratchet & Clank)* ____

9. Tenk på forrige uke. Hvilke spill spilte du mest? *(Mest spilt som nr. 1, nest mest spilt som nr. 2, osv.)*

   1_____

   2_____

   3_____

10. På hvilken plattform spiller du mest? (xbox, nettbrett, datamaskin, etc.)

_____

11. Hvor mange timer spiller du gjennomsnittlig i løpet av en uke?

_____

12. Hvor mange timer spiller du gjennomsnittlig i løpet av en måned?

_____

Appendix B: Request of participation in study and consent form

Forespørsel om deltakelse i forskningsprosjekt

"Korttidseffekter av nettbrett-spill på oppmerksomheten"

Bakgrunn og formål
Formålet med studien er å se om nettbrett-spill har korttidseffekter på oppmerksomheten. Prosjektet er en mastergradsstudie ved NTNU, og gjennomføres ved psykologisk institutt på Dragvoll.

Hva innebærer deltakelse i studien?
Datainnsamlingen vil starte med at deltaker fyller ut et kort spørreskjema på papir for å kartlegge informasjon om erfaring med video- data-, telefonspill m.m., kjønn og alder. Deretter vil deltakere få en oppmøtetid og dato på Dragvoll i januar. Her vil enda et kort spørreskjema utfylles. Etter at spørreskjemaet er utfylt skal deltaker gjennomføre tre oppmerksomhetstester; Stroop-testen, Attentional blink-testen og Simon-testen. Til sammen vil disse ta ca 25-30 min å gjennomføre. Deretter skal deltakeren spille et utvalgt spill på nettbrett i ca 1 time eller lese i en bok i ca 1 time. Til slutt skal deltaker gjennomføre Stroop-testen, Attentional blink-testen og Simon-testen en gang til. Testene vil måle oppmerksomhet. Data registreres på en datamaskin.

Hva skjer med informasjonen om deg?
Alle personopplysninger vil bli behandlet konfidensielt. Det er kun student og veileder som vil ha tilgang til personopplysninger. Personopplysninger lagres for å ivareta konfidensialitet ved at ingen navn vil registreres. Deltakerkode vil knyttes til et mobilnummer. Denne listen vil lagres adskilt fra øvrige data.

Deltakere vil ikke kunne gjenkjennes i publikasjon.

Prosjektet skal etter planen avsluttes 01.05.2015. Etter denne datoen vil personopplysninger slettes.

Frivillig deltakelse
Det er frivillig å delta i studien, og du kan når som helst trekke ditt samtykke uten å oppgi noen grunn. Dersom du trekker deg, vil alle opplysninger om deg bli anonymisert.

Studien er meldt til Personvernombudet for forskning.

Samtykke til deltakelse i studien

Jeg har mottatt informasjon om studien, og er frivillig til å delta

……

(Signert av prosjektdeltaker, dato)