The Effects of non-Substance Addiction Related Stimuli on Time Perception: Evidence from Gambling and Facebook/Internet Modified Paradigms

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ABSTRACT

Research has identified that addiction related stimuli can cause attentional bias effects due to preferential treatment and allocation of cognitive resources. Furthermore, *scalar expectancy theory* (SET) and *internal clock models* (ICM) account for the role of arousal, attention, and memory in time keeping and time perception. This thesis investigated the effects of addiction related stimuli in time perception by attempting to discriminate between each of the three factors of arousal, attention, and memory. Initially this thesis replicated the Stroop interference caused by gambling stimuli and then expanded on into Facebook/Internet related stimuli (chapter 2). Findings from both of the above paradigms suggest that gambling related and Facebook/Internet related stimuli can cause *attentional bias effects*. In chapter 3 using a novel gambling modified temporal bisection task, this thesis investigated whether gambling related stimuli can cause temporal interference due to arousal or attentional mechanism, and whether negative or positive gambling related stimuli would further affect these effects. Findings indicated that Poker players underestimated durations for gambling related stimuli but not for neutral ones. No such findings were discovered for the control group. Furthermore, Poker players exhibited better temporal discriminability compared to the control group. In chapter 4, using a novel Facebook/Internet modified temporal bisection task, these findings were using Facebook/Internet related stimuli (*salient)* and neutral ones. Participants demonstrated underestimation of time for *salient* stimuli but not neutral ones. Furthermore, repetition and familiarity did not have an effect on time perception. Therefore, one could conclude that it is the emotional content of said *salient* stimuli that drove these effects and not familiarity. Finally, in chapter 5, this thesis investigated to what extent increasing memory load would affect the previously mentioned temporal perception distortions. Using a temporal bisection and N-back (or Sternberg) dual task, results suggested that *salience* effects on time perception disappear when memory load increases. Taken together, the above findings propose that addiction can provide greater insight and support to *SET* and *ICM.* On the other hand, time perception should also be used as a tool for detecting *attentional* and *arousal effects* in addictions in general, including both substance and non-substance addictions.

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DECLARATIONS

I declare that the work presented in this thesis is my own and was carried out under normal supervision. Any information used by other sources and published work, either mine or others', has been properly mentioned and cited.

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September 2019 (How time flies!)

Publications

Chapter 4, parts of the chapter including Exp5:

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Chapter 1 INTRODUCTION

Theoretical Background

Overview

The aim of this doctoral work was to investigate the effects of non-substance addiction related stimuli (salient stimuli) on our perception of time, more specifically the effects of gambling and Facebook/Internet related stimuli. This investigation employed a number of experimental paradigms that will be outlined at the methodological section of this introductory chapter. Prior to that, I will outline relevant psychological theories that account for attentional bias effects due to addiction related salient stimuli. Furthermore, I will provide evidence from previous research that support such theories. I will then discuss the *internal clock model* (ICM) and the *scalar expectancy theory* (SET) and provide examples of previous research that documented factors that could affect our time perception. I will then conclude the theoretical part of this chapter by bringing together addiction theories and time perception literature and provide the rationale of why we should expect distortions in our time perception when exposed to gambling and Facebook/Internet related stimuli.

Addiction Theories and Attentional Bias

Attentional Bias (AB) in addiction is generally characterised as the tendency of addicted individual for preferential allocation of attentional resources towards addiction related stimuli. This has been documented across a number of addiction types such as ***alcohol*** (e.g., Jones, Bruce, Livingstone, & Reed, 2006; Klein, 2007; Noël et al., 2006; Sharma, Albery, & Cook, 2001; Stormark, Laberg, Nordby, & Hugdahl, 2000; Townshend & Duka, 2003; Waters & Green, 2003), ***cannabis*** (e.g., Cane, Sharma, & Albery, 2009; Field, Mogg, & Bradley, 2004; Field, Eastwood, Bradley, & Mogg, 2006; Field, 2005), ***opioids*** (e.g., Bearre, Sturt, Bruce, & Jones, 2007; Carpenter, Schreiber, Church, & McDowell, 2006; Copersino et al., 2004; Franken, Kroon, Weirs, & Jansen, 2000; Sharma & Money, 2010; Vadhan et al., 2007), ***pathological gambling*** (e.g., Brevers et al., 2011; Ciccarelli, Nigro, Griffiths, Cosenza, & D'Olimpio, 2016; McGrath, Meitner, & Sears, 2018; Molde et al., 2010;

Wölfling et al., 2011), and ***excessive internet use*** (Jeromin, Nyenhuis, & Barke, 2016; Metcalf & Pammer, 2011a; Zhou, Yuan, & Yao, 2012a). It should be noted though for *excessive internet use* research on attentional bias has mainly focused on online gaming and computer gaming. No research has been carried out regarding attentional bias due to Facebook or general Internet use.

A number of psychological theories have attempted to provide support for the AB effects elicited from addiction related stimuli. Even though some theories might not explain AB directly, they can still account for it by generalising. A good example of such theory is the *dual affect model* as proposed by Baker, Morse, and Sherman (1986). According to this model, there are two systems in play, a positive-affect and a negative-affect system. Any stimuli associated with the positive-affect system could activate addiction related activities, where as any stimuli associated with the negative-affect system could activate an inhibitory behaviour. Even though the model makes these claims for substance related addiction one can easily see that they can be generalised for non-substance related addiction such as gambling and Internet use.

Robinson & Berridge (1993) further expanded this notion by providing a biological explanation, specifically a dopaminergic interaction that came to be known as the *incentive-sensitisation theory*. The general idea of the theory is that when we use a substance we initiate a dopaminergic reaction that becomes sensitised with subsequent use. This gradually attributes salient properties to the addictive behaviour and leads to motivating the user to abuse again. The above can explain AB as an extension of substance abuse. Addiction related stimuli could also be associated with this dopaminergic interaction hence motivate the user to abuse. This incentive driven motivation could elicit preferential processing for addiction related stimuli. The claims by Robinson and Berridge also provide support to Tiffany's (1990) cognitive model of drug use where addictive behaviour is mainly disciplined by automatic processes. Hence, any AB effects could even occur without the user's awareness.

Franken (2003) provided further support for the *incentive-sensitisation theory* by proposing that the AB bias effects are merely a result of classical conditioning. When addiction related cues trigger the dopaminergic interaction they acquire *salient* properties and become the centre of attention that later on could lead to craving and urge to use. This direct implication that external cues get preferential attentional treatment could explain the AB effects. Furthermore, if the user abstains, the urge and craving to use could increase these AB effects due to a reciprocal relation between the addiction related stimuli and the dopaminergic activation (Ryan, 2002).

A further explanation for AB comes from the *theory of current concerns* (Klinger & Cox, 2004). The authors define as *current concerns* a time-binding brain process that motivates us to notice and act upon stimuli that are related to our current goal. In terms of addictive behaviour such as gambling, this could mean that when a gambler has a goal to engage with gambling activity he/she would notice and react to gambling related stimuli. This gambling primed state of mind could explain a possible preferential treatment of gambling related stimuli that could trigger AB.

One could argue that all the above theories share a common aspect of addiction related stimuli are processed automatically and activate a behavioural cycle leading to increased urge and craving to use as well as AB effects. One theory that attempted to bring together automatic processes and craving to use was the *elaborated intrusion theory* (EI) as proposed by Kavanagh, Andrade, and May (2005). EI proposes that external cues can initially activate automatic desire thoughts. By then elaborating on these desire thoughts increased craving occurs that further enhances the effects of external stimuli. This cycle can explain AB as a result of *associated thoughts* that reduce the cognitive resources available to supress the effects of external cues (see Figure 1).

Even though EI was originally proposed for substance use, it could be easily generalised to non-substance addictions such as gambling and Internet use. It is also important to note that EI highlights the importance of both attentional and working memory resources in order for the subjective state of desire to be initiated and maintained. EI predicts that by reducing the availability of attentional resources one could reduce the amount of intrusive thoughts. Furthermore, by limiting the availability of working memory resources one could restrict the level of elaboration. Even though restricting attentional resources, in the form of attention training, has been fairly researched, the same cannot be said for the role of working memory resources (May, Kavanagh, & Andrade, 2015). In Chapter 5, we will investigate the role of working memory load on the time perception of addiction related stimuli.

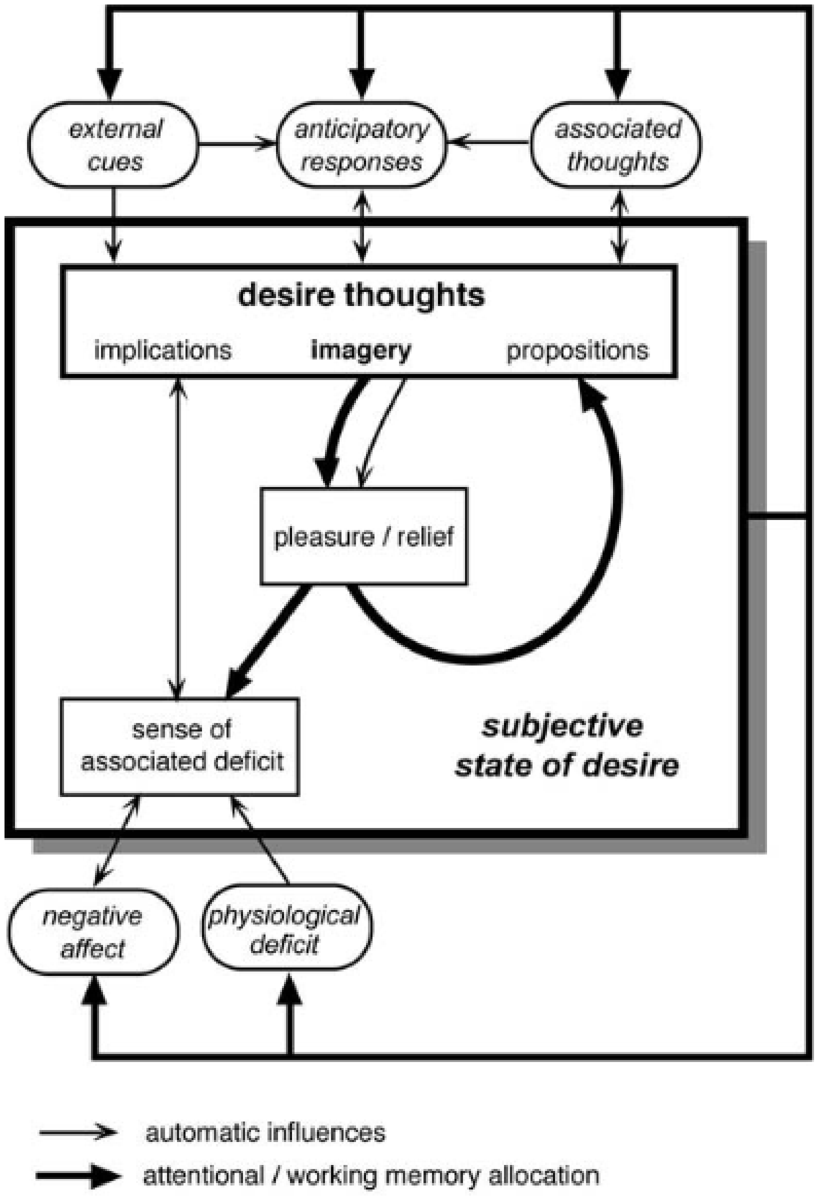


Figure 1. The Elaborative Intrusion Theory as presented in Kavanagh, Andrade, and May (2005)

Evidence of AB from Addiction Modified Paradigms

As already stated AB is a quite robust phenomenon that has been researched for decades using a variety of experimental paradigms. One of the most commonly used paradigm is the **Addiction Modified Stroop** task. Participants are presented with either words or images through a coloured layered and are instructed to ignore the content of the image or the word and report the colour as fast and as accurately as they can. Typically, for the Addiction Modified task, half of the stimuli are addiction related and half are neutral. Previous findings suggest that participants are overall slower at reporting the colour of addiction related stimuli compared to neutral stimuli (alcohol related task: Bauer & Cox, 1998). Furthermore, in addiction modified Stroop tasks a more common finding is that addiction abusers are typically slower at reporting the colour of addiction related stimuli compared to healthy control participants (alcohol related task: Cox, Fadardi, & Pothos, 2006). These findings are quite consistent across different types of addiction (for a review see Field & Cox, 2008), including Pathological or Problem Gambling (for a review see Hønsi, Mentzoni, Molde, & Pallesen, 2013). Specifically, for gambling, as it is one of the two focuses of this thesis, the findings have been very consistent; gamblers have been slower at reporting the colour of gambling related stimuli compared to neutral words. No such difference was observed for the control groups (e.g., Boyer & Dickerson, 2003b; Molde et al., 2010).

Another task that has been used to investigate AB is the **visual probe task**. The task involves presenting simultaneously two stimuli on a computer screen, one addiction related and a neutral one. Once the stimuli disappear, a visual probe is presented in the place of one of the two original stimuli. Participants have to respond to the visual probe as fast as they can. AB is observed when pathological users are quicker to respond to probes that replace addiction related stimuli compared to probes that replace neutral stimuli (for a general addiction review see: (Munafò & Albery, 2006). This AB has also been demonstrated in gambling modified visual probe tasks (Vizcaino et al., 2013) with gamblers being quicker to respond to probes replacing gambling related stimuli compared to neutral ones. No such difference was observed in the healthy control group.

The **flicker-induced change blindness** (flicker ICB) has also been used to investigate AB in addiction. The task involves the quick presentation of pairs of images, with a blank image in between them, in quick succession that creates the sensation of flickering. The two images will differ in two small details/objects and will perpetually be presented on the screen until the participant can spot one for the two changes. Typically, when a change occurs it will result in a motion signal at the location of the change. However, with the blank image interfering the motion signal is now directed towards the entire image, thus resulting in difficulty in detecting the occurred change. This is known as change blindness. For the addiction modified task, one changed detail/object would be addiction related (salient) and one neutral. AB would be observed when participants would spot the salient object and such findings have been reported across different types of addiction (e.g., heroin: Bearre et al., 2007; cannabis: B. Jones, Jones, Blundell, & Bruce, 2002; alcohol: B. T. Jones, Bruce, Livingstone, & Reed, 2006a; gambling: Brevers et al., 2011). Brevers et al. (2011) combined the flicker ICB task with eye-tracking and reported that gamblers showed more initial engagement with gambling related stimuli (initial directions and fixation time) compared to neutral stimuli. This was not the case for the control group.

Eye tracking has been used across different forms of addiction combined with some of the behavioural paradigms mentioned above. Specifically, when combined with the visual probe task research has shown that problematic use participants exhibited increased fixation times towards addiction related stimuli compared to neutral stimuli (e.g., alcohol: Christiansen, Mansfield, Duckworth, Field, & Jones, 2015; cocaine: Marks, Pike, Stoops, & Rush, 2014a; smoking: Kang et al., 2012; Meernik et al., 2016). Besides eye tracking other direct measurement methods include event-related potentials (ERP) and functional magnetic resonance imaging (fMRI). However, these studies were focusing more on inhibition, neural responses, and brain damage and not AB per se (for a review see Marhe, Luijten, & Franken, 2014).

In conclusion, we can argue that AB towards addiction related stimuli has been operationalised by a number of different behavioural paradigms and has been measured either directly or indirectly. The Addiction Modified Stroop task appears to be the most prevalent task. Even though this task has been used for investigating gambling AB the same cannot be said for Facebook/Internet AB. Furthermore, time perception paradigms have not been used in conjunction with gambling nor Facebook/Internet related stimuli. Either to investigate the direct impact of addiction related stimuli on our time perception or using time perception distortions as an indirect measurement of AB.

Time Perception

Time has been at the centre of human *skepsis* for centuries with representations in ancient theologies, arts, and philosophy. Kant in his *Critique of Pure Reason* proposed that we are born with senses of time and space. It is therefore a given and independent of life experiences. Time has also been at the centre of sciences and specifically physics for millennia with Aristotle proposing that time is a sort of number that is defined as the difference between what was and what is. For psychology and human behaviour *time* has been research since the early days of the science, the 19th century, with Fechner arguing that the *sense of time* or *sense of judging duration* should be regarded as an innate sense like hearing and vision.

Despite the early interest in the study of *sense of time*, psychologists only started formulating plausible theories in the second half of the 20th century. Even though experimental work on time perception was as old as 1850s with Vierordt's Law stating that we humans tend to reproduce short durations as longer and long durations as shorter. In a sense, we tend to gravitate towards central durations (as reported in Lejeune & Wearden, 2009). Early 1960s saw scientists Creelman, in 1962, and Treisman in 1963, proposing *internal clock models* (ICM) that will later be defined in more detail by Gibbon (1977) and Church and Gibbon (1982). Furthermore, Church and Gibbon expanding on their previous work and together with Meck formulated the *scalar expectancy theory* (SET, 1984). Furthermore, Zakay and Block (1995) expanded on the model by highlighting the role of attention in prospective temporal events.

SET expanded on Treisman's work and included three distinct stages, *the clock stage, the memory stage,* and *the decision stage*. It is also worth noting that SET has seen a number of different adaptations, for a more recent one see Figure 2 as it was presented in Sylvie Droit-Volet and Meck (2007). The *clock stage* includes three key mechanisms, the *pacemaker*, the *mode switch* and the *accumulator*. The variable-rate *pacemaker* is generating pulses from the onset to the end of an event and is sensitive to arousal. In a similar manner as a physical clock ticks every second. These pulses reach the *accumulator* that acts like a storage facility. The *mode switch,* when we are focused on the event, allows these pulses to make it to the *accumulator*, in other words the *switch* is ON. When we get distracted, the *mode switch* opens, goes to OFF position, and some of the pulses do not make it to the accumulator.

The memory stage involves the elements of *working memory* and *reference memory.* In the *reference memory,* we have stored previous temporal experiences. For example, in the case of the temporal bisection task that will discuss later on we will have memory representations of a *short* duration event and a *long* duration event. In the *working memory*, we temporarily store our experienced current event. Finally, at the *decision stage* we have the *comparator* that helps us decide whether the duration of the current event is matching what we have in our *reference memory* or not. It is easy for anyone to see that one of the strengths of this model lie in its simplicity and clear associations with different cognitive mechanisms such as attention, arousal, and memory.

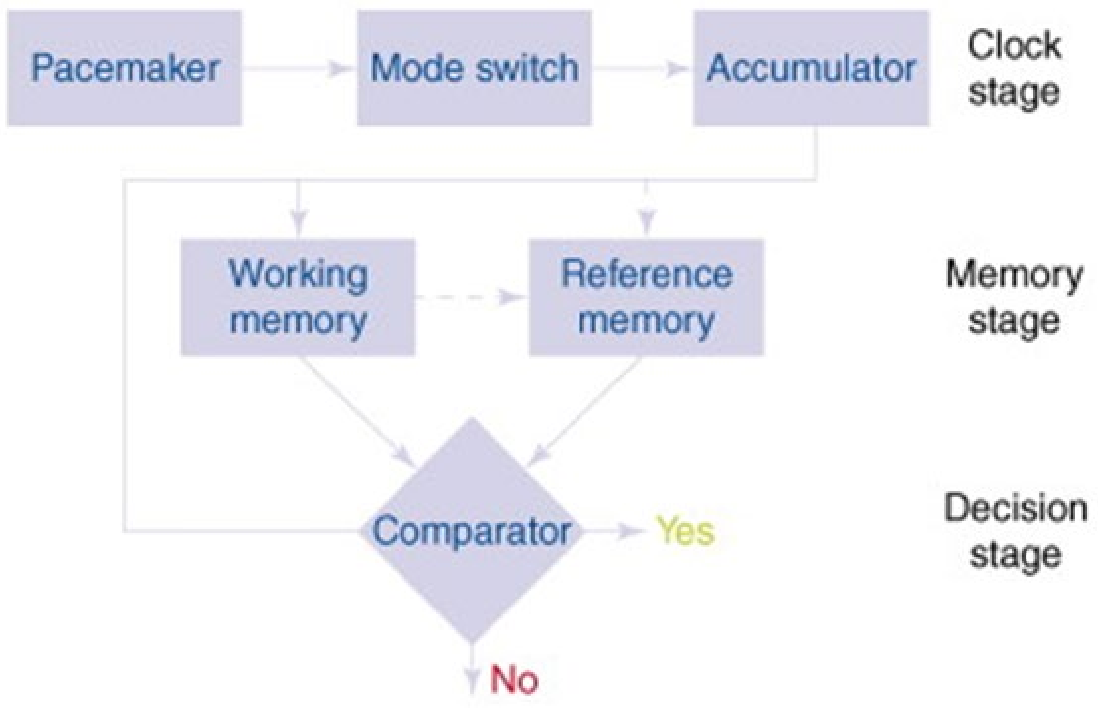


***Figure 2. A generalised conceptual representation of ICM as guided by the SET principles* (Sylvie Droit-Volet & Meck, 2007)**

Indeed, research in time perception has already provided evidence of how manipulating arousal can distort our time perception. Drew et al., (2003) administered D1 and D2 antagonists to rats that were trained to produce 12 and 36s. Their findings suggested that when a D2 antagonist was administered rats to overestimate their time production, which indicated a decelerated *pacemaker*. Furthermore, Cheng, Ali, and Meck (2007) demonstrated that increasing arousal by administering cocaine to rats that had received minimal training led to lengthening their experience due to an accelerated *pacemaker*. Contrary, administering cocaine to rats that had received extensive training did not yield the same results. Furthermore, in the case of rats with extended training, when also administered with ketamine in conjunction with cocaine the same temporal behaviour as with the minimal training rats was observed. Therefore, by biochemically affecting the arousal levels we can affect the perceived passage of time.

Similar effects were also observed when repetitive audio stimuli, clicks, were used to accelerate and decelerate the *pacemaker.* A typical example of such research is the one carried out by Wearden, Philpott, and Win (1999) where clicks either timed with a faster clock or a normal clock were presented together two tones. Participants had to judge which of the two tones was longer. Evidence suggested that tones presented with the faster paced click were judged to last longer. Thus, providing support that an increased *pacemaker* could result in overestimate time. These effects on the *pacemaker* can also be observed when the pacemaker would be accelerated using visual stimuli, flickers. Ortega and Lopez (2008) used the temporal bisection task in conjunction with flickering stimuli. The temporal bisection task involves training participants to discriminate two standards, one of short duration and one of long duration, and then asking them to classify duration in-between these two standards as either short or long (for more details see the second part of this chapter regarding the Experimental Paradigms). The findings were similar to audio click results. Participants would overestimate time for flickering stimuli as a result of an accelerated *pacemaker*.

Further from biochemical and repetition effects, temporal distortions due to arousal have also been demonstrated with emotional stimuli. Tipples in 2008 used angry, happy, fearful, and neutral faces as stimuli in a temporal bisection task. Results indicated that the durations of angry faces were overestimated compared to all other facial expressions. Which could be an indication of accelerated *pacemaker* in the presence of threatening stimuli. This finding is consistent with numerous other studies involving emotional stimuli (e.g., Cheng, Tipples, Narayanan, & Meck, 2016; Sylvie Droit-Volet & Meck, 2007a; Gil & Droit-Volet, 2009, 2012a; Mella, Conty, & Pouthas, 2011; Noulhiane, Mella, Samson, Ragot, & Pouthas, 2007; Tipples, 2011).

Emotional content however, could also have an impact on the *mode switch*. Specifically, emotional stimuli could grab our attention while we are experiencing an event, resulting in opening the *mode switch*, thus losing some of the generated pulses. This should result in underestimating time as fewer pulses reach the *accumulator*. Tipples in 2010 employed a temporal bisection task using sexual taboo words and other words with different levels of arousal and valence. His results indicated that participants underestimated time for taboo words compared to non-taboo words, providing support to the notion that taboo words can grab our attention. This finding is in line with the predictions made by Zakay and Block (1996) regarding the role of attention and attention shifting.

However, one could ask how can we distinguish between arousal and attentional effects, as stimuli can be arousing and accelerate the *pacemaker* and at the same time, they can grab our attention and open the *mode switch.* One possible answer to this is that opening the *mode switch* should have a constant subtracting effect on our time perception across different durations. Whereas arousal effects should produce increasing effects as durations increase. For example, when we are experiencing two separate events of 400 and 1600ms attentional effects should be similar for both durations. That would result in a perception of 300 and 1500ms respectively. On the other hand, if we have arousal effects the distortion for 1600ms should be a multiple of the distortion of the 400ms. So 400ms could feel like 500ms and 1600ms like 2000ms. In this thesis, we will also propose a different approach where the *point of subjective equality* should be used for attentional effects and *Weber's ratio* should be used for arousal effects. More details on this claim and justification on their use will be presented in Chapter 3.

Investigation Rationale

By examining the addiction theories mentioned above and the ICM one can easily highlight that are mechanisms that are present in both. Specifically in EI, the role of attention towards external salient stimuli could have direct implications on our time perception when we are exposed to such stimuli. One should expect that salient stimuli should distract us from timekeeping thus resulting in underestimating time. Furthermore, EI also implies that memory resources are crucial for this intrusive/elaborative cycle to occur therefore, it should be interesting to investigate what is the impact of memory load on the intrusive salient stimuli and how that would impact our time perception. Specifically, since ICM require memory resources both for maintaining the temporal standards and the current experienced event. Finally, EI and also the *incentive-sensitisation* theory also predict that salient stimuli should have an dopaminergic effect, thus affect our arousal levels, which should have a direct effect on our *pacemaker* and time perception overall.

Therefore, exploring the effects of attention, arousal, and memory load on the time perception when exposed to addiction related salient stimuli would provide valuable insights for both the fields of addictions and time perception.

Experimental Paradigms and Methodological Considerations

For the purposes of this thesis, a number of different experimental paradigms was employed. Below each paradigm will be discussed briefly highlighting the reasoning behind its use and discussing methodological considerations. The paradigms are mentioned in the order that are reported in the thesis.

1. Addiction Modified Stroop tasks: Chapter 2
2. Addiction Modified Temporal Bisection task (Gambling): Chapter 3
3. Addiction Modified Temporal Bisection task (Facebook/Internet): Chapter 4
4. Memory Association Temporal Bisection task (Facebook/Internet): Chapter 4
5. N-back and Sternberg tasks: Chapter 5

Addiction Modified Stroop tasks

The Stroop task in its traditional form was proposed by Stroop (1935) and it involved the presentation of colour words written either in the same or different ink colour. Trials could be either *congruent* (e.g., word “GREEN” written in green ink) or *incongruent* (e.g., word “GREEN” written in blue ink). Participants were usually instructed to name the colour of the ink and ignore the colour word itself. Any differences in reaction time (RT) between *congruent* and *incongruent* trials are known as Stroop effect. In addition, control trials could be added with non-colour related stimuli written in different ink colours (e.g., “XXXX” written in blue ink). This would allow research to further discriminate between *interference* Stroop effect (difference between *incongruent* and *neutral* trials) and *facilitating* Stroop effect (difference between *congruent* and *neutral* trials). It has been proposed that the Stroop effect is the result of conflicting process that prevent us from ignoring irrelevant to the task information (Macleod, 1991).

Even though the original version of Stroop involved only colour words and ink colours, the paradigm has since evolved and a number of variations have been use in research. One such variation is the emotional Stroop task either in word or pictorial version (Aswin, Wheelwright, & Baron-Cohen, 2006; Constantine, McNally,

& Hornig, 2001; de Ruiter & Brosschot, 1994; Frings, Englert, Wentura, & Bermeitinger, 2010; Mark, Williams, Mathews, & Macleod, 1996; McKenna & Sharma, 2004; Phaf & Kan, 2007). The emotional Stroop involves presentation of stimuli that can be emotionally loaded (either words or images). In the case of word version, words are written in different ink colours and in the case of the pictorial version, each picture is presented through a coloured filtered. Research has consistently shown that anxious individuals, or individuals with phobias, are slower in reporting the colour for emotional stimuli compared to neutral stimuli. This threat related bias can be referred as emotional Stroop effect.

For the purposes of this thesis, we developed two further variations of the pictorial emotional Stroop task. One gambling-modified Stroop task and one Facebook/Internet modified Stroop task. Gambling-modified Stroop tasks have been used before (e.g., Boyer & Dickerson, 2003) and demonstrated slower RTs for naming the colour of gambling related words compared to neutral words for Poker players only. Our version was a pictorial one and aimed to replicate such findings (Chapter 3, Exp1). A Facebook/Internet modified Stroop task (Chapter 3, Exp2) has not been used before and our aim was to discover similar slower RTs for the salient stimuli compared to the neutral ones.

Addiction Modified Temporal Bisection tasks

As discussed earlier in ICM and SET one of the challenges in research of timing and time estimation is the isolation of individual components of the theoretical constructs. Specifically, distinguishing the effects of the *pacemaker* from the effects of the *switch*. One common task used in relevant research is the Temporal Bisection task (TB). The TB involves training participants in two standards, one of *short* duration and one of *long* duration. This training phase is followed-up by a test phase where stimuli are presented in a number of different durations between *short* and *long*. Participants are asked to classify them into one of the two standards by responding SHORT (S) or LONG (L); (Note: Below, the letters S and L will be used to denote participants' response and not actual duration). The purpose of the TB task is to estimate the point of subjective equality where a participants transitions from responding S to responding L. For example if a participant is presented with stimuli in durations of 200, 400, 600, 800, and 1000ms and analysis reveals that he/she would respond 50% S and 50% L at 480ms, then the 480ms will be the *Temporal*

Bisection Point (TBP).

Originally, Wearden (1991) proposed that the TBP should be equal to the arithmetic mean or else TBP = (*short* + *long*) / 2. However, his data contradicted his own theoretical model, indicating that the TBP could be close to the theoretical mean but still below it. More interestingly, in the case of ambiguous durations participants tended to respond L in most of the trials. This indicated a bias that automatically discarded the notion of the TBP located at the arithmetic mean. To account for this bias, Allan and Gibbon (1991) proposed the use of the geometric mean adjusted by the bias for L (β). This resulted in TBP= $\sqrt{\frac{short \times long}{\beta}}$. The strength of both methods is that they account/acknowledge response biases and the role of memory in timing (due to *short* and *long* standards being stored in working memory). However, both methods were inaccurate when matched with experimental data.

Wearden and Ferrara (1996) finally proposed that the S & L responses should not be expected to be placed on a linear pattern. Instead, they proposed that depending on the duration of the stimulus the S & L responses should resemble a logarithmic distribution. Even though this solution had its flaws, it accounted for timing performance more accurately (Kopec & Brody, 2010). Building on this logarithmic notion, all TBP in this thesis were calculated using probit analysis that takes the assumption of the logarithmic distribution into account when estimating the point of subjective equality (more on the Bisection Point technical calculations in Chapter 4, Exp3).

Moving away from the psychometric calculations behind the TB task it is also important to highlight why this task was ideal for the purposes of this thesis. Previous research employing this experimental paradigm has identified that this task can detect both attentional and arousal effects (e.g., Sylvie Droit-Volet & Meck, 2007b; Gil & Droit-Volet, 2009, 2012a; Tipples, 2008, 2011). Attentional effects would typically result in a horizontal shift in our performance Figure 3, whereas arousal effects would result in “steeper” curves in our performance. Therefore, using the TB task would not just reveal information regarding distorted time perception but would also inform addiction and cognitive models on the role of attention and or arousal.

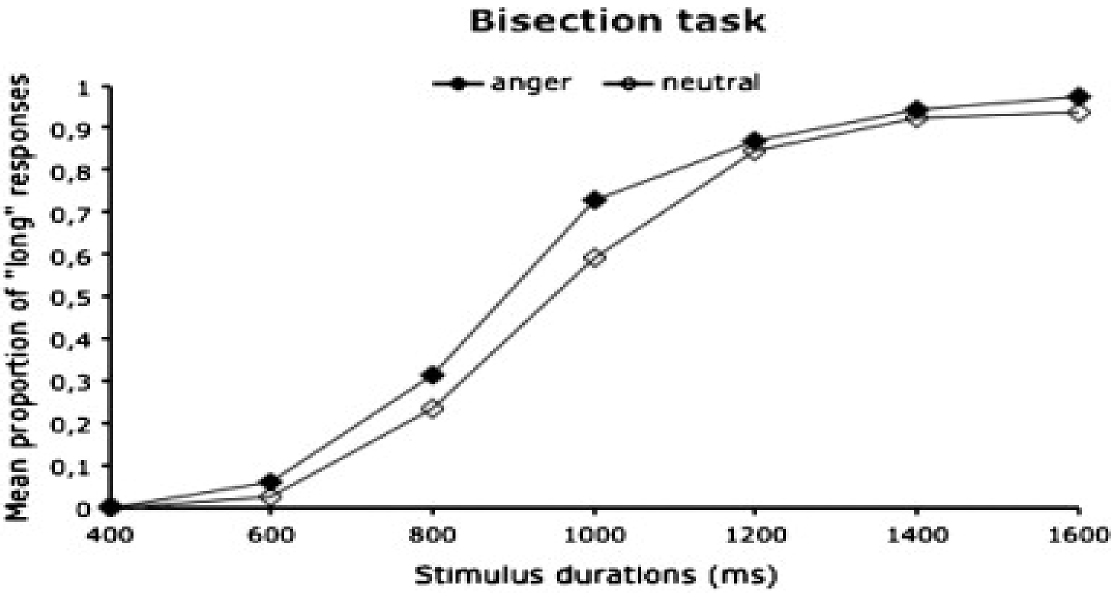


Figure 3. Typical attentional effects where we can clearly observe a horizontal shift between the two curves. As presented in Gil and Droit-Volet, 2011

Memory Association Temporal Bisection task

During the course of this research, criticism arose on whether the observed temporal distortion effects were due to emotional content of the salient stimuli or whether it was simply a familiarity effect. Block, Hancock, and Zakay (2010) carried out a meta-analytic review investigating the impact of different factors in time perception. One of these factors was *familiarity*, and the authors found no effect size differences between *low* and *high* conditions. Despite this finding, we wanted to be even more certain that our effects were not due to *familiarity*.

We did that by training participants to associate non-words with salient and neutral stimuli. We then employed the Temporal Bisection task using learnt and not learnt (novel) non-words instead of the original pictorial stimuli. We used a similar methodology as in Sharma and Money (2010) with the key differences that the participants completed a Temporal Bisection task and not a Stroop task. One further strength of this experimental paradigm is that it would weaken any criticism on whether specific pictorial details of the salient stimuli could be driving the effects and not their actual emotional content.

The N-Back and Sternberg tasks

As mentioned earlier the ICM besides the *pacemaker* and the *switch*, which are guided by arousal and attentional processes, also includes components that involve *working memory* (WM). It would therefore add to our scientific knowledge regarding the how the ICM operates when we are exposed to addiction related stimuli. Furthermore, by loading our WM we are also loading executive control functions, which in turn typically results in increased distractors effects (Lavie & De Fockert, 2005). This could have direct implications on the effects of addiction related stimuli on time perception.

First, we employed an N-back task, which was originally developed by Kirchner (1958). The task involves the presentation of stimuli on sequential order and the participant has to respond whether the current stimulus matches the stimulus presented previously. Specifically, the task commonly has four variations, 0-back, 1-back, 2-back, 3-back. In the 1-back variation the participant has to respond whether the current stimulus matches the exact previous one, in the 2-back whether it matches the one presented two trials prior, and the 3-back whether it matches the one presented three trials prior. The 0-back involves no WM manipulation, as the participants do not have to do any matching. As expected, increasing the value of *N* increases also the WM load and decreases accuracy of responses.

Secondly, we employed a Sternberg task which was originally developed by Sternberg (1966). The task involves a learning and a testing phase. During the learning phase participants have to memorise a number of characters that are presented rapidly in succession. Then in the test phase, characters are presented and participants have to respond whether the current character was presented during the learning phase. The key difference between the N-back and the Sternberg task is that the latter does not involve an update stage.

The Sternberg task relies heavily on short-term memory capacity as participants are only required to maintain the learnt set of characters in mind for the entire duration of the experiment. Thus, employing mainly the visuo-spatial sketchpad without the need to draw upon more cognitive resources such as the executive attention. However, the same cannot be said about the N-back task as constant processing and manipulation of the stored information is required (with the exception of the 0-back). Therefore, executive attention is needed to constantly coordinate the processes of retrieving memory content, compare it with the current stimulus, and update its content.

During the Sternberg task participant only have recall whether the current stimulus was part of the originally learnt characters. Once they respond “yes” or “no” this stimulus is no longer needed and no deliberate effort should be made to maintain in WM. In the N-back task however, the current stimulus, after responding whether it matches or not a previous one, it then needs to be store so it can be compared to an upcoming stimulus. For example, in the 1-back variation we start by maintaining the first stimulus, we then compared the second stimulus to the first and respond whether they are the same or not. Furthermore, we need to deliberately update the “remembered item”, meaning removing the first stimulus from memory and replacing it with the second stimulus. In other words, the updating process involves replacing an item in memory. This becomes even more effortful in the 2-back task. We now have to match the current stimulus with the one presented two trials ago. After we respond “yes” or “no” we then need to store this stimulus in a temporary memory slot and then after the next trial “shift” it to the remembered item position. Hence, the updating process now involves replacing and shifting.

For the purposes of this thesis, we only employed 1-back and 2-back, as the 0-back would not manipulate cognitive load and the 3-back would have been too difficult in a dual task paradigm. Similarly, for the Sternberg task we employed *low* and *high* load by presenting four and eight characters to memorise respectively.

Research Questions by Chapter

As mentioned earlier, this thesis examined the effects of addiction related stimuli on time perception, specifically gambling and Facebook/Internet related ones. Before proceeding to exclusively, time perception related investigations we wanted first to establish that gambling and Facebook/Internet related stimuli could elicit attentional bias effects.

In **Chapter 2** therefore, we focused on investigating such effects by using a robust paradigm such as the Addiction Modified Stroop task. Specifically, we wanted to replicate previous findings related to gambling and Stroop effect and expand that to Facebook/Internet Stroop Effect.

In **Chapter 3**, we wanted to investigate whether gambling related stimuli could distort our time perception. We then explored this effect further by presenting threatening, exciting, or neutral stimuli.

In **Chapter 4**, we wanted to investigate whether Facebook/Internet related stimuli could distort our time perception as gambling did. We then proceeded in investigating these effects further by exploring the role of repetition, semantic priming, and familiarity.

In **Chapter 5**, we wanted to manipulate the memory load and in extend the cognitive load and investigate what would the implications be on the ICM when interacting with addiction related stimuli.

Chapter 2 : STROOP TASK AND ADDICTION RELATED STIMULI

Attentional bias towards addiction related stimuli has been researched extensively in the last 30 years (Field & Cox, 2008) and it is now considered to be a robust phenomenon, even though the mechanisms behind it are still, to a degree, not fully determined (Ciccarelli et al., 2016). Specifically in addiction, attentional bias refers to preferable allocation of attentional resources towards addiction related stimuli (Matt Field & Cox, 2008; Franken, 2003; Tiffany, 1990).

Addiction models predict that due to selective attention addicts will tend to addiction related stimuli more than neutral stimuli (Franken, 2003). This increased attention can lead to increased dopaminergic activity that can reinforce attentional bias further, leading to a vicious circle. Furthermore, addiction related cues can initiate a circle of desire and associated thoughts that will make shifting attention away from addiction stimuli more difficult (The Elaborative Intrusion Theory of Desire (EI), Kavanagh, Andrade, & May, 2005). The above highlight the connection between external cues and activation of automated processes that in turn activate non-automated schemata related to substance use and relapse (Tiffany, 1990).

Experiment 1: Gambling Modified Stroop Task

Due to the complex nature of attention as a system, attentional bias can have either positive or negative effects on human performance. In an experiment by Field, Eastwood, Bradley, and Mogg (2006) cannabis users, compared to non-users, were faster at approaching responses related to cannabis cues but it also took them longer to divert their attention off the cannabis related stimuli. Similar findings have been documented across the spectrum of substance addiction (Cane et al., 2009; Copersino et al., 2004; Ehrman et al., 2002; Matt Field et al., 2006b; Marks, Pike, Stoops, & Rush, 2014b; Miller & Fillmore, 2011; Marcus Munafò, Mogg, Roberts, Bradley, & Murphy, 2003; Oliver & Drobes, 2015; Wilcockson & Pothos, 2015).

Similarly, to the above substance addiction related examples, attentional bias can also be observed with non-substance related addictions, behavioural addictions. In behavioural addictions such as gambling, online gaming, or general Internet addiction, problematic users display attentional bias towards stimuli related *salient* addiction related stimuli. A number of studies have already investigated attentional bias in gambling using a variety of paradigms. In modified Stroop tasks (Boyer & Dickerson, 2003a; McCusker & Gettings, 1997) gamblers demonstrate higher reaction times in reporting the colour of salient stimuli compared to neutral stimuli. In Posner tasks (Ciccarelli et al., 2016) gamblers demonstrated a facilitation in spotting gambling stimuli and attended to them for longer (disengagement bias). In eye-tracking studies (Brevers et al., 2011) gamblers demonstrated faster reaction times, increased fixation duration, and increased number of initial saccades towards salient stimuli compared to neutral ones, for review see Holst (2013), Molde et al. (2010).

Addiction related Stroop effect is a robust finding in addiction research (Cox, Fadardi, & Pothos, 2006b). By Addiction Stroop effect we refer to the increased reaction time (RT) in reporting the colour of a salient stimulus compared to a neutral stimulus. This effect is the manifestation of the salient content of the current stimulus on how fast we respond its colour and it is known as a fast effect. The investigation of the fast and slow Stroop effects (as it will be described below) has allowed us to explore further the mechanisms behind attentional processes.

McKenna and Sharma (2004) identified that besides the existence of a fast effect, slower RT in naming the colour of a salient current stimulus compared to a neutral current stimulus, there is also a slow effect which is a slowdown in naming the colour of current neutral stimulus when it follows a salient stimulus compared to when it follows a neutral stimulus. The authors even suggested that the actual fast effect has a very small impact in the interference. However, Frings, Englert, Wentura, and Bermeitinger, (2010) argued that both fast and slow effects play an important role and this could be due to two possible reasons. First, there could be two separate attentional mechanisms and automated one and a more controlled one, with the fast effect associated with the automated one and the slow effect associated with the more controlled one. Second, there could be just one attentional mechanism with the fast effect revealing an interference process and the slow effect a disengagement process that carries over to the next stimulus.

The hypothesis is that was that frequent poker players would be slower at reporting the colour of gambling related stimuli compared to neutral stimuli, this would not be observed in non-players. Furthermore, fast and slow effect analysis would highlight possible explanations behind these potential differences.

Experiment 1: Method

Participants

In total, 37 participants were recruited for this experiment (22 males and 15 females). All participants were students at the University of Kent aged between 18 and 28 (*M* = 20.35, *SD* = 2.00). Participants in the *control* group (*N* = 19) were Psychology students, they were recruited via the Kent RPS website and received course credits. Participants in the *poker* group (*N* = 18) were members of the Kent University Poker Society and participating in this experiment allowed them to take part in a Poker tournament for free. The usual cost for registering in a similar Poker tournament would be £3, which is equivalent to the two RPS credits that were given to the control group participants.

Design

This was a mixed design experiment defined by Group (Poker, Control) x Image (Gambling(G), Neutral(N). Group was a between-subjects factor and Image was a within-subjects factor. The dependent variable was the reaction time (RT) it took participants to respond the colour of the presented filtered image.

Materials

Hardware and software. The study was conducted in the labs of the School of Psychology where each participant was alone in an individual cubicle. The experiment was presented on a Psychology department Dell desktop computer with a 19 inches monitor (4:3 factor). The custom computer software used to present the stimuli was programmed in Psychopy v1.83 (Peirce, 2007, 2009).

Visual stimuli. Google images (“Google,” 2015) and “gambling images” as a search criterion were used. Twenty-four images were selected with items commonly associated with gambling such as roulette, dice, poker chips, and cards. Such items have been used before in gambling related research (eg., Brevers et al., 2011). For each gambling object an image was selected with a neutral object that had similar physical and visual properties such as shape, colour, and size. Furthermore, ten additional neutral objects were selected to be used in the practice trials.

All of the above images were resized to 1,024x768 pixels and were converted to 256 greyscale. Then Adobe Photoshop ® was used to apply four different filters.

These were red (255, 0, 0), green (0, 255, 0), blue (0, 0, 255) and yellow (255, 255, 0) with 40% opacity. This resulted in a total of 192 images. A similar procedure was also followed in order to create a collection of 40 stimuli (10 items filter for the above four colours), leading to a final collection of 232 stimuli. This time the search term was “office equipment” and the final 40 images were used during the Stroop training phase. It should also be mentioned that all image sizes were less than 200kb to avoid discrepancies in loading times. For detailed stimuli, see Appendix A.

Questionnaires. The committee of the Kent University Poker society agreed to advertise the study to its members with the agreement that the experiment will not take longer than 10 minutes. This imposed restraints to the number of the questionnaires that we could use to assess gambling severity. In order to keep the experiment at ten minutes participants only reported gender and age and were asked one question that would assess their Poker playing frequency. This item was “*In the field below type in how many poker games you play in a week (both cash and tournaments, online or not*”.

Procedure

Participants were first briefed about the experiment, provided their consent, and then entered an individual cubicle in order to complete the experiment. Once the experiment started, they were offered instructions on the screen that they would see images, one at a time, through coloured filters, red, green, blue, or yellow. Their task was to ignore the content of the image and report the colour as quickly and as accurately as they could. Reporting the colour was done by pressing the corresponding keys on the keyboard that coloured stickers were placed on (red:’A’, green:’S’, blue:’k’, yellow:’l’). Once participants were happy with the instructions they could press ‘space’ and the training phase would begin. The training phase was comprised of 40 trials with no inter-trial pause. Once a response key was pressed the next image would come on the screen with a frame buffer delay varying from 0ms to 16.7ms. After the training phase finished the experiment would pause and present the same instructions as earlier. By pressing ‘space’ the testing phase of the experiment would begin that comprised of 384 trials (2 repetitions of 192 unique trials) that were presented in random order. Finally, participants reported their gender, age, and how may poker games they played a week. Upon completion of the experiment, participants were debriefed and thanked for their participation.

Experiment1: Results

Poker Frequency

The answer from the Poker frequency question was entered in a one-way ANOVA with Group (Poker, Control) being the between-subjects factor. There was a significant difference between the two groups, $F(1, 36) = 9.07$, $p = .005$, $\eta_p^2 = .206$, (Poker: $M = 9.28$, $SD = 13.16$; Control: $M = 0.05$, $SD = 0.23$, numbers represent games per week). In the Control Group only one participant reported one game per week with the rest reporting zero games per week. In the Poker Group three participants reported more than 30 games a week and the rest reported less than ten games a week. Even when treating these three players as outliers and removing them from the ANOVA the result of the comparison remained significant ($F(1, 33) = 55.930$, $p < .001$, $\eta_p^2 = .636$). It was decided to leave these participants in the analysis.

Stroop Data Preparation

Prior to the data analysis the first trial and all other trials with incorrect responses for each participant were removed. This resulted in dropping 37 first trials and 773 trials with incorrect responses (originally 14,208 trials, 5.44% incorrect responses). Furthermore, all trials with response time outside ±3SD's based on each participant and condition specific mean were also removed. This resulted in dropping a further 226 trials leaving 13,172. Also, all trials with responses faster to 300ms were removed resulting in a final sample that contained 13,163 trials (the overall reduction from original sample to final sample was 7.35%).

Analysis of Errors

A two-way mixed analysis of variance for ratio of errors over total trials was conducted with Group (Poker, Control) as a between-subjects factor and Image (G, N) as a within-subjects factor. Both the main effects and the interaction were non-significant, all *F*'s < 0.85 and all *p*'s > .363.

Reaction Time Analysis

The mean correct RTs were entered into a two-way ANOVA including Group

(Poker, Control) and Image (G, N). There was no significant main effect of Image, $F(1, 35) = 1.38$, $p = .248$, $\eta_p^2 = .038$, with observed power (1-β) = .21 (α = .05)[1]. There was a significant interaction of Image x Group, $F(1, 35) = 7.13$, $p = .011$, $\eta_p^2 = .169$, with observed power (1-β) = .74 (α = .05). Further pairwise comparisons with Bonferroni adjustment revealed a significant simple effect of Image for the Poker group ($p = .011$, Gambling: *M* = 810.12ms, *SD* = 95.74; Neutral: *M* = 788.53ms, *SD* = 97.91ms). There was no simple effect of Image for the Control group ($p = .248$, Gambling: *M* = 883.13, *SD* = 145.04; Neutral: *M* = 891.54, *SD* = 140.37ms). This suggests that the Poker group was significantly slower at reporting the colour of Gambling stimuli compared to Neutral stimuli, as predicted in our hypothesis. Finally, there was a main effect of Group, $F(1, 35) = 4.86$, $p = .034$, $\eta_p^2 = .122$, with observed power (1-β) = .57 (α = .05). This suggests that overall, the Poker group was faster at reporting the image colour (*M* = 799.32ms, *SD* = 96.06ms) compared to the Control group (*M* = 887.33ms, *SD* = 140.85ms).

Group Effect Investigation

The above finding of the Poker group being faster than the Control group presented the question whether this speed difference could be driving the simple effect of Image in the Poker group. To answer this question, we carried out a further analysis where we compared similar speed RTs between the two groups. We grouped the RTs per participant and Image in four bins. Then we calculated the difference of z-scores between the Gambling RT and Neutral RT for each participant and each bin. This resulted in four difference scores, Bin (b1, b2, b3, b4). We then ran a two-way ANOVA with Group (Poker, Control) and Bin (b1, b2, b3, b4). There was no significant main effect of Bin nor a significant interaction of Group by Bin (both *F*'s < 2.217, *p's* > .090). This suggests that the differences in reporting the colour in the Poker group were not due to being overall faster. As expected, there was a main effect of Group, $F(1, 35) = 6.68$, $p = .014$, $\eta_p^2 = .160$, with observed power (1-β) = .71 (α = .05), suggesting that the differences were greater for the Poker group. Moreover, these differences seem to increase as we move from the first to

[1] All observed power reported throughout this thesis were calculated as post-hoc power analysis using G*power. The figures were also confirmed, where possible, by the observed power reported by SPSS 27

the fourth Bin indicating that attentional effects are greater as the RT gets higher, see Figure 4.

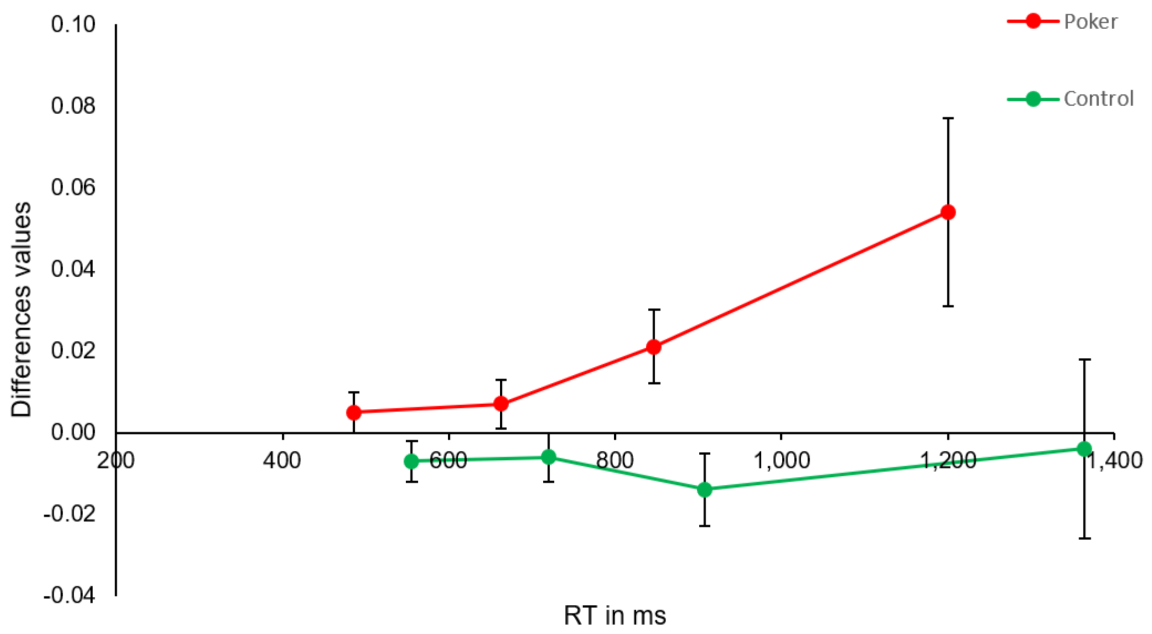


Figure 4. Differences in reaction times between Gambling and Neutral stimuli per group. Each Bin is represented by its mean reaction time.

Fast and Slow Effect Analyses

Furthermore, we also analysed correct reaction times in terms of fast and slow effects. We ran two separate two-way ANOVA with Group and Image (slow effect: current Neutral with previous Gambling vs. current Neutral with previous Neutral; fast effect: current Neutral with previous Neutral vs. current Gambling with previous Neutral). Both analyses revealed no significant main effects nor interactions (all F's < 1.691, all p's > .202). In order to investigate more what was driving the differences in RTs for the Gambling Group we explored whether the two previous trials stimuli would impact the RT for the current stimuli. Including the current trial, we formed triads of trials and separated them in two categories, triads with at least two (AL2) Gambling stimuli (GGG, GMG, MGG, GGM) and triads with at most one (AM1) Gambling stimulus (MMM, MMG, MGM, GMM). We then compared the RTs of these two categories for the Gambling Group (the same took place for the Control Group and as expected there were no significant differences). On average AL2 trials had higher RT than the AM1 trials (AL2: M = 811.08ms, SD = 93.09ms; AM1: M =

786.25ms, *SD* = 99.64ms). This difference was significant t (17) = 3.786, p = .001, η_p^2 = .457, with observed power (1-β) = .99 (α = .05). The above result suggests that attentional bias effects triggered by the presence of a Gambling stimulus are enhanced by the existence of a second Gambling stimulus within the immediate triad of trials.

Experiment 1: Discussion

The aim of the current experiment was to show that gambling related stimuli could cause attentional bias effects. Specifically, the hypothesis was that Poker players would be slower at naming the colour of gambling stimuli compared to naming the colour of neutral stimuli. Furthermore, no such differences would be observed in the control group. The results indeed revealed slower colour naming for gambling stimuli compared to neutral stimuli only for the Poker players group. This is in line with previous research (Boyer & Dickerson, 2003a; Brevers et al., 2011; Cox et al., 2006a) and it provides further evidence that addiction related stimuli can activate automated processes that can in turn impact attention.

Furthermore, Poker players were overall faster in the task compared to non-players. This could very well be due to an excitation effect caused by an increased dopaminergic activity as proposed by Franken (2003). This increased dopaminergic activity could lead to an increased arousal that can in turn lead to reduced RT in Stroop task (Hogervorst, Riedel, Jeukendrup, & Jolles, 1996; Lambourne & Tomporowski, 2010). It should be noted though that without any explicit measures of arousal, one should be cautious about this conclusion.

The analysis also revealed that for Poker players as RT got bigger so did the differences in RT between salient and neutral stimuli, this was not observed in the control group. This is general finding in the classic Stroop task as RTs increase across quantiles (Kinoshita, de Wit, Aji, & Norris, 2017). This finding provides support for the Elaborative Intrusive Theory (Kavanagh et al., 2005) that argues that the longer we attend to external cues the more desire and associated thoughts get activated, leading to even stronger attentional bias effects.

Moreover, there was no fast nor slow effect. Instead, the presence of two gambling stimuli was required in order to trigger attentional effects on the third stimuli. This could be regarded as a carry-over effect similar to the slow effect that has been reported before in addiction-modified Stroop tasks (e.g., Cane et al., 2009; Sharma & Money, 2010). The difference here is that the carry-over effect takes place only if an additional salient stimulus is presented to reinforce the impact on the current stimulus. One possible explanation could be that the Poker players that took part in the experiment were not pathological gamblers; however, without such measurement this can neither be accepted or rejected. A more plausible explanation is the fact that the slow effect is associated with negative emotions (Cane et al., 2009; Frings et al., 2010). Therefore, the lack of it could be due to the Poker players not having developed negative emotions yet towards gambling stimuli. However, this could also be due to a limitation of this study that had to do with the fact that Poker players did not complete any gambling questionnaires. However, this was unavoidable in this case but it should be avoided in future research.

Experiment 2: Facebook and Internet Modified Stroop Task

Despite the wealth of research on gambling, other forms on non-substance addiction have not been subjected to equal experimental investigations. One such under-researched for of non-substance addiction is the Internet addiction (IA). Even more so in terms of investigating for attentional bias effects. IA research has mainly focused on excessive gaming (R. J. Van Holst et al., 2012), online gaming (Metcalf & Pammer, 2011b; Zhou, Yuan, & Yao, 2012b), and online pornography addiction (Love, Laier, Brand, Hatch, & Hajela, 2015). Internet addiction though includes many more behaviours than the ones mentioned above. Young (1999) proposed five types of Internet addiction, computer addiction, information overload, cyber-sexual addiction, cyber-relationship addiction, and net compulsion. Moreover, Kuss and Griffiths (2011) suggested that excessive use of Facebook or generally Social Network Sites (SNS), should be regarded as a separate addiction. Their argument relies on the fact that people who use SNS excessively can also display some of the addiction criteria such as neglecting personal life or concealing addictive behaviour.

Furthermore, the authors originally categorised Facebook addiction as cyber-relation addiction. However, in the recent years Facebook has evolved to a more holistic platform that now incorporates games, transactions, news feeds, advertising, shopping, and other online activities. So, one could argue that Facebook addiction is now a more general online addiction that includes most of the types that Young has proposed. The above, in conjunction with the availability of Facebook on mobile phones which makes its potential severity even greater, highlight the need for investigating its implications on human behaviour.

The current study aimed to look into attentional biases triggered by gambling and Facebook/Internet related stimuli and highlight any similarities and differences to the gambling addiction. Similarities between the two could provide further evidence that non-substance addictions are associated to attentional bias. Furthermore, and more interestingly, any potential differences could help formulate novel research questions to explore addiction even further. The task used was , a Facebook/Internet modified Stroop, similar to the gambling modified Stroop in Experiment 1.The hypothesis was that participants will be slower at reporting the colour of Facebook and Internet related stimuli (salient) compared to neutral stimuli.

Experiment 2: Method

Participants

Seventy-four Psychology students from the University of Kent took part in this experiment (8 males and 66 females). Age varied from 18 to 34 (*M* = 19.20, *SD* = 2.00). Participants were recruited via the Kent Psychology RPS website and received course credits.

Design

This was a within-subjects design with Image(Facebook, Internet) and Salience(Salient, Neutral) as the independent variables and the colour naming reaction time (RT) as the dependent variable.

Materials

Hardware and Software. For the temporal bisection task, the images were presented on a 19-inch monitor (1,024 x 768, 60Hz) connected to an Intel i5 powered PC. The software used to present the stimuli and collect the responses was Psychopy v1.83 (Peirce, 2009). Standard keyboard and mouse were used to input responses and all images were presented in grey background.

Visual Stimuli. In total, 20 images were used in this experiment: 5 Facebook salient (FS), 5 Facebook matched (FM), 5 Internet salient (IS) and 5 Internet matched (IM). Initially, five images related to Facebook were selected and used as reference to create five matching images. These matching images had similar geometrical features as the five Facebook ones. Similarly, we selected five images related to the use of Internet (e.g. email icon) and proceeded with creating five matching images as described above. Furthermore, in order to avoid colour saliency issues between stimuli all matching images had similar colour and luminosity means. This was checked using Photoshop® and independent online tools (e.g. http://mkweb.bcgsc.ca/color-summarizer). The dimensions of all images were 300 x 300 pixels. All of the above images were then converted to 256 greyscale. Adobe Photoshop ® was then used to apply four different filters similarly to Exp1. These were red (255, 0, 0), green (0, 255, 0), blue (0, 0, 255) and yellow (255, 255, 0) with 40% opacity. This resulted in a total of 80 images, for detailed stimuli see Appendix B. Furthermore, the" office equipment" stimuli from Exp1 were used during the Stroop training phase.

***Young's Internet Addiction Test* (YIAT)**. Young's IAT (1998) was used in order to measure the severity of problems caused by the use of Internet. This is a 20-item questionnaire (e.g., '*How often do you find that you stay online longer than you intended?*') with five-point Likert scale items 5-point scale: 1, *rarely;* 2, *occasionally*; 3, *frequently*; 4, *often*; 5, *always* (0, *not applicable*), see Appendix C. The items measure the impact of the Internet on sleeping pattern, feelings, social life, productivity, and daily routine. Scores can range from 0 to 100 with the author suggesting four different severity groups. For scores of 0-30 the use of Internet is average and non-problematic, scores of 31-49 mild Internet addiction, 50-79 moderate Internet addiction, 80-100 severe Internet addiction causing significant problems. However, these cut-off points have been arbitrarily selected and are not based on empirical evidence (D. J. Kuss, Griffiths, Karila, & Billieux, 2014). An alternative cut-off point at 51 has also been proposed by Stavropoulos, Alexandraki, and Motti-Stefanidi (2013). The questionnaire has been found to have moderate to good internal consistency with Cronbach's alphas ranging from .54 to .82 (Chang & Man Law, 2008; Khazaal & Billieux, 2008). The YIAT was completed online at the Qualtrics website (Qualtrics ©, http://www.qualtrics.com, 2015). Similarly, to the paper version, all questions were presented in one block and participants had to click on the response of their choice.

The Compulsive Internet Use Scale (CIUS). The CIUS (Meerkerk, Van Den Eijnden, Vermulst, & Garretsen, 2009) is a brief questionnaire designed to assess the severity of compulsive Internet use. It contains 14 items (e.g., ‘do you find it difficult to stop using the Internet when you are online?’) with a 5-point scale: 0, *never;* 1, *seldom;* 2, *sometimes*; 3, *often*; 4, *very often*, see Appendix D. Similarly, to the paper version, all questions were presented in one block and participants had to click on the response of their choice. It has been found to have high internal consistency with Cronbach’s alpha at .89 and has been adapted to assess a variety of Internet related addictions (Meerkerk et al., 2009; Nele Nyenhuis, 2013). However, one of the limitations of this instrument is the lack of cut-off points (D. J. Kuss et al., 2014).

The Facebook Compulsive Internet Use Scale (FCIUS). A modified version of the CIUS was used in order to assess the Compulsive Use of Internet. Similar questionnaires have been developed in the past by replacing the key terms in the questionnaire (e.g., “Internet”) with a more appropriate one (e.g., “World of Warcraft”). In this case the new key term was “Facebook” (e.g., ‘do you find it difficult to stop using Facebook when you are online?’). For details see Appendix E.

Procedure

The procedure for this experiment was identical to Exp1. The key difference was the number of trials during the testing phase. There was a total of 240 trials, three repetitions of 80 unique trials that were randomly presented. The task was the same as in Exp1, participants had to report the colour of the stimulus, by pressing the corresponding key, and ignore the content. This had to be done as quickly and accurately as possible. Upon completion of the Stroop task participants had to complete the online questionnaires (Qualtrics ©, http://www.qualtrics.com, 2015).

Experiment 2: Results

Stroop Data Preparation

Prior to the data analysis, the first trial and all other trials with incorrect responses for each participant were removed. This resulted in dropping 74 first trials and 910 trials with incorrect responses (originally 17,760 trials, 5.12% incorrect responses). Furthermore, all trials with response time outside ±3SD's based on each participant and condition specific mean were also removed. This resulted in dropping a further 287 trials leaving 16,489. Finally, any trials with responses faster to 300ms were removed which resulted in a final sample that contained 16,446 trials (the overall reduction from original sample to final sample was 7.40%).

Analysis of Errors

A two-way analysis of variance for ratio of errors over total trials was conducted with Image (Facebook, Internet) and Salience (Salient, Neutral). Both the main effects and the interaction were non-significant, all *F*'s < 2.59 and all *p*'s > .112.

Reaction Time Analysis

The mean correct reactions times (RT) were entered into a two-way ANOVA including Image (Facebook, Internet) and Salience (Salient, Neutral). There was a significant main effect of Salience, $F(1, 73) = 5.692$, $p = .020$, $\eta_p^2 = .072$, with observed power (1-β) = .95 (α = .05). This is in line with our hypothesis as it indicates higher RTs for Salient stimuli compared to Neutral (Salient: *M* = 804.33ms, *SD* = 15.71ms; Neutral: *M* = 789.99, *SD* = 15.44ms). There was no significant main effect of Image, nor a significant Image x Salience interaction (both *F*'s < 0.532, *p* > .468).

Fast and Slow Effect Analyses

Furthermore, correct reaction times were also analysed in terms of fast (current Neutral with previous Neutral vs. current Salient with previous Neutral) and slow effects (current Neutral with previous Salient vs. current Neutral with previous Neutral). For this purpose, a two-way ANOVAs was ran with Current trial (Neutral, Salient) by Previous trial (Neutral, Salient). As expected from the above reaction time analysis there was significant main effect of Current trial, $F(1, 73) = 5.76$, $p = .019$, $\eta_p^2 = .073$, with observed power (1-β) = .95 (α = .05). Furthermore, there was a main effect of Previous trial, $F(1, 73) = 5.67$, $p = .020$, $\eta_p^2 = .072$, with observed power (1-β) = .95 (α = .05), indicating a reinforcing carry over effect when the previous stimulus is Salient compared to when the previous is Neutral (Previous Salient: *M* = 804.00ms, *SD* = 9.92ms; Previous Neutral: *M* = 790.00, *SD* = 9.64ms). The above result suggests that attentional bias effects triggered by the presence of a previous Salient stimulus, also known as *slow effect*.

Questionnaire Analysis

The YIAT scores varied from 5 to 60 (M_{YIAT} = 28.32, SD_{YIAT} =12.33, Cronbach α = .912). Twenty-five participants had scores between 30 and 49 and were, and five had scores between 50 and 79. There were no participants with scores higher than 80 that would indicate significant problems due to use of Internet (Young, 1998). The CIUS means per participant varied from 1 to 3.93 (M_{CIUS} = 1.9, SD_{CIUS} =0.61, Cronbach α = .905). The FCIUS means per participant varied from 1 to 4.21 (M_{CIUS} = 2.25, SD_{CIUS} =0.65, Cronbach α = .902). Furthermore, correlational analysis was carried out between the YIAT, CIUS, FCIUS scores and the attentional bias scores (*salient –matched)* in RT. All correlations between attentional bias scores and each of the questionnaires were non-significant (*r*'s < .124, *p*'s > .169). As expected the questionnaires were highly correlated (all *p*'s < .001; YIAT-CIUS: *r*(74) = .78, YIAT-FCIUS: *r*(74) = .45, FCIUS-CIUS: *r*(74) = .54). Finally, in order to see if there were any differences between participants who scored high in the questionnaires versus participants who scored low, groups were created based on cut-off points for all three questionnaires, using a median split. Furthermore, specifically for the YIAT an extra cut-off point was created separating participants who scored more than 51 and less than 51, this value has been identified as a second potential cut-off point instead of 71 (Chang & Man Law, 2008; Khazaal & Billieux, 2008). All the above two-way ANOVA's (Salience, Group) revealed non-significant effects (all *F*'s < 1, *p*'s > .367).

Experiment 2: Discussion

The aim of the current experiment was to show that Internet and Facebook related stimuli (referred to as salient) could cause attentional bias effects. Specifically, the hypothesis was that participants would be slower at responding the colour of salient stimuli compared to neutral ones. The results indeed revealed slower colour naming for salient stimuli compared to neutral stimuli. Similarly to Experiment 1 with the gambling stimuli, this is in line with previous research (Boyer & Dickerson, 2003a; Brevers et al., 2011; Cox et al., 2006a) and provides evidence that addiction related stimuli can impact attention. It should be noted though that only a very small number of participants scored moderately high in the addiction questionnaires, and group comparison between high scoring and low scoring participants revealed non-significant results. One could argue that these results should not be attributed to addiction related stimuli and other explanations should be sought after. A possible explanation here could be that participants use excessively the Internet and Facebook on a daily basis and that has led to related stimuli becoming emotionally salient.

This emotional impact of Facebook and Internet related stimuli (salient) could explain the differences in RT and also the fast and slow effect. Indeed, in Experiment 2 we had some distinct findings in comparison to Experiment 1. Contrary to Experiment 1 where we only had fast effects, in Experiment 2 both slow and fast effects were found. This means that the stimuli were salient enough to activate an interference process in the colour naming of the current neutral trial (fast effect). Furthermore, a previous salient trial can attract one's attentional resources to the extent that a disengagement process is activated affecting the colour naming of current neutral trials (slow effect). This provides some initial evidence that Internet and Facebook related stimuli can trigger attentional bias even in non-problematic users.

However, it could be argued that the observed effects, are merely effects of familiarity, especially in Experiment 2, as the participant encounter the salient stimuli used on a daily basis. This is a plausible argument that future research needs to address. A second limitation of this study could have to do with the nature of the Stroop task itself. It is ideal for detecting attentional conflicts, and even though some of the results hinted possible arousal effects perhaps future research should use paradigms more suitable of investigating the role of arousal as well.

Chapter Conclusion

Despite its limitations, this study discovered similarities and differences in attentional biases caused by gambling and Facebook/Internet related stimuli. Both types of stimuli (gambling, Internet/Facebook) seem to trigger a disengagement process that carries over to the trial that follows salient stimuli. More so in the Facebook/Internet paradigm as in the gambling one two salient stimuli are required. This could be due to Facebook and Internet having a substantial role in our life therefore becoming part of our emotional associations, at least to a greater extent than the emotional impact of gambling stimuli for the Poker players. Furthermore, in the Facebook/Internet paradigm a fast interference effect was observed, but not in the gambling paradigm. This could indicate that Facebook/Internet stimuli are highly relevant to us as suggested by (Schimmack, 2005).

Chapter 3 : THE EFFECTS OF GAMBLING RELATED STIMULI ON THE TIME PERCEPTION OF GAMBLERS AND NON-GAMBLERS

The previous chapter explored whether addiction related stimuli (gambling, Internet, Facebook) could cause attentional bias effects. It was found that all three types of stimuli could be associated with Stroop effects. However, there were also questions on whether arousal effects were also present, in particular for the gambling related stimuli. Furthermore, there were indications that gambling related stimuli were possibly not perceived as threatening. The aims of this chapter are to explore whether gambling related stimuli could be perceived as threatening, and to better discern whether such stimuli could have arousal and/or attentional effects. Indeed, in chapter 2 we did not detect a Stroop *slow* effect, indicating that gamblers might not have associated gambling stimuli with negative consequences. In order to further explore this, we will manipulate the level of perceived threat by presenting stimuli associated with different chances of winning or losing. Thus, by manipulating the level of threat we aim to explore whether temporal distortions, different for each level of threat will appear.

Experiment 3: Introduction

One cognitive model that can predict distinct attentional and arousal effects is the *internal clock* model (ICM) that was originally posited by Gibbon (Gibbon, 1977, 1991; Gibbon, Church, & Meck, 1984). Gibbon in his *scalar expectancy theory* (SET) proposed a model that involved a *clock stage,* a *memory stage,* and a *decision stage* as already detailed in Chapter 1.

In brief, to draw the cognitive connections between different clock stages, attention, arousal, and memory process I will summarise the ICM. The *clock stage* consists of three components, the *pacemaker*, the *mode switch*, and the *accumulator.* The *pacemaker* is producing pulses at a certain rate that could be affected by *arousal*. The *mode switch* that allows the pulses to reach the *accumulator*. However, when we get distracted the *mode switch* switches to off resulting in a number of pulses not reaching the *accumulator*. Therefore, *attention* is a crucial component for the switch to stay on. In the case of external events distracting us, the *mode switch* opens and a number of pulses do not reach the *accumulator*, which is the next component of the *clock stage.* The *memory stage* is holding mental representations of past temporal experiences and the *comparator* in the *decision stage* is assessing to what extent our current temporal experience is similar to past ones.

This distinct *stage* approach allows us to isolate individual components which are sensitive to context and can result in distorted time perception (Sylvie Droit-Volet & Gil, 2009). Indeed, this perceptual distortion is not a result of a faulty clock model but more so of the clock's ability to adjust to current experience. This makes time perception a valuable tool in investigating emotion, attention, and arousal effects. Specifically, any arousal effects should affect the *pacemaker* and any attentional effects should affect the *mode switch*.

Previous research in time perception has demonstrated that increased arousal can directly affect the *pacemaker* thus resulting in overestimating time duration of temporal events (Casini, 2001). Furthermore, a number of researchers have demonstrated that arousal, due to negative emotions in particular, can affect our time perception (e.g., S Droit-Volet, Fanget, & Dambrun, 2015; Sylvie Droit-Volet & Meck, 2007; Kramer, Weger, & Sharma, 2013; Tipples, 2008, 2011; Tipples, Meck, Cheng, & Narayanan, 2016). The above findings are suggesting that threatening stimuli could elicit negative emotions and that arousal effects could be causing the distorted time perception. Mella, Conty, and Pouthas (2011) provided more evidence to support this claim by using physiological measures of arousal. Specifically, they used skin conductance response (SCR) together with emotional regulation and found that participants were perceiving the duration of highly arousing stimuli to last longer.

Even though Wittman et al. (2007) have demonstrated that participants who were dependent on stimulants had impaired time perception no similar research has been conducted to investigate the effects on non-addiction related stimuli on time perception, especially using the temporal bisection task (TB). With this experiment (Experiment 3), I aim to examine whether gambling related stimuli could lead to distortions in the perception of time for gamblers. Any potential such findings could provide further support to the work discussed in the previous chapter. A further aim was to investigate whether the above effects could be due to attentional or arousal effects.

The TB (for more details see method section below) has been found to consistently detect distortions in our time perception when we are exposed to salient stimuli (Sylvie Droit-Volet, Bigand, Ramos, & Bueno, 2010; Sylvie Droit-Volet & Meck, 2007a; Tipples, 2011; Wittmann, Leland, Churan, & Paulus, 2007). Participants were either gamblers or non-gamblers and the TB was modified to include gambling and non-gambling (neutral) related stimuli. Specifically, poker related stimuli were chosen as the gambling stimuli because the participants for the gambling group were members of Poker Society at the University of Kent. The hypothesis was that gamblers would exhibit distorted time perception, where as non-gambler would not. Specifically, and following from the findings in Experiment 2, our first hypothesis was that gamblers would underestimate time for gambling stimuli compared to neutral stimuli (result of attentional effects). Furthermore, the overestimation should exist in non-gamblers. Our second hypothesis was that gamblers would exhibit better temporal discriminability compared to non-gamblers as an effect of increased arousal from being exposed to gambling stimuli.

Experiment 3: Method

Participants

Forty-five participants were recruited for this experiment, 20 for the Poker condition (all males, M_{age} = 20.45, SD_{age} = 4.03) and 25 for the Control condition (six males, 17 females, 2 did not disclose gender, M_{age} = 20.26, SD_{age} = 3.99). All participants were students at the University of Kent and were recruited using two separate methods. For the Poker condition, the experiment was advertised at the Poker Society of the University of Kent and each participant was offered a free entry to a Poker tournament with a trophy of £100 to be distributed to the top three players. The typical entry to similar tournaments of £100 with a player pool of up to 30 players is usually £3. For the control condition, the experiment was advertised at the RPS website, as mentioned in previous chapters, and each participant was awarded 2 credits. The compensations for the two conditions were matched to approximate 30 minutes of work.

Design

This was a mixed design experiment defined by Group (Poker, Control) x

Image (Gambling(G), Neutral(N)) x Duration (400, 600, 800, 1000, 1200, 1400, 1600ms). Group was a between-subjects factor; Image and Duration were within-subjects factors. Participants had to report the duration of presented events as either *long* or *short*. These responses were used to calculate the dependent variable of *p(long)* as the proportion of *long* responses over the total number of trials. The *p(long)* responses were further used to obtain the Bisection Point (BP) and the Weber's Ratio (WR) psychometrics. More details on BP and WR are provided below at the results section.

Materials

Hardware and software. The study was conducted in the labs of the School of Psychology where each participant was alone in an individual cubicle. The experiment was presented on a Psychology department Dell desktop computer with a 19 inches monitor (4:3 factor). The custom computer software used to present the stimuli was programmed in Psychopy v1.83 (Peirce, 2007, 2009).

Visual stimuli. For this experiment, we used a reduced subset of images from Exp1. From all the gambling related stimuli, only the ones directly related to Poker were used, together with their Matched Neutral items. This was due to the possibility that Poker players might have not been familiar with other gambling activities. These resulted in three Gambling stimuli and three Neutral stimuli[2].

Questionnaires.

DSM-IV gambling criteria based scale (APA, 1994). We used a questionnaire based on the DSM-IV criteria. This questionnaire was used during British Gambling Prevalence Survey in 2007 (for more information on BGPS read Orford, Wardle, Griffiths, Sproston, & Erens, 2010). The questionnaire included ten items and asked the participant to think of activities and behaviours for the past 12 months. An example of an item was "*Have you needed to gamble with more and more money to get excitement you are looking for?*". The response options were "never", "occasionally", "fairly often", and "very often". These options were scored with 0, 1, 2, 3 respectively. The first item was asking whether a participant would go back another day to win the money they lost. The response options for this item were "Every time I lost", "Most of the time I lost", "Some of the time I lost", and "Never".

[2] Comparing across stimuli did not reveal any item differences within Gambling and Neutral sets.

These options were scored with 3, 2, 1, 0 respectively. DSM-IV was found to have satisfactory internal validity, *Cronbach's α* = 0.78 (Orford et al., 2010). For detailed items see Appendix F.

Problem Gambling Severity Index (PGSI; Ferris & Wynne, 2001). Similarly to the DSM-IV questionnaire, the PGSI was asking participants how often they would exhibit a behaviour in the past 12 months. An example of an item was "…*have you borrowed money or sold anything to get money to gamble?*". The response options were "Never", "Some of the time", "Most of the time", "Almost always" and were scored with 0, 1, 2, 3 respectively. The PGSI was found to have good internal validity during the BGPS, *Cronbach's α* = 0.90 (Orford et al., 2010). For detailed items see Appendix G.

Gambling Craving Scale (GACS) by Young and Wohl (2009)**.** The GACS was developed in order to assess craving to gamble. It is a 9-item scale and includes three factors. *Anticipation*, example item "Gambling would be fun right now." *Desire*, example item "I have an urge to gamble." *Relief*, "Gambling would make me less depressed.". Participants had to respond on a 7-point scale (1-*strongly disagree* to 7-*strongly agree*). All three subscales demonstrated good reliability with *Cronbach's* *α* = 0.84, *α* = 0.81, *α* = 0.85, respectively. For detailed items see Appendix H.

Procedure

Once participants were recruited, they were instructed to arrive at a Psychology lab at the University of Kent. After being briefed and providing consent, each participant completed the experiment in individual cubicles. The experiment was comprised of a temporal durations training phase, a testing phase, and finally a questionnaires phase. During the training phase, participants were instructed that the first two tasks were training tasks and that the experimenter would stay in the cubicle in order to provide further instructions if needed. Participants were told that the purpose of the training tasks was to introduce them to the "*short*" (400ms) and "*long*" (1600ms) standards. This would have provided them with sufficient training to discriminate between them 400 and 1600ms.

During the first training task, it was explicitly mentioned that a single image would be shown over the course of the "*short*" and "*long*" standards. The image would be presented in a fixed alternating short-long order and that the participant would have to respond "*short*" (by pressing "s") or "*long*" (by pressing "l"). After each response, feedback (“correct” / “incorrect”) was displayed on the centre of the screen for 1 second. Consequently, a randomly varying inter-trial interval (0.5s to 1.5s) would follow. During the second training task, the same image was presented on the screen either for 400ms or 1600ms, but in a random order. The second training task lasted until the participant produced eight consecutive correct responses. Again, feedback (“correct” / “incorrect”) was provided after each response.

Once the second training task was completed, instructions regarding the test phase were displayed on the screen. The instructions informed the participants that more stimuli would be presented in varying durations and they would have to respond whether these durations were closer to “*short*” or “*long*”. The experimenter would ask the participant if he/she was happy with the instructions and then leave the cubicle before the test phase would start. During this task six images (three gambling, three neutral) would be presented for seven durations (400, 600, 800, 1000, 1200, 1400, 1600ms) in random order. This was repeated fort three blocks resulting in 126 trials (three blocks of 42 trials each). During the test phase participants had to respond “*short*” or “*long*” again but with no with no feedback following their responses. Once this task was finished participants had to answer the experiment questionnaires and then were fully debriefed and thanked for their participation.

Experiment 3: Results

Data Preparation and Analysis

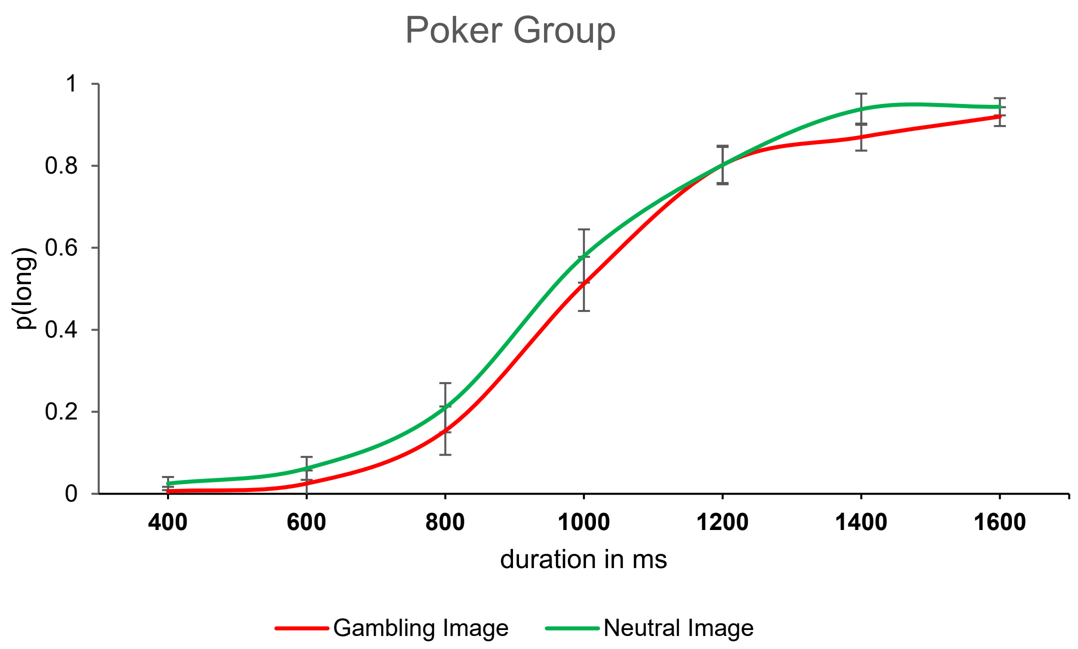
Initially the mean proportion of long responses, *p(long)*, was calculated for each participant and type of image. Furthermore, *probit* analysis was used to calculate the Bisection Point (BP) and the Weber’s Ratio (WR). The p(long) value is calculated as the ratio of “long” responses divided by the total number of responses and it is a first indication on whether there was an overestimation or underestimation of the time intervals per duration. The BP indicates at which duration each participant was crossing the threshold to pressing “*long*” over “*short*” response. BPs were calculated by running *probit* analysis and acquiring the values for probabilities equal to .5 or *p(50)*. The WR is a measurement of discriminability and is the ratio of half the difference between p(75) and p(25) divided by p(50), for more details read Droit-Volet and Rattat (2007). In this case WR indicates the minimum time interval in durations that a participant would be able to detect. Therefore, the smaller the WR the better a participant would be at detecting smaller changes in durations. Furthermore, the BP value was used as an exclusion criterion for filtering out participants that were not performing as instructed. Any participants with BP below 400 or above 1600 were consistently removed in all the experiments and prior to carrying out the analysis of variance, as described in (Gonidis & Sharma, 2017). In Exp3 four participants, all from the Control Group, were removed for violating the BP criterion. One more participant from the Poker Group was removed as he/she did not complete the Temporal Bisection task, resulting in 40 participants.

P(long) Analysis

The *p(long)* values were entered into a three-way analysis of variance including Duration (400, 600, 800,1000, 1200, 1400, 1600ms), Image (*G*, N) and Group (Poker, Control). As expected, there was a main effect of Duration, F (1, 38) = 343.725, p < .001, η_p^2 = .9, with observed power (1-β) = 1.00 (α = .05), indicating that participants were significantly reporting higher p(long) as the duration of the stimuli increased (*Means* respectively for 400 to 1600ms: .020, .085, .289, .585, .788, .892, .934). There were no other main effects (all *F's* < 2.134 and *p*'s > .152). There was a significant Image x Group interaction, F(1, 38) = 11.104, p = .002, η_p^2 = .226, with observed power (1-β) = 0.90 (α = .05). Follow-up post-hoc analysis with Bonferroni corrections revealed a simple effect of Image for the Poker Group indicating an underestimation for the Gambling stimuli (*M* = .47) compared to the Neutral stimuli (*M* = .51), see Figure 5. (**All subsequent post-analyses and pairwise**

comparisons will be with Bonferroni correction unless stated otherwise).

Finally, there was a significant Duration x Group interaction, *F* (1, 38) = 4.362, $p <$ .001, η_p^2 = .103, with observed power (1-β) = 0.99 (α = .05). The two groups performed significantly different at 600ms (Poker, *M* = .043, *SD* = .025; Control, *M* = .126, *SD* = .023) and at 800ms (Poker, *M* = .182, *SD* = .057; Control, *M* = .396, *SD* = .051).



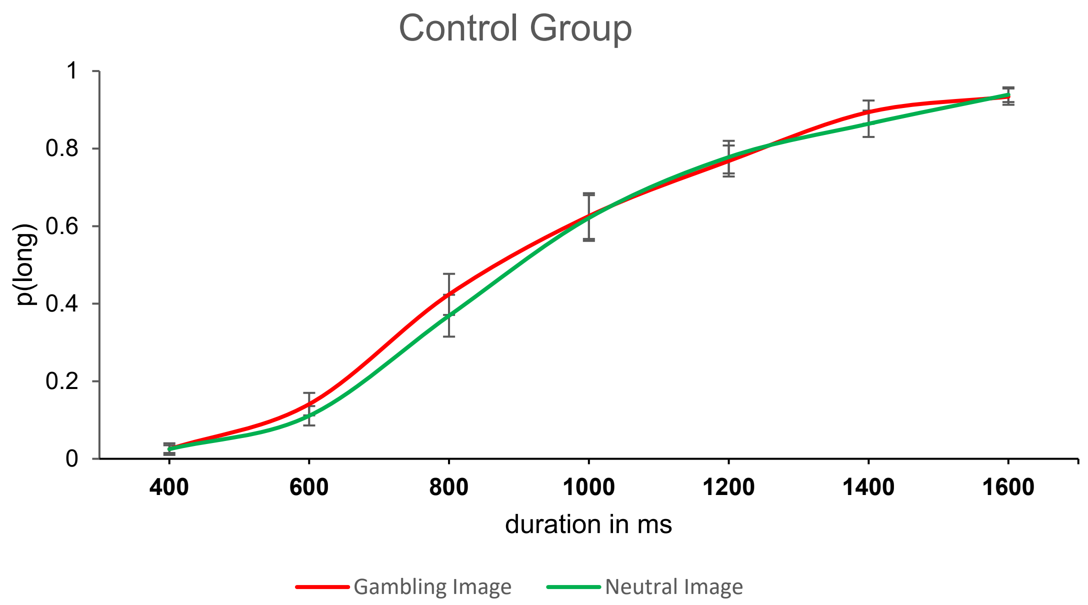


Figure 5 p(long) performance for the Poker and control group. Smoothing of the lines was carried out by the Excel smooting algorithm (as for the rest of the figures in this thesis).

BP Analysis

The BP values were entered into a two-way analysis of variance including Image (*G*, N) and Group (Poker, Control). There was no main effect of Image, F (1, 38) = 2.08, p = .158. There was also no main effect of Group, F (1, 38) = 1.74, p = .196. However, there was a significant interaction between Image and Group, F (1, 38) = 10.62, p = .002, η_p^2 = .218, with observed power (1-β) = 0.89 (α = .05), (see

Figure 6). Further pairwise comparisons with Bonferroni adjustment revealed a significant simple effect of Image for the Poker condition (*p* = .003, Gambling: *M* = 1050.44ms, *SD* = 136.52ms, Neutral: *M* = 991.21ms, *SD* = 138.29ms). There was no simple effect of Image in the Control condition (*p* = .184, Gambling stimuli: *M* = 937.55ms, *SD* = 201.18ms, Neutral stimuli: M_N = 960.45ms, SD_N = 203.00ms).

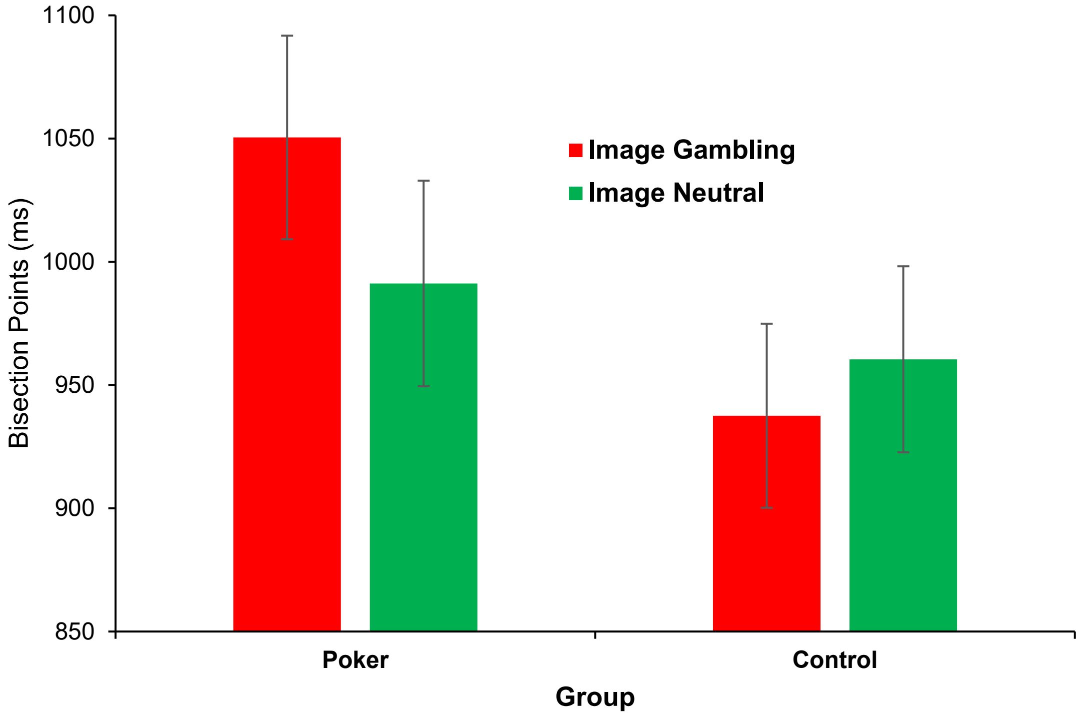


Figure 6 BP differences between the Gambling and Neutral Stimuli for the Poker and control group

These findings are in line with our hypothesis that Poker players would significantly underestimate time for Gambling stimuli compared to Neutral stimuli and no such effect would be observed in the Control Group.

WR Analysis

A two-way analysis of variance was carried out on the WR scores including Image (G, N) and Group (Poker, Control). There was a main effect of Group, F (1, 38) = 4.90, p = .033, η_p^2 = .114, with observed power (1-β) = 0.63 (α = .05), with Poker Group participants demonstrating significantly lower WR scores (Poker Group: *M* = .158, *SD* = 0.08, Control Group: *M* = .216, *SD* = 0.08). There was no main effect of Image nor a significant interaction (all *F*'s < .217 and *p*'s > .644). These findings suggest that Poker players have an overall better time discriminability, which could be due to increased arousal.

Questionnaires Analysis

We calculated the means for the three questionnaires, DSM-IV, PGSI, and GACS. Furthermore, we also calculated the means for the three factors of the GACS which are Anticipation, Desire, and Relief. The above means were entered in one-way ANOVA with Group (Poker, Control) being the between factor. There were significant main effects of group in DSM-IV: F (1, 39) = 7.584, p = .009, η^2= .17, with observed power (1-β) = 0.79 (α = .05); in PGSI: F (1, 39) = 10.759, p = .002, η^2= .22, with observed power (1-β) = 0.91 (α = .05); in GACS: F (1, 39) = 8.582, p = .006, η^2= .18, with observed power (1-β) = 0.82 (α = .05); in Anticipation: F (1, 39) = 13.001, p = .001, η^2= .25, with observed power (1-β) = 0.94 (α = .05),; in Desire: F (1, 39) = 5.624, p = .023, η^2= .13, with observed power (1-β) = 0.92 (α = .05),. There was no main effect of Group in Relief, F (1, 39) = 0.398, p = .532, η^2= .01 (for means and standard deviation see table 1). As expected, the Poker Group participnats scored significantly higher than the Control Group participants. The only exception was in the Relief factor as no significant differences were observed.

Table 1

Means and Standard Deviations per Questionnaire/Factor and Group

Table 3-1. **Means and Standard Deviations per Questionnaire/Factor and Group**

	Group	
Questionnaire/Factor	Poker	Control
DSM-IV	0.72 (0.33)	0.46 (0.25)
PGSI	0.65 (0.25)	0.44 (0.16)
GACS	2.96 (0.74)	2.26 (0.77)
Anticipation	4.89 (0.67)	3.52 (1.50)
Desire	1.93 (0.90)	1.39 (0.50)
Relief	2.07 (0.93)	1.86 (1.14)

Note. Numbers in brackets represent standard deviation

Correlational Analysis

We calculated the differences in BP and WR indices between Gambling and Neutral stimuli. Then in order to investigate for possible relations between the explicit scores (questionnaires) and the implicit measures (TB task) we ran correlational analysis for all the above. The results are presented in Table 2.

Table 2

Corellations Between Implicit and Explicit Measures

Table 3-2. Correlations Between Implicit and Explicit Measures

	dBP	dWR	DSM	PGSI	GACS Overall	GACS Anticipation	GACS Desire	GACS Relief
dBP		.246	.285	.285	**.406****	.292	**.390***	.305
dWR			.186	-.063	- .105	-.002	-.244	-.072
DSM				.916**	.547**	.428**	.550**	.346*
PGSI					.584**	.459**	.616**	.346*
GACS Overall						.816**	.766**	.762**
GACS Anticipation							.428**	.323*
GACS Desire								.548**
GACS Relief								

Note. Numbers in bold represent the only two significant correlations between implicit and explicit measures.

**p* < .05. ***p* < .01

As expected, the Gambling questionnaires are significantly correlated (DSM, PGSI, GACS). Furthermore, dBP significantly correlates with GACS and GACS *Desire*.

Experiment 3: Discussion

The aim of this experiment was to investigate the effects of gambling related stimuli on time perception, specifically on individuals with gambling habits. Furthermore, following up from the findings in Chapter 2, we wanted to have a greater insight on whether these potential intrusion effects would be due to arousal, attention or both. Our hypotheses were that gamblers would underestimate time for gambling stimuli compared to neutral stimuli, whereas non-gamblers would not exhibit similar behaviour. The findings from Experiment 3 suggest that gambling related stimuli could lead to distorted time perception in gamblers, as predicted by the internal clock model.

Indeed, gamblers demonstrated higher BP for gambling stimuli compared to neutral ones. This is associated with an underestimation of time intervals for gambling stimuli compared to neutral stimuli, no such effect was found for non-gamblers. This underestimation of time could be due to attentional effects associated with the salient stimuli as predicted by the mode switch. As participants were exposed to salient stimuli, their attention was divided between the temporal estimation task and the visual content. This salient information could initiate an elaborate intrusion cycle as proposed by Kavanagh et al., (2005). This intrusion cycle would open the mode switch resulting in a number of generated pulses being lost leading to an underestimation of time. As a result, gamblers exhibited a delayed closure of the switch due to attending the gambling content and failing to attend to time. This relation between the AB and the elaborate intrusion is also supported by the positive association between the difference in BP between gambling and neutral stimuli and the overall GACS and Desire scores. As the elaborate intrusion takes place, desire thoughts are activated that further reinforce the effects of external cues. This strongly suggests that gambling stimuli are associated with attentional bias affects in gamblers and further supports our finding in Chapter 2.

As mentioned earlier we were also interested in exploring whether the *interference* effects we detected in Chapter 2 were due to attention, arousal, or both. The WR analysis results clearly suggest that besides attention related effects we also have arousal effects. Indeed, gamblers demonstrated significantly lower WR values compared to non-gamblers in both experiments, thus having better temporal discriminability. One possible explanation for this enhanced discriminability is increased arousal. The calculation for WR incorporates the first and third quartile of responding *long* (first quartile: 25% chance of answering *long*; third quartile: 75% chance of answering long). Lower WR values are associated with steeper gradient graphs can be a result of increased arousal. This is in line with previous findings on stimuli that can increase our arousal, such as threatening stimuli (Allman et al., 2012; Sylvie Droit-Volet & Meck, 2007b; Gil & Droit-Volet, 2012b; Tipples, 2008, 2011; Tipples et al., 2016). Furthermore, it supports our claim in Chapter 2 that gamblers' overall smaller RT in the Gambling modified Stroop could have been due to increased arousal.

In conclusion, with this novel gambling modified TB paradigm we demonstrated that gamblers, when exposed to gambling related stimuli can gain better temporal discriminability as a result of increased arousal. Moreover, gamblers would underestimate durations for salient stimuli compared to neutrals ones, whereas non-gamblers would exhibit very similar temporal perception for both types of stimuli.

Experiment 4: Introduction

In the previous experiment we clearly showed that gambling related stimuli can distort gamblers' time perception due to both arousal and attentional effects. This adds more detail to our existing findings from Experiment 1 and 2 where the Stroop Effects could not discriminate between arousal and attentional effects. Thus, already demonstrating that the TB task can provide more insights in the study of non-substance addiction than the already applied Addiction modified Stroop Test.

However, these temporal distortion effects could be attributed to a number of different reasons that could be related to the salient content of the stimuli. Previous research on time perception has shown negative and positive stimuli can affect our time perception differently. Droit-Volet, Brunot, and Niedenthal (2004) used the TB task in order to investigate participants' time perception when presented with emotional faces. Their findings suggest that there is a greater overestimation of durations for angry faces compared to happy or sad. This was attributed to angry faces being associated to high arousal compared to low arousal happy and sad faces. Contrary, Gable and Poole (2012) have shown that we tend to underestimate time when exposed to positive stimuli or having fun with a high approach motivation. Furthermore, they argued that approach motivation could be responsible for underestimating time more than increased arousal or attention distraction.

The above could be of great importance for the study of gambling behaviour as it could provide the means to provide experimental evidence on whether gambling related stimuli would trigger elaborate intrusion thoughts related past negative experiences (e.g., money loss) or related to positive past experiences (e.g., winning money). In this experiment (Experiment 4), we seek to find evidence that will discriminate between the two types of intrusive thoughts (negative vs positive). A sample gamblers and non-gamblers were presented with a poker modified TB. This time the stimuli were poker hand combinations and we manipulated the winning and losing chances of the participant versus a hypothetical opponent. Our hypothesis was that only gamblers would display distorted time perception for the winning and losing card combinations and not for the potential draw ones. Again, these anticipated distortions could have been a result of intrusive thoughts (negative or positive) or arousal and attentional effects. Specifically, if gamblers would overestimate time, it would be due to arousal effects from previous negative experiences (perceiving stimuli as threatening). Whereas if they found the experience of playing poker, they would underestimate time. We also hypothesised that non-gamblers should not display any distortions due to the lack of salience of the winning and losing scenarios for non-gamblers.

Experiment 4: Method

Participants

In total 63 participants were recruited for this experiment (34 Males, 28 Females, one did not report gender). The average age ranged from 18 to 37 (*M* = 21.26, *SD* = 3.45). For the gambling group, the recruitment took place in Grosvenor casino in Coventry during the UK student poker championship (6^{th} to 10^{th} of April, 2016) and participants were offered £3 for their time (28 Males, 2 Females, *M* = 21.72, *SD* = 1.81). For the control group, the recruitment took place at the University of Kent using the Psychology RPS website and participants were rewarded with 2 RPS course credits for their time (6 Males, 26 Females, *M* = 20.85, *SD* = 4.41).

Design

This was a mixed design experiment with Group (Poker, Control) as between-subjects factor and Hand Outcome (Very Probable Win, Close Win, Tie, Close Loss, Very Probable Loss) as within-subjects factor, see Materials for more details. The dependent measures were the mean proportion of “long” responses p(long), the Bisection Point (BP), and the Weber’s Ratio (WR). The p(long) value is calculated as the ratio of “long” responses divided by the total number of responses and it is a first indication on whether we have an overestimation or underestimation of the time intervals per duration.

Materials

Visual Stimuli. For the purposes of this experiment a collection of poker hands was created. The simulated game was Texas Hold’em Poker, where each player gets 2 cards that he/she can combine with five community cards (cards that can be used by all players). The combinations of hands were designed to represent different probabilities of win and loss. These combinations were, Very Probable Win(VPW): AAsd vs 49ch, KKhc vs 38ds, QQsh vs 28cd; Close Win(CW): 1010hs vs AKdd, 77cd vs A9hh, 99dc vs KQss; Tie(T): 55ch vs 55sd, 66hs vs 66dc, 88dc vs 88sh; Close Loss(CL): AKdd vs 1010hs, A9hh vs 77cd, KQss vs 99dc; Very Probable Loss(VPL): 49ch vs AAsd, 38ds vs KKhc, 28cd vs QQsh. For detailed expected win/lose probabilities see table 3-3.

Questions. Originally the experiment design included the DSM-IV, PGSI, and GACS questionnaires. In addition, there were also detailed demographic questions. However, due to casino's request to cause minimal interference to the poker players, the design had to be reduced to a 15 minutes experiment. That resulted in removing the questionnaires leaving only two questions: "*In the field below type in how many poker games you play week (both cash and tournaments, online or not).", "I play more than one poker games a week.*". For the first question they simply had to type in a number whereas the question was a Likert 5-point scale question (1: *Strongly Disagree* to 5: *Strongly Agree*).

Hand Strength Estimation and Confidence. All the hands from the temporal bisection task were also presented, one at a time, at the end of the experiment. This time the participants had to answer three questions. First, report the chances of winning in percentage, they did that moving a slider from 0% to 100%. Second, report their confidence in that % by answering the 5-point Likert scale question "*How confident are you about your above estimation?*", 1: "*Extremely confident*" to 5: "*Not confident at all*". Third, report whether they were feeling excited or intimidated by seeing this hand, "*To what extent you would feel excited about winning or intimidated about losing in the above hand?*". This was also a 5-point Likert scale question, 1: "*Very excited about winning*", 3: "*Neither excited nor intimidated*", 5: "*Very intimidated about losing*". The purpose of these questions was to check whether the hands were perceived as exciting or threatening as intended and whether players had a realistic perception of their winning/losing chances.

Procedure

Due to recruiting participants in two different places, procedure differed up to the moment of starting the temporal bisection task. In the casino, Poker players were approached by the experimenter and were asked whether they would be interested in taking part in an experiment that was part of a PhD research. Those who were interested were then escorted to a quiet room, were fully briefed and provided their consent. Participants at the University of Kent signed up on the RPS system as mentioned in the participants section. All participants were informed that they would have to complete a computerised task and a number of questions afterwards. The first two parts of the computerised task were similar to the temporal bisection training as was described in Exp3. The key difference was that the image was presented on the left and right of the centre of the screen at the same time, this was done to keep the training similar to the test phase that participants would see two images presented at the screen at the same time (their hand cards vs their opponent's hand). The instructions remained the same, participants had to report whether the duration of the event felt *short* or *long*. Next, participants received instructions for the test phase. The instructions were "*For the next session we would like you to imagine that you have moved all in preflop and your opponent has called. Both of you show your hands, your hand is on the left side of the screen and your opponent's on the right side. You will then be presented with the two poker hands on the screen, yours on the left side, your opponent's on the right side. This presentation of hands will have various durations. However, your task remains the same. Once the images are gone you will have to report whether the duration felt as short or long.*". The test phase included 105 trials, the 15 hand combinations that were mentioned in the materials each presented once per for each duration of 400, 600, 800, 1000, 1200, 1400, and 1600ms. Upon completion of the test phase participant reported their gender and age and completed the questions regarding the *hands* strength estimation and confidence (as mentioned in the relevant materials section).

Experiment 4: Results

Data Preparation and Group Differences

Based on their BP scores five participants were excluded from the analysis, three from the Control Group and two from the Poker Group. Initial analysis of how many games per week participants play, revealed three outliers for the Poker group. These three participants reported playing 999, 100, and 30 games per week. These three values were replaced with the closest higher value that was 10 games a week. One-way ANOVA on the number of games per week showed significantly higher number of games for the Poker group, $F(1, 55) = 50.21$, $p < .001$, $\eta_p^2 = .456$, with observed power (1-β) = 0.99 (α = .05) (Poker Group: $M = 4.38$, $SD = 3.32$, Control Group: $M = 0.21$, $SD = 0.60$). Furthermore, one participant in the control group reported playing three Poker games per week and it was decided to be removed from the sample. It should be noted though that analysis was run both including and excluding this participant and no significant differences were found.

Hand Winning Chances, Excitement and Confidence Scores

For each participant mean percentages of win were calculated per Hand Combination (for a summary see Table 3-3). These were then aggregated per Hand Outcome(HO) and were compared between groups and against the Actual %. Overall, the Poker group was much more accurate at judging winning odds compared to the control group, as one would expect from frequent players. Furthermore, excitement and mean confidence scores were calculated per participant and HO (for a summary of descriptive statistics see Table 3-3).

Excitement Scores Analysis. A two-way ANOVA for HO and Group on excitement scores revealed a main effect of HO, $F(2, 110) = 26.12$, $p < .001$, $\eta_p^2 = .303$, with observed power (1-β) = 0.99 (α = .05), indicating that participants were significantly more excited for the VPW hands ($p < .001$) compared to the TIE and VCL hands (VPW: $M = 2.17$, SD = 0.90; TIE: $M = 3.07$, SD = 0.69; VCL: $M = 2.94$, SD = 0.76, lower scores correspond to higher excitation). Furthermore, there were no significant differences between the excitement levels of TIE and VCL. Finally, there was no main effect of Group, nor a significant interaction of Hand by Group (F's < 1.64, p's > .198).

Confidence Scores Analysis. A two-way ANOVA for HO and Group on confidence scores revealed a main effect of HO, $F(2, 110) = 3.26$, $p = .042$, $\eta_p^2 = .052$, with observed power (1-β) = 0.67 (α = .05). Pairwise comparisons revealed that VPW cards were signicantly judged less confidently compared to VCL cards, $p = .013$. TIE cards confidence estimations were not significantly different to any of the other two HO (VPW: $M = 3.49$, SD = 0.91; TIE: $M = 3.36$, SD = 1.2; VCL: $M = 3.15$, SD = 0.93, lower scores correspond to higher confidence). There was also a significant main effect of Group, $F(1, 55) = 32.24$, $p < .001$, $\eta_p^2 = .389$, with observed power (1-β) = 0.99 (α = .05), with the Poker Group reporting less confidently compared to the Control Group (Poker: *M* = 3.84, SD = 0.85; Control: *M* = 2.83, SD = 0.91 There was also a significant interaction of HO by Group, $F(2, 110) = 6.09$, $p = .003$, $\eta_p^2 = .092$, with observed power (1-β) = 0.74 (α = .05). Further pairwise comparisons between HO for each Group revealed that Confidence estimations of VPW were siginificantly different to TIE and VCL for the Control Group (*p*'s < .23) (TIE and VCL were not significantly different). There were no significant differences in the Confidence estimations for the Poker Group (see Table 3-3). Furthermore, pairwise comparisons between Groups for each HO revealed that the two Groups differed significantly in their Confidence estimations in each HO (*p*'s < .25, see Table 3-3). Interestingly, the Control Group was reporting higher confidence across all HO. This could be an indication of Poker players putting more thought in judging winning outcomes or Control players judging more naively due to lack of expertise.

HP(long) Analysis Including All Five HO

The *p(long)* values were entered into a three-way analysis of variance including Duration (400, 600, 800,1000, 1200, 1400, 1600ms), HO (VPW, CW, TIE, CL, VPL) and Group (Poker, Control). As expected, there was a main effect of Duration, $F(6, 366) = 488.48$, $p < .001$, $\eta_p^2 = .89$, with observed power (1-β) = 0.99 (α = .05) indicating that participants were significantly reporting higher p(long) as the duration of the stimuli increased (*Means* respectively for 400 to 1600ms: .038, .127, .341, .634, .825, .887, .918). There was also a significant Duration by Group interaction, $F(6, 1344) = 2.44$, $p = .025$, $\eta_p^2 = .04$, with observed power (1-β) = 0.99 (α = .05). Pairwise comparisons revealed that the two Groups were only significantly different at 800ms, $p = .011$ (Poker: *M* = .220, *SD* = .02; Control: *M* = .352, *SD* = .02 , for more details see Figure 7). All other main effects and interactions were non-significant (*F*'s < 2.3, *p*'s > .133).

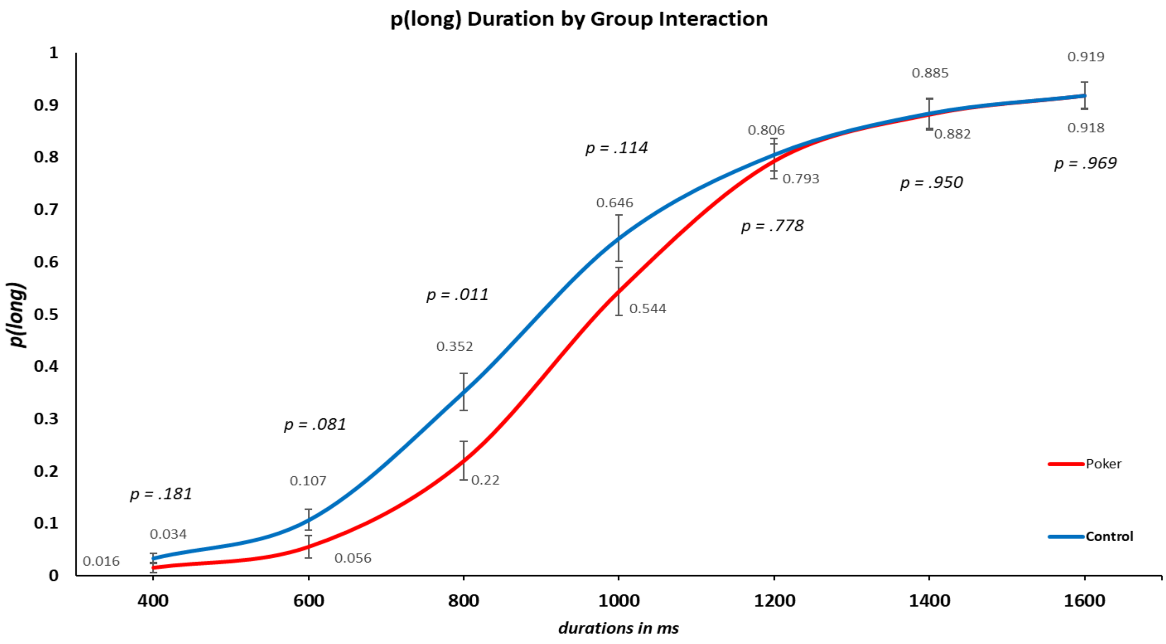


Figure 7. Duration by Group Interaction: Including p(long) mean values per duration and significance values pair comparison

Table 3-3. Objective and subjective % of win per hand, confidence, and excitation scores per group

		% of Win			Confidence***		Excitement-Intimidation****	
			Group		Group		Group	
Hand Outcome	Hand Combination	Actual	Poker	Control	Poker	Control	Poker	Control
VPW	AAsd vs 49ch	86.81	83.93	74.42*	3.72	3.30	2.07	2.21
	KKhc vs 38ds	86.94	85.14	75.42*	3.79	3.30	2.00	2.24
	QQsh vs 28cd	86.83	85.03	73.73*	3.72	3.09	2.00	2.48
Tie	55ch vs 55sd	2.16	17.86**	47.52*	4.10	2.73	3.10	2.94
	66hs vs 66dc	2.17	19.93**	46.82*	4.00	2.82	3.24	2.91
	88dc vs 88sh	2.17	17.97**	43.94*	4.10	2.39	3.10	2.94
VCL	AKdd vs 1010hs	45.92	48.17	57.76*	3.72	2.58	3.03	2.91
	A9hh vs 77cd	46.36	46.90	56.88*	3.72	2.48	2.93	2.91
	KQss vs 99dc	47.42	47.59	60.27*	3.69	2.73	3.00	2.85

*Control group predictions of % of win significantly differed from both the Actual % and from the Poker group predictions

**Poker group predictions of % of win differed significantly from the Actual % only for the Tie hands

***Higher scores indicate higher uncertainty/lower confidence

****Higher scores indicate higher feeling of being intimidated by the opponents cards

BP and WR Analysis All Five HO

Similarly, to Experiment 3 the BPs were calculated and the entered in to a two-way ANOVA including HO (VPW, CW, TIE, CL, VPL) and Group (Poker, Control). There were no main effects of HO or Group and the interaction was non-significant, all *F*'s < 1.27, *p*'s > .263. For descriptive statistics see Table 3-4. These results indicate that there were no time perception differences for the two groups.

Furthermore, the WR scores were also entered in to a two-way ANOVA including HO (VPW, CW, TIE, CL, VPL) and Group (Poker, Control). There was no significant main effect of HO nor a significant interaction both *F*'s < .16, *p*'s > .91. There was however, a significant main effect of Group, $F(1, 56) = 4.90$, $p = .031$, $\eta_p^2 = .08$, with observed power (1-β) = 0.88 (α = .05). With the Poker Group demonstrating better temporal discriminability ($M = .145$, $SD = .01$) compared to the Control Group ($M = .183$, $SD = .01$). This could be an indication of increased arousal effect, as it will be discussed further in the following experiment discussion.

Table 3-4. BP and WR means and standard deviations

	Poker		Control		Overall	
	BP	WR	BP	WR	BP	WR
VPW	982.56 (142.19)*	.148 (.081)	975.43 (179.57)	.183 (.114)	978.87 (161.23)	.166 (.100)
VCW	999.09 (162.78)	.145 (.087)	945.14 (139.96)	.181 (.198)	971.19 (152.50)	.164 (.155)
TIE	1002.20 (160.94)	.130 (.086)	940.08 (172.86)	.183 (.088)	970.06 (168.68)	.157 (.090)
VCL	997.24 (201.11)	.152 (.076)	953.97 (157.05)	.179 (.104)	974.86 (179.39)	.166 (.092)
VPL	995.65 (179.13)	.151 (.076)	955.20 (177.35)	.189 (.098)	974.73 (177.81)	.170 (.089)

*Numbers in brackets represent standard deviations.

Experiment 4: Discussion

With this experiment we wanted to investigate whether positive and negative potential outcomes could have different effects on gamblers' time perception. Previous research has stated that in the presence of negative stimuli we tend to overestimate time (e.g., Tipples, 2008), whereas in the presence of positive stimuli we tend to underestimate time (Gable & Poole, 2012). Our hypothesis was that gamblers would overestimate time due to arousal effects from previous negative experiences, or they would underestimate time if they would have predominantly positive thoughts about playing poker.

We attempted to detect such differences by using different Poker Hand combinations and manipulating their potential winning and losing outcomes. This was done under the assumption that losing hands would trigger negative thoughts (high arousal and attentional distraction) and winning hands would trigger positive thoughts (increased excitation). However, *p(long)* and BP analysis did not reveal any difference in the time perception between positive and negative outcomes, despite the fact that Poker players were successful in estimating the chances of winning or losing. This means Poker players were aware of the different outcomes in terms of winning or losing but these different outcomes did not trigger negative or positive intrusive thoughts.

One could argue that these null effects could be explained by Tiffany's cognitive processing model (1990). Tiffany suggested that when we are exposed to addiction related stimuli then an automatic cognitive process of craving is set in motion that can lead to attentional bias. This can happen regardless of positive or negative associations with the stimuli. Some support for this claim comes from our WR analysis where again gamblers displayed better time discriminability (lower WR compared to non-gamblers). Thus, in the presence of gambling related stimuli an automatic cognitive process of craving was initiated that resulted in increased arousal. Further support to that argument comes from Franken's theory (2003) stating that addiction related stimuli can increase dopamine levels. Finally, there is the possibility that floor and ceiling effects in p(long) values for *short* and *long* durations respectively could result in null findings.

However, the question remains on why we did not also see differences between positive and negative outcomes. One other explanation could be that gamblers could be equally desensitised for both positive and negative stimuli. This means that they do perceive them as addiction related stimuli but without attributing them with positive or negative valence. This seems to be the most plausible explanation given that we failed to observe any BP and WR differences between positive and negative stimuli. A similar finding was reported by Hudson et al. (2017) where high-risk gamblers would demonstrate selective attention for gambling related stimuli but not for negative or positive stimuli. Furthermore, Zack and Poulos (2004) found no differences in RT in reading speed between negative and positive affect. They did however find significant differences between gambling and neutral words, suggesting that gamblers focus on the gambling content and not the type of affect.

Finally, two important limitations of this experiment should be highlighted. First, the data collection took place in two different places (casino vs lab). This could have played an important role in Poker players behaviour as they most probably were in a gambling state of mind compare to the participants in the control group who were not exposed in such environment. Second, the time restriction imposed limited the duration of the experiment resulting in a reduced number of measurements that could have provided better insights.

Chapter Conclusion

In conclusion, in this chapter we added to the knowledge of addiction related attentional effects. We provided support for the *internal clock model* and we did discriminate between attentional and arousal effects, when comparing gamblers to non-gamblers in Experiment 3. Our findings also have shed some light on whether gamblers can perceive gambling related stimuli as threatening or not, with evidence pointing towards the direction that gamblers do not discriminate between positive and negative stimuli. This can have implications on designing gambling interventions, as gamblers may be “immune” to negative thoughts when presented with gambling cues. However, due to limitations in Experiment 4 our findings need to be replicated to strengthen our confidence in said results. It is therefore important to include a variety of positive and negative stimuli, related and non-related to gambling and ideally combine them with physiological measurements that will allow us to quantify increases in arousal.

Chapter 4 : **REPETITION, PRIMING, AND FAMILIARITY EFFECTS**

Four experiments will be discussed in this chapter. With Experiment 5, we aimed in replicating the attentional and arousal effects we observed for the gambling related stimuli but this time using Facebook and Internet related stimuli. Furthermore, we employed five blocks with one-minute breaks between blocks, as we also wanted to investigate how repetitive testing would affect time perception. With Experiments 6 and 7, we aimed to replicate the findings from Experiment 5 but also investigate whether priming would further affect our findings. Therefore, in Experiment 6, we divided our participants in two groups. One group accessed their Facebook account only after Block 1 and the second group accessed their Facebook account in all four breaks. In Experiment 7, we focused on only two Blocks and employed three different *priming* conditions involving seven minutes tasks. Finally, with Experiment 8, we wanted to explore whether the *salience* effects on time perception were due to *familiarity* or *emotional content* of the stimuli. Therefore, we employed a Temporal Bisection task where we replaced the images with associated *non-words*.

Internet addiction (IA) emerged during the last 20 years with the introduction of the web, and has since seen a constantly increasing prevalence (e.g. Kuss, Griffiths, & Binder, 2013; Kuss & Griffiths, 2011). Traditionally, addiction was strictly associated with the abuse of a substance, such as alcohol, nicotine, or other drugs. This association required the presence of a substance that would be associated with an uncontrolled urge to use, withdrawal symptoms, or relapse. However, in the presence of non-substance related addictive behaviours the study of addiction shifted from the classical view to a more holistic biopsychological perspective (Griffiths, 2005). Griffiths (1996) proposed that all addictions consist of seven components (salience, mood modification, tolerance, withdrawal, conflict, and relapse). This allowed us to focus on addictive behaviours and not necessarily substances, behaviours such as pathological gambling or Internet addiction. Contrary perhaps to most substance addictions, IA is an umbrella term that can include a number of different addictive behaviours. This was apparent even from the early years of IA research where Young (1999) identified five different types of IA.

These were computer addiction, information overload addiction, net compulsion addiction, cyber-sexual addiction, and cyber-relationship addiction. This categorisation is very important as different factors can affect different IA types. For example, a form of information overload addiction could be the urge to surf the Internet in constant search for new information, whereas, a form of cyber-relationship addiction could be an addiction to social networks such as Facebook. Furthermore, researchers have found that excessive Facebook users exhibit a number of addiction criteria such as thought withdrawal symptoms and mood swings when they cannot access Facebook (for a review see Kuss & Griffiths, 2011).

Despite the fact that IA shares similarities with substance addictions, the majority of the research focuses on the prevalence of use, personality traits, motivation and correlational research. To the knowledge of the authors the amount of research that focuses on implicit phenomena such as attentional bias or arousal in IA is rather limited. The same cannot be said for substance addictions where attentional bias has been well researched and is a robust finding, examples among others include research on alcohol (Sharma, Albery, and Cook, 2001), nicotine (Ehrman et al., 2002), cannabis (Cane, Sharma, and Albery, 2009), cocaine (Copersino et al., 2004), heroin (Waters, Marhe, and Franken, 2012), and opioids (Lubman et al., 2000); for a review see Cox, Fardadi and Pothos (2006). Furthermore, attentional bias has also been researched on Pathological Gambling (e.g. Molde et al., 2010; Brevers et al., 2011).

This limited research highlights the need for more investigation on IA and implicit measures, especially if we consider the first two components that Griffith proposed, salience and mood modification. IA salience could refer to raising the activity of “being online” as the predominant thought and preoccupation throughout the day. This could lead to craving to go online and consistent with addiction theories could initiate a vicious circle between craving and attentional bias (Franken, 2003; Kavanagh, Andrade, and May, 2005). Furthermore, mood modification could result in arousal changes that can lead to increased dopaminergic activity that can further enhance the activation of IA related cues and the urge to go online.

This highlights the possibility that IA, through dopaminergic activity triggered by the presence of salient stimuli, could affect time perception. The effects of dopamine in time perception have been demonstrated in a number of studies (e.g., Buhusi & Meck, 2005; Meck, 2005, 2006; Tipples, Meck, Cheng, & Narayanan, 2016). Dopamine has been thought to affect arousal which in the internal clock models can affect the rate of the pulses generated by the pacemaker (Buhusi & Meck, 2002, 2005). However, studies that compare Parkinson’s disease (PD) patients to neurologically healthy groups are reporting mixed results, in the best case, or even non-significant differences (Wearden et al., 2008; Wearden et al., 2009). Therefore, investigating time perception in non-substance addiction could be informative for both time perception and addiction models as it could provide further evidence for the role of dopamine.

Moreover, using time perception paradigms could provide implicit measurements of the effects of IA in our internal clock, especially since arousal and attention are factors that affect its accuracy. One of the most popular internal clock models is the one proposed by the scalar timing theory (Gibbon, 1977; Gibbon et al., 1984). This model consists of three distinct stages, the clock stage, the memory stage, and the decision stage. In the clock stage, a pacemaker is generating pulses throughout the duration of an event; a mode switch is either allowing the pulses to be carried to the accumulator or not. In simple terms, when our attention is focused on the event then the mode switch stays on and the generated pulses gather in the accumulator. When we are distracted, mode switch could be turned off disallowing the pulses from reaching the accumulator. The comparator then compares the accumulator content to the memory component content in order to determine whether the experienced event felt shorter or longer to the memory stored event, for more details see Droit-Volet and Gil (2009).

A number of studies have provided evidence that the use of drugs that affect arousal can impact our time perception. This is thought to be mainly by influencing the pacemaker, thus affecting the rate at which pulses are generated (Drew et al., 2003; Cheng et al., 2007). Furthermore, negative stimuli can accelerate the pacemaker and lead to temporal overestimation compared to positive or neutral stimuli (e.g., Droit-Volet and Meck, 2007; Tipples, 2008; Tipples, 2011). In addition, attention can also have an impact on our time perception (Thomas & Weaver, 1975; Zakay & Block, 1996). Attending to a distractor and not to time would result in the mode switch switching off thus not allowing the generated pulses to reach the accumulator. This would lead to fewer pulses being accounted thus perceiving the event as shorter (temporal underestimation). Attentional bias effects could result in underestimation when we shift our attention to external cues or events (Tipples, 2008).

Experiment 5: Introduction

Attention effects on the internal clock are not limited to merely attentional bias. Another factor that could affect our mode switch is the attentional resources available to time (Sylvie Droit-Volet, Bigand, Ramos, & Bueno, 2010; Thomas & Weaver, 1975). Additionally, Hansen and Trope (2013) have suggested that the amount of the attentional resources available to time could depend on our mind-set. Their findings suggest that when we are primed with a concrete mind-set less attentional resources are allocated to time leading to a shorter experience of time. Contrary, when we are primed with an abstract mind-set more attentional resources are allocated to time leading to a longer experience of time. This could help us distinguish even more between the effects of different stimuli in IA. One could argue that by using general Internet related stimuli we are primed with a more abstract mind-set since the Internet is a collection of a number of different activities. On the other hand, using Facebook related stimuli we are primed with a more concrete mind-set since Facebook has more specific and detailed uses compared to the Internet as a whole.

This experiment is the first to investigate the effects of internet salient stimuli on time perception. We used the temporal bisection task to investigate predictions from the internal clock model for Internet salient stimuli. If salient stimuli elicit intrusive cognitions, then this could be due to attention and/or arousal. The internal clock model predicts that if the effects are due to attention, we should have an underestimation of time durations leading to a change in the subjective point of equality (also known as the bisection point). If the effects are due to arousal, we should expect differences in our time perception discriminability, which can be reflected in changes in Weber's ratio (Sylvie Droit-Volet & Meck, 2007). Therefore, we hypothesised that salient stimuli, compared to neutral stimuli will lead to distorted time perception due to effects on attention and/or arousal.

Experiment 5: Method

Participants

Forty-four University of Kent psychology students (33 females, 11 males) were recruited via the Kent Psychology RPS website for course credit. The mean age was 20 with a standard deviation of 5.12 (age ranged from 18 to 44). All participants had to be over 18 years old and have a Facebook® account in order to participate.

Design

The experiment employed a 2x2x5x7 within participants design: *Image* (Facebook, Internet) x *Salience* (Salient, Neutral) x *Block* (1, 2, 3, 4, 5) x *Duration* (400, 600, 800, 1000, 1200, 1400, 1600ms) being the IVs. The dependent measures were the mean proportion of “long” responses p(long), the Bisection Point (BP), and the Weber’s Ratio (WR).

Materials

Visual Stimuli. In total, 20 images were used in this experiment: 5 Facebook salient (FS), 5 Facebook matched (FM), 5 Internet salient (IS) and 5 Internet matched (IM). Initially, we selected five images related to Facebook and proceeded with creating five matching images. These matching images had similar geometrical features as the five Facebook ones. Similarly, we selected five images related to the use of Internet (e.g. email icon) and proceeded with creating five matching images as described above. Furthermore, in order to avoid colour saliency issues between stimuli all matching images had similar colour and luminosity means. This was checked using Photoshop® and independent online tools (e.g. http://mkweb.bcgsc.ca/color-summarizer). Furthermore, a neutral image was selected to be used in the two training tasks. The dimensions of all images were 300 x 300 pixels.

Hardware and Software. For the temporal bisection task, the images were presented on a 19-inch monitor (1,024 x 768 resolution, 60Hz refresh rate frequency) connected to an Intel i5 powered PC. The software used to present the stimuli and collect the responses was Psychopy v1.82 (Peirce, 2009). Standard keyboard and mouse were used to input responses and all images were presented in grey background.

***Young’s Internet Addiction Test* (YIAT)**. Young’s IAT (1998) was used in order to measure the severity of problems caused by the use of Internet. This is a 20-item questionnaire (e.g., ‘*How often do you find that you stay online longer than* *you intended?*') with five-point Likert scale items 5-point scale: 1, *rarely;* 2, *occasionally*; 3, *frequently*; 4, *often*; 5, *always* (0, *not applicable*). For more details see Chapter 2 Exp2 Materials or Appendix C.

Procedure

After being briefed and providing consent, each participant completed the experiment in individual cubicles. The experiment was comprised of two training tasks, one main task of five blocks with 140 trials each, followed by completion of the online version of the YIAT questionnaire. Participants were instructed that the first two tasks were training tasks and that the experimenter would stay in the cubicle in order to provide further instructions if needed. Participants were told that the purpose of the training tasks was to introduce them to the "short" (400ms) and "long" (1600ms) standards and also to provide them with sufficient training to discriminate between them. During the first training it was explicitly mentioned that the single image would be shown over the course of the "short" and "long" standards. The image would be presented in a fixed alternating short-long order and that the participant would have to respond "short" (by pressing "s") or "long" (by pressing "l"). After each response, ("correct" / "incorrect") feedback was displayed on the centre of the screen for 1 second. Consequently, a randomly varying intertrial interval (0.5s to 1.5s) would follow. During the second training task, the same image was presented on the screen either for 400ms or 1600ms, but in a random order. The second training task lasted until the participant produced eight consecutive correct responses. Again, feedback was provided after each response. Once the second task was completed the instructions about the main task were presented on the screen. The instructions informed that more stimuli would be presented in varying durations and they would have to respond whether these durations were closer to "short" or "long". The experimenter would ask the participant if he/she was happy with the instructions and then leave the cubicle before the main task started. During this task 20 images would be presented for seven durations (400, 600, 800, 1000, 1200, 1400, 1600ms) in random order, this resulted in 140 trials. The participant responded "short" or "long" with no feedback following responses. Upon the completion of one block there was a break of one minute before the next block. Finally, once the temporal bisection task was finished, the online YIAT questionnaire was completed. Participants were fully debriefed and thanked for their participation.

Experiment 5: Results

P(long) Analysis

The p(long) values were entered into a four-way within-participants analysis of variance including Image (*F, I*), Salience(*S, M*), Block (1-5), and Duration (400, 600, 800, 1000, 1200, 1400, 1600ms). There was a main effect of Image, $F(1, 34) = 6.334$, $p = .017$, $\eta_p^2 = .157$, with observed power (1-β) = 0.68 (α = .05), indicating an underestimation of time for the Facebook images compared to the Internet images (respective p(long) means: .606 and .617). There was a main effect of Block, $F(4, 134) = 13.173$, $p < .001$, $\eta_p^2 = .279$, with observed power (1-β) = 0.99 (α = .05), indicating that participants overestimated time more as we moved from Block 1 to 5 (respective p(long) means: .556, .588, .624, .636, .656). Furthermore, Block 1 was not significantly different from Block 2, however they were both significantly different from Block 3, 4, and 5. Finally, there was no significant difference after Block 3 suggesting that perhaps a peak in p(long) responses had been reached. There was also a main effect of Duration, $F(6, 204) = 543.591$, $p < .001$, $\eta_p^2 = .940$, with observed power (1-β) = 0.99 (α = .05), indicating as expected that the p(long) values would increase as the time duration increased (respective means for 400 to 1600ms: .041, .178, .481, .755, .903, .950, and .974). Furthermore, there was a Salience by Duration interaction, $F(1,34) = 3.60$, $p = .002$, $\eta_p^2 = .096$, with observed power (1-β) = 0.95 (α = .05). Simple main effects of Salience showed significant effects at durations 800ms ($p = .024$), 1400ms ($p = .009$), and 1600ms ($p = .041$), indicating an underestimation of time at 800ms for Salient stimuli compared to Neutral stimuli, and an overestimation of time at 1400ms and 1600ms for Salient stimuli compared to Neutral stimuli.

There was also a significant Block by Duration interaction, $F(1,34) = 6.96$, $p < .001$, $\eta_p^2 = .170$, with observed power (1-β) = 0.99 (α = .05). There were significant simple main effects of Block at durations 400ms, 600ms, 800ms, and 1000ms (all *F*'s > 2.83, all *p's* < .036) but not 1200ms and 1400ms (all *F*'s < 1, *p* > .5). Although there was a simple main effect of Block at duration 1600ms, further post-hoc t-tests did not reveal any significant differences. At duration 400ms Block 5 was significantly different from all other Blocks (all *p*'s < .014). At duration 600ms, 800ms and 1000ms, Blocks 1 and 2 were significantly different from 3, 4 and 5 (all p's < .022), see Figure 8.

Finally, there was a significant Image by Salience interaction, *F*(1, 34) = 4.87, *p* = .034. There was a significant simple main effect of Salience for Facebook images (*p* = .042) but not Internet images (*p* = .324). There was also a significant simple effect of Image for Salient stimuli (*p* = .003), see Figure 9

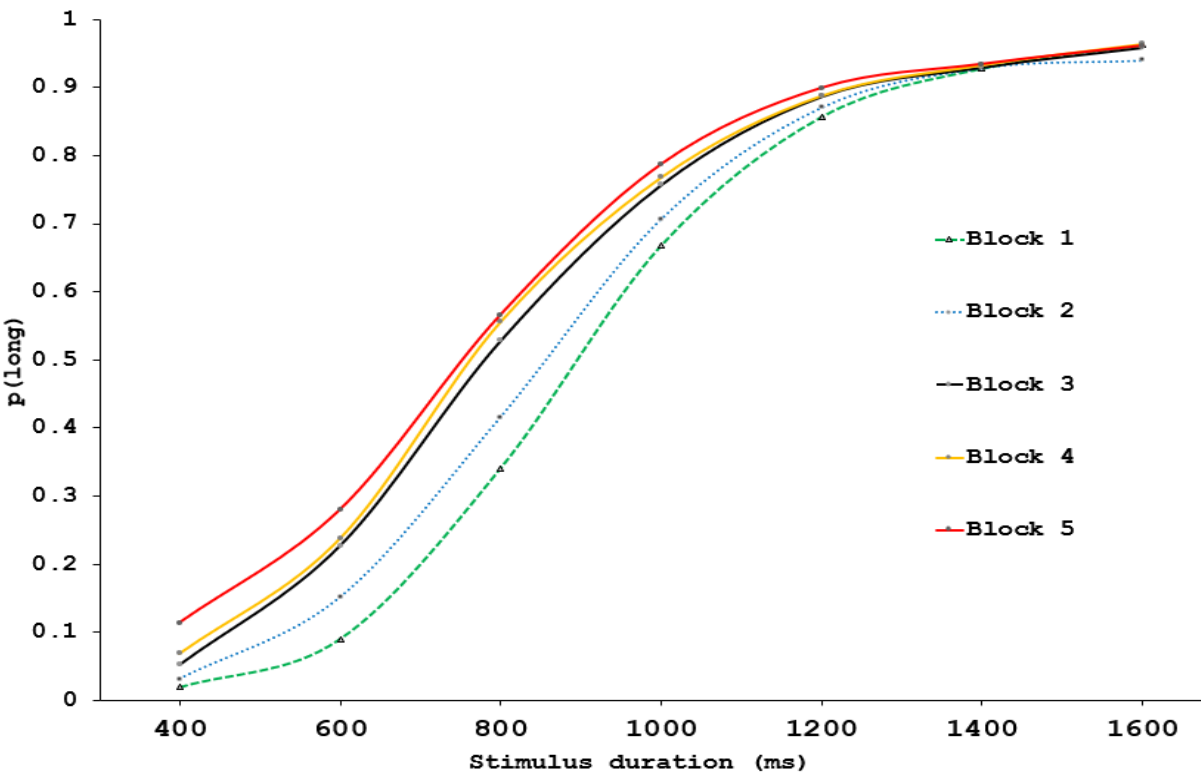


Figure 8. P(long) ratio of responses per duration and block indicate a tendency to overestimate time as the task is repeated

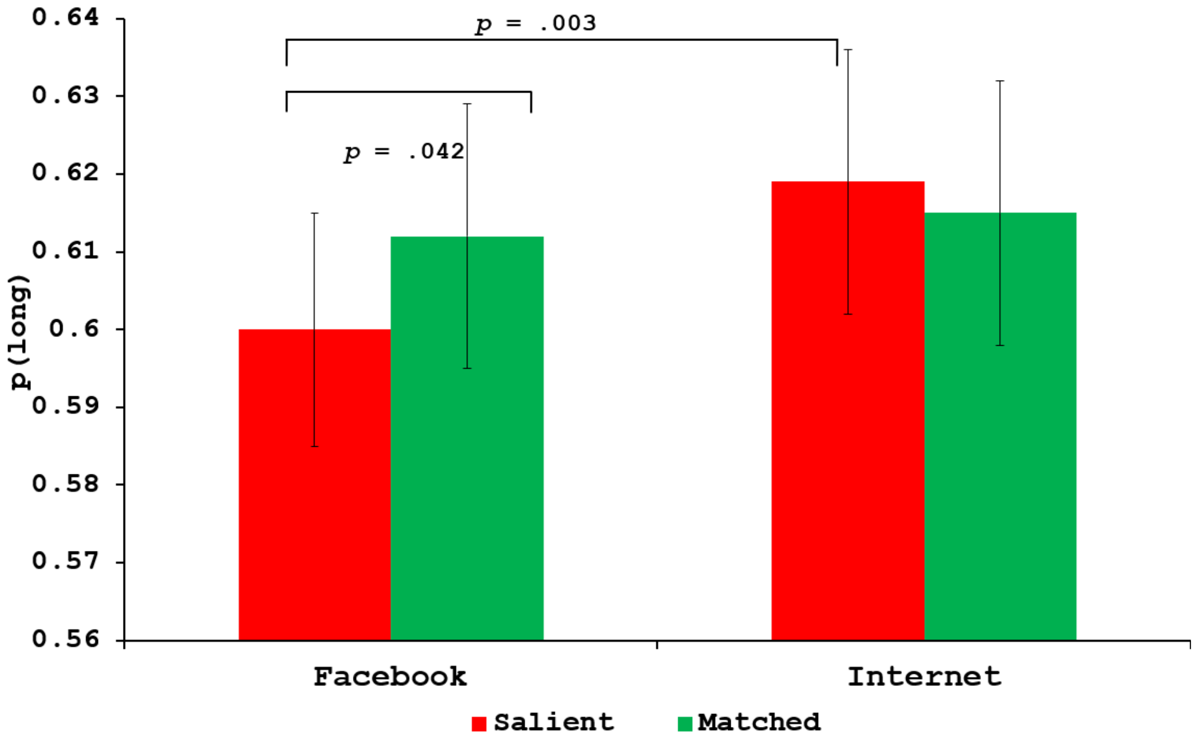


Figure 9. Image by Salience interaction indicating an overall underestimation of time for Facebook salient compared to Facebook matched and Internet salient.

BP Analysis

A three-way within-participants ANOVA including Image(2), Salience(2), and Block(5) was carried out. During the probit analysis for the calculation of BP, a number of participants had BP outside the 400 – 1600ms range. These participants were excluded from all analyses resulting in a final number of 35 participants in the analysis. There was a main effect of Image, F(1,34) = 4.46, p = .042, η_p^2 = .116, with observed power (1-β) = 0.54 (α = .05), indicating that Facebook related stimuli had a higher BP. There was a main effect of Block, F(4,136) = 12.57, p < .001, η_p^2 = .270, with observed power (1-β) = 0.99 (α = .05), indicating that BPs were significantly reducing from Blocks 1 to 5 (respectively 924.26ms, 877.40ms, 827.10ms, 810.18ms and 776.94ms) with no significant difference between Blocks 1 and 2 but these were both significantly different from Blocks 3, 4 and 5. There was no main effect of Salience F(1,34) = 1.05, p = .31.

There was a significant interaction between Image and Salience, *F*(1, 34) = 5.20, *p* = .03, η_p^2 = .133, with observed power (1-β) = 0.60 (α = .05). Simple main effect analysis of Salience within Facebook images (FS=858ms, FM=841ms, p = .036) was significant but not for Internet images (IS=832ms, IM=839ms, p = .293). No other interactions were significant (all F's<2.3, p>.07).

WR Analysis

A three-way within-participants analysis of variance including Image(2), Salience(2), and Block(5) was carried out. There was a main effect of Salience, $F(1, 35) = 16.39$, $p < .001$, $\eta_p^2 = .324$, with observed power $(1-\beta) = 0.98$ ($\alpha = .05$), indicating that salient stimuli had significant lower WR (0.167) than matched images (0.189), indicating participants were better able to discriminate changes in time durations for salient images compared to their matched image. No other main effect or interaction were found. It is however worth noting that even though the main effect of Block was non-significant (p = .162) the WR means showed a trend of reduced discriminability as participants progressed from Block 1 to Block 5 (respectively: 0.185, 0.202, 0.213, 0.239, 0.262).

YIAT Score and Correlations

The YIAT scores varied from 23 to 73 (M_{YIAT} = 45.01, SD_{YIAT} =10.74). Twenty-three participants had scores between 30 and 49 and were classified as average online users, 16 had scores between 50 and 79 and were classified as online users with frequent problems due to Internet use. There were no participants with scores higher than 80 that would indicate significant problems due to use of Internet (Young, 1998). Furthermore, we ran correlational analysis between the YIAT scores and the attentional bias scores (*salient –matched)* in BP and WR for each image type in each block. All correlations were non-significant (r's < .243, p's > .114).

Experiment 5: Discussion

The aim of this experiment was to investigate the effects of Facebook and Internet *salient* stimuli on time perception. We employed a modified temporal bisection task and looked into possible effects of *salient* stimuli on the predictions of the *internal clock* due to either attention, arousal, or both. The internal clock model predicts that attention can affect our time perception by causing underestimation of time duration due to distraction. However, arousal can have bidirectional effects either by accelerating or decelerating the *pulse maker*, leading to distorted time perception (e.g. Droit-Volet, Fanget, & Dambrun, 2015; Tipples, 2008).

Our data provided support for attentional effects as predicted by a *mode switch* in the *internal clock* model. This was supported consistently across by two results: the main effects of Block and Image. As Block increased BP decreased suggesting an overestimation of time. This lengthened time experience could be a result of reduced attention allocated on stimuli caused by this repetitive exposure, hence leaving more attentional resources devoted to time. Another explanation for this effect could be in terms of boredom and that participants could lose interest in looking at the stimuli (Matthews, 2011).

With regards to Image, there were higher BP scores for Facebook than Internet stimuli. This indicates an underestimation of time for Facebook stimuli than Internet stimuli suggesting greater attentional resources being allocated to Facebook than Internet stimuli. This highlights greater attentional bias due Facebook *salient* stimuli over Internet *salient* stimuli and no difference between the *matched* ones. This is a very interesting finding underlining perhaps differences between behaviours within the IA itself. This could provide further support to arguments that there are different behaviours and motivation behind different types of IA as were first identified by Young (1999). For example, an IA that is driven by *net compulsion* or *cyber-sexual addiction* could be driven by the need to surf the web in search of news and thus be more associated to excitation and arousal (Cooper, Putnam, Planchon, & Boies, 1999). On the other hand an IA that has *cyber-relationship addiction* in its core (the use of Facebook has been identified as such, Kuss and Griffiths, 2011) could have more emotional motives and thus perceive Facebook *salient* stimuli as not threatening and not trigger arousal effects that are associated with overestimations (e.g. Tipples, 2008, 2011).

A different explanation on why Facebook stimuli cause different effects than the Internet ones could lie in the effects they have on our mind-set. Hansen and Trope (2013) have hypothesised that placing ourselves in an abstract or concrete mind-set can affect our time perception. This is due to the fact that concrete mental representations (one that focuses more on specific details) take up more attention resources from the perception of time. It could be argued that Facebook addiction is a more specific form of IA. Thus, Facebook stimuli might prime a more concrete mind-set than Internet stimuli.

Our findings also support arousal effects on the *pacemaker* within the *internal clock* model. The differences in WR scores between *salient* and *matched* stimuli suggest that our discriminability for *salient* stimuli remains better across all blocks compared to the *matched* ones. This could mean that *salient* stimuli are associated with higher arousal levels compared to *matched neutral* ones, resulting in more pulses being generated by the *pacemaker*; hence experiencing time as longer when we see *salient* stimuli compared to *matched*. This finding is in line with predictions from addiction models that addiction related cues can lead to craving and excitation and thus increased arousal (Franken, 2003; Kavanagh et al., 2005).

Experiment 6: Introduction

At the time that Experiment 5 was conducted it was the first that investigated attentional bias effects of Internet and Facebook related stimuli (salient) on our time perception. It was therefore vital that we replicated the experiment in order to see if we would arrive to the same conclusions regarding the attention and arousal effects on our internal clock when viewing salient stimuli. Experiment 6 was a close replication of Experiment 5 with one key difference. Participants were allocated to one of two groups where they had to access their Facebook account in their mobile phones during each break between blocks or access their Facebook account only during the first break between blocks 1 and 2. This allowed to better control what participants did during their first break and see whether we would get similar results to Experiment 5 with regards to block 1 and 2 temporal distortion effects. Furthermore, it allowed us to investigate whether accessing Facebook on each break would change the *fatigue* effect we observed in Experiment 5 where temporal distortions disappeared after the second block. Our hypothesis was that salient stimuli will cause temporal distortions similar to the Experiment 5 ones, at least during the first two blocks. Our second hypothesis was that the temporal distortions will continue for all blocks only for the participants assigned to access their Facebook account during each break.

Experiment 6: Method

Participants

Eighty-four University of Kent psychology students (70 females, 14 males) were recruited via the Kent Psychology RPS website for course credit. The mean age was 19.83 with a standard deviation of 3.85 (age ranged from 18 to 41). Participants had to be over 18 years old and have a Facebook® account in order to participate.

Design

The experiment employed a 2x2x2x5x7 mixed design. *Image* (Facebook, Internet) x *Salience* (Salient, Neutral) x *Block* (1, 2, 3, 4, 5) x *Duration* (400, 600, 800, 1000, 1200, 1400, 1600ms) were the within-subjects the IVs and *Group* (First Break, All Breaks) was the between-subjects IV. The dependent measures were the mean proportion of "long" responses p(long), the Bisection Point (BP), and the Weber's Ratio (WR).

Experiment 6: Results[3]

P(long) Analysis

The p(long) values were entered into a five-way within-participants analysis of variance including Image, Salience, Block, Duration, and Group. There was a main effect of Block, $F(4, 268) = 5.21$, $p < .001$, $\eta_p^2 = .072$, $\eta_p^2 = .096$, with observed power $(1-\beta) = 0.97$ ($\alpha = .05$), indicating that participants overestimated time as they progressed from Block 1 to 5 (respective p(long) means: .518, .555, .588, .593, .604). Furthermore, Block 1 was significantly different from Block 2, and they were both significantly different from Block 3, 4, and 5. Finally, there was no significant difference after Block 3 suggesting again that perhaps a peak in p(long) responses had been reached.

There was also a main effect of Duration, $F(6, 402) = 1247.78$, $p < .001$, $\eta_p^2 = .949$, with observed power $(1-\beta) = 1.00$ ($\alpha = .05$), indicating as expected that the p(long) values would increase as the time duration increased (respective means for

[3] Participants with BP values outside the range of 400ms and 1600ms were excluded from the analysis. In this case this led to the removal of 17 participants, resulting in 69 valid participants.

400 to 1600ms: .042, .149, .422, .702, .838, .909, and .938). Furthermore, there was a significant Block by Duration interaction, $F(24, 1608) = 10.35$, $p < .001$, $\eta_p^2 = .134$, with observed power (1-β) = 0.98 (α = .05). Further post-hoc analysis revealed that for the durations of 400ms and 600ms Block 1 and Block 2 were significantly different to the rest of the blocks, for the duration of 800ms Block 1 was significantly different to the rest of the Blocks, and for the duration of 1000ms Blocks 1 and 2 were significantly different to Blocks 3, 4, and 5. For the durations of 1200, 1400, 1600ms no significant simple effects were observed, see Figure 10.

There was also a significant Image by Salience interaction, $F(1, 67) = 25.50$, $p < .001$, $\eta_p^2 = .276$, with observed power (1-β) = 0.99 (α = .05), with post-hoc analysis revealing significant simple main effects of Salience and Image, see Figure 11 for details. Finally, there was a significant Salience by Duration by Group interaction, $F(6, 402) = 2.35$, $p = .031$, $\eta_p^2 = .034$, with observed power (1-β) = 0.97 (α = .05),. However, post-hoc analysis did not reveal any significant simple effects. There were no other significant main effects or interactions (all *F*'s < 2 and *p*'s > .1)

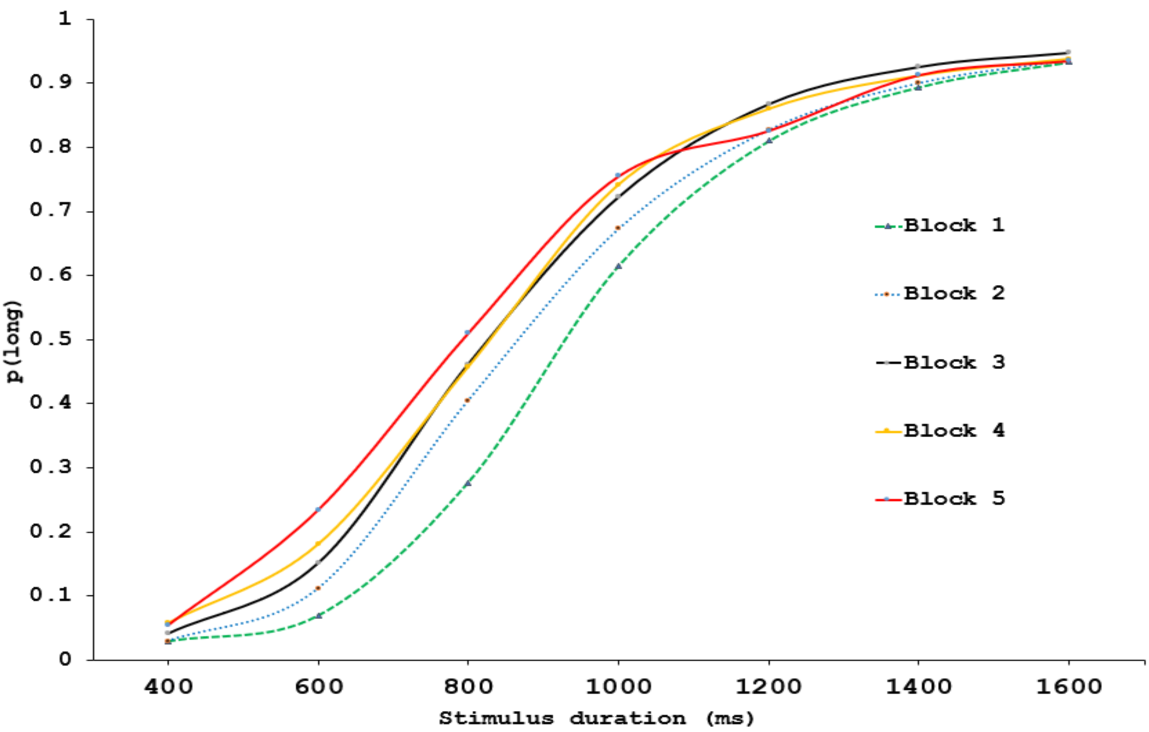


Figure 10. P(long) ratio of responses per duration and block indicate a tendency to overestimate time as the task is repeated

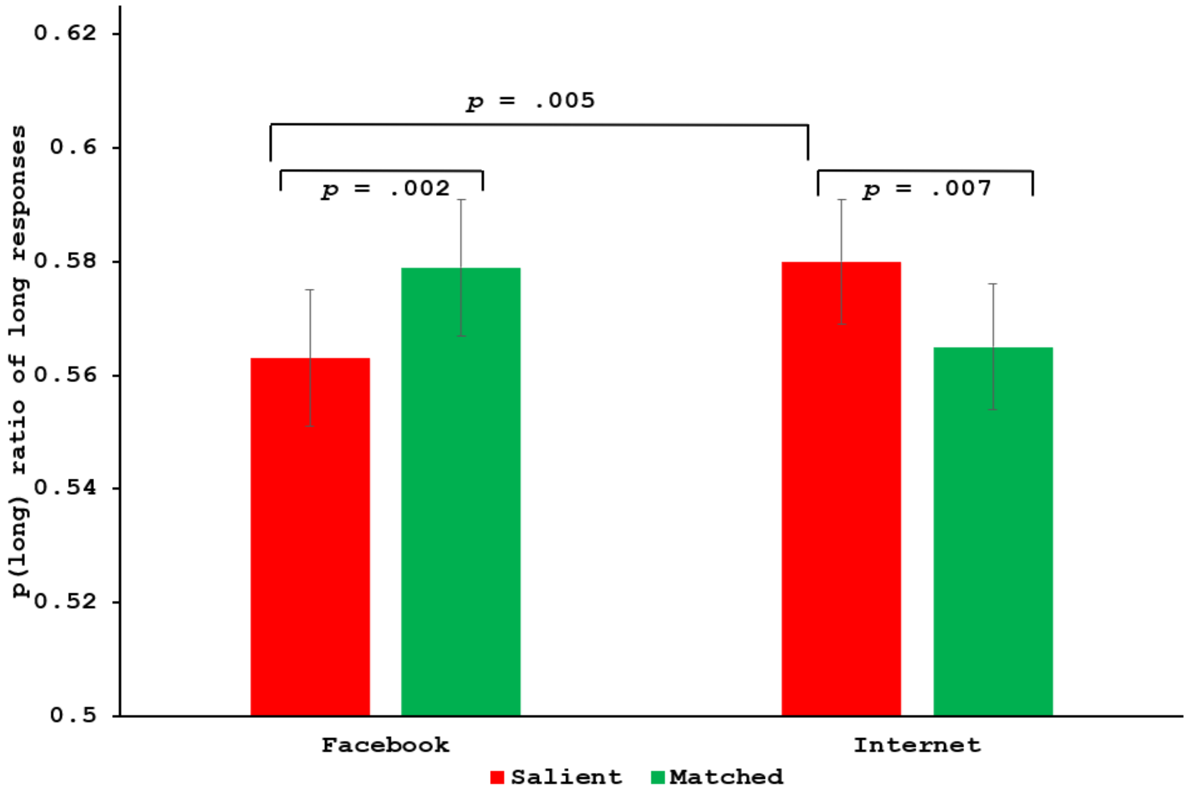


Figure 11. Simple effect of Salience for both Image type indicates an underestimation of time for Facebook salient stimuli compared to matched neutral and Internet salient.

BP Analysis

A four-way ANOVA for BP including Group(2), Image(2), Salience(2), and Block(5) was carried out. There was a significant main effect of Block, $F(4, 268) = 18.38$, $p < .001$, $\eta_p^2 = .215$, with observed power (1-β) = 1.00 (α = .05),indicating that BPs were significantly reducing from Blocks 1 to 5 (respectively 979.80ms, 928.48ms, 875.51ms, 866.86ms, and 850.00ms) with no significant difference between Blocks 1 and 2 but these were both significantly different from Blocks 3, 4 and 5. These findings are in line with Experiment 5 and provide more evidence that we tend to overestimate time as we repeat a task. There was also a significant Image by Salience interaction, $F(1, 67) = 24.62$, $p < .001$, $\eta_p^2 = .269$, with observed power (1-β) = 0.99 (α = .05),with post-hoc analysis revealing significant simple effects of salience for both Facebook ($p = .002$) and Internet images ($p = .005$) but with opposite direction, see Figure 12. There were no other significant main effects or interactions (all *F*'s < 2 and *p*'s > .1).

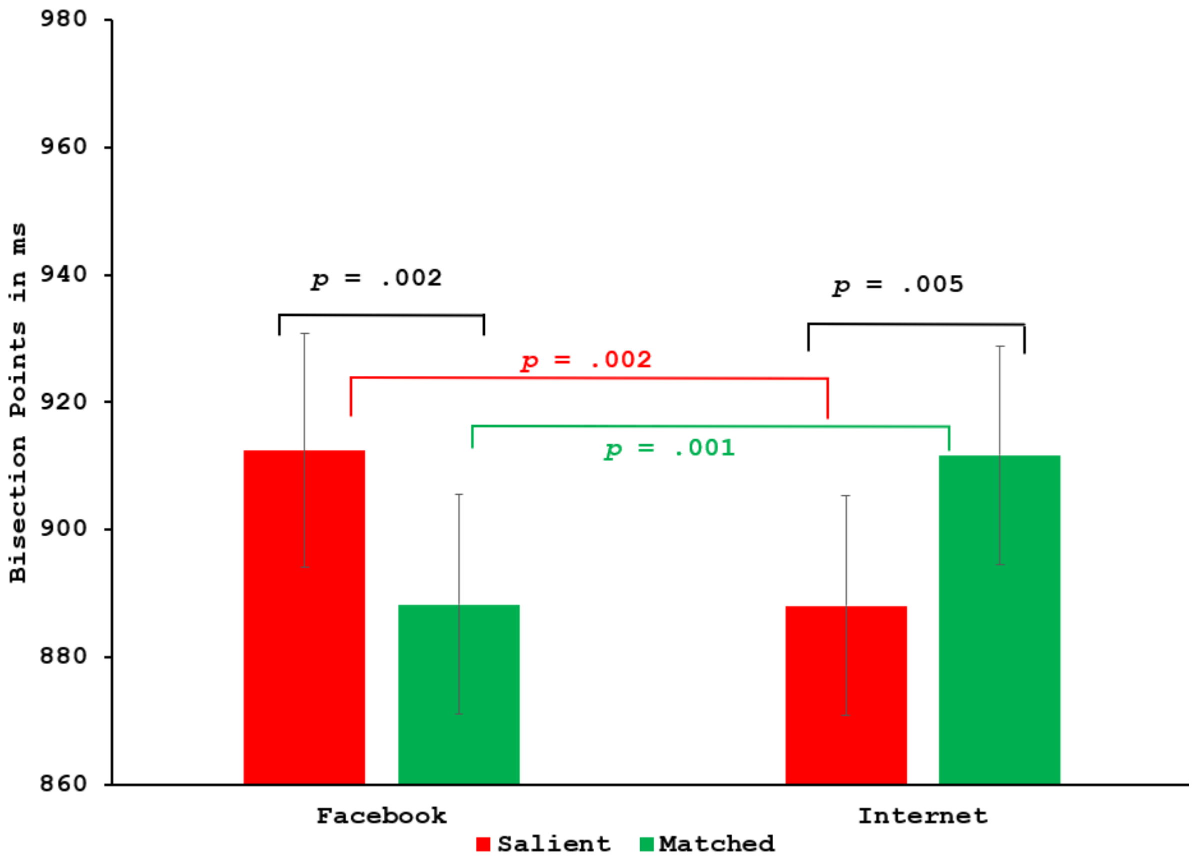


Figure 12. Image by Salience interaction indicates an overall underestimation of time for Facebook salient stimuli compared to Facebook matched neutral and Internet salient stimuli

WR Analysis

A four-way ANOVA for WR including Group(2), Image(2), Salience(2), and Block(5) was carried out. There was a significant main effect of Block, $F(4, 268) = 8.01$, $p < .001$, $\eta_p^2 = .107$, with observed power (1-β) = 0.99 (α = .05),indicating that WRs were significantly increasing from Blocks 1 to 5 (respectively .185, .202, .213, .239, .262) as a result of reduced discriminability, possibly due to fatigue or reduced arousal. There was also a significant Image by Salience interaction, $F(1,67) = 10.01$, $p = .002$, $\eta_p^2 = .130$, with observed power (1-β) = 0.88 (α = .05). However, post-hoc analysis did not reveal any significant simple effects (*p*'s > .3).

YIAT Score and Correlations

The YIAT scores varied from 1 to 64 ($M_{YIAT} = 33.60$, $SD_{YIAT} = 13.44$). Thirty-participants had scores between 30 and 49 and were classified as average online users, 8 had scores between 50 and 79 and were classified as online users with frequent problems due to Internet use. There were no participants with scores higher than 80 that would indicate significant problems due to use of Internet (Young, 1998). Furthermore, we ran correlational analysis between the YIAT scores and the attentional bias scores (*salient –matched)* in BP and WR for each image type in each block. All correlations were non-significant (*r*'s < .244, *p*'s > .103).

Experiment 6: Discussion

The aim of this experiment was to replicate the findings of Experiment 5 and at the same time assess the impact of accessing Facebook either during the first break or during each break. Similarly to Experiment 5, we employed a modified temporal bisection task and looked into possible effects of *salient* stimuli on the predictions of the *internal clock* due to either attention, arousal, or both (for more details see Experiment 5: Discussion). All findings were very similar to the ones reported in Experiment 5.

Our data provided further support for attentional effects as predicted by a *mode switch* in the *internal clock* model. Again, we found that as Block increased BP decreased suggesting an overestimation of time. Furthermore, there were again higher BP scores for Facebook than Internet stimuli providing additional support to our prior claim that Facebook *salient* stimuli can cause greater attentional bias compared to Internet *salient* stimuli. This replicated finding adds to our previous evidence that accessing Facebook is intrinsically different to a general use of the Internet and an interesting finding that future research could focus on.

Contrary to Experiment 5, this time we also had a significant block effect in WR clearly showing that participants' temporal discriminability deteriorated as they progressed through the blocks. Even though there was a similar trend in Experiment 5, finding significant differences in Experiment 6 could be due to accessing Facebook which could have resulted in increased cognitive load and fatigue. Furthermore, we did not observe any salience effects on WR which previously we have associated with craving to use Facebook and Internet as a result of being exposed to salient stimuli as predicted by Franken (2003), and Kavanagh et al., (2005). These craving effects could have now disappeared as participants were able to access their Facebook accounts according to the group they were allocated at.

Experiment 7: Introduction

Focusing on the results of Experiments 5 and 6 we could conclude that there was no further need to include five blocks as the temporal distortion effects due to salience would mainly occur during the first two blocks. Furthermore, fatigue was the main driving factor in blocks 3 to 5. In addition, in Experiment 6 we observed that allowing participants to access their Facebook accounts affected their temporal discriminability. However, we did not include a control condition or even a condition with an Internet related activity. This posed the question whether the observed behaviour was due to the nature of accessing Facebook, or whether it would occur with any given task as a break.

In the current Experiment 7 we aimed to address this limitation of Experiment 6 by adding two matched conditions as well as increasing the duration of the between two blocks break activity. This time, the task involved either accessing their Facebook account on the experiment PC, or accessing and reading a psychology paper online, or reading the same paper in a printed form. Participants were allocated to one of the three tasks randomly at the beginning of the experiment. Our hypothesis was that if the previous findings were due to the nature of accessing Facebook, then we should observe difference between the three groups. Furthermore,

Experiment 7: Method

Participants

One hundred and thirty-seven psychology students (101 females, 23 males) were recruited via the Kent Psychology RPS website for course credit. The mean age was 19.32 with a standard deviation of 2.32 (age ranged from 18 to 41). Participants had to be over 18 years old and have a Facebook® account in order to participate.

Design

The experiment employed a 2x2x2x7x3 mixed design. *Image* (Facebook, Internet) x *Salience* (Salient, Neutral) x *Block* (1, 2) x *Duration* (400, 600, 800, 1000, 1200, 1400, 1600ms) were the within-subjects the IVs and *Group* (Access Facebook, Read Online, Read Printed) was the between-subjects IV. The dependent measures were the mean proportion of "long" responses p(long), the Bisection Point (BP), and the Weber's Ratio (WR).

Experiment 7: Results[4]

P(long) Analysis

The p(long) values were entered into a five-way analysis of variance including Image, Salience, Block, Duration, and Group. There was a main effect of Block, $F(1, 121) = 88.85$, $p < .001$, $\eta_p^2 = .423$, with observed power (1-β) = 1.00 (α = .05), indicating that participants underestimated time in Block 1 ($M = .527$) compared to Block 2 ($M = .594$). There was also a Salience main effect, $F(1, 121) = 6.76$, $p = .01$, $\eta_p^2 = .053$, with observed power (1-β) = 0.73 (α = .05),showing an underestimation of time for Salient stimuli ($M = .556$) compared to Neutral ($M = .566$). As expected, there was also a main effect of duration, $F(6, 726) = 1941.4$, $p < .001$, $\eta_p^2 = .941$, showing that the p(long) values would increase as the time duration increased (respective means for 400 to 1600ms: .034, .115, .381, .680, .846, .926, and .944).

Furthermore, there was a significant Block by Duration interaction, $F(6, 726) = 20.99$, $p < .001$, $\eta_p^2 = .148$, with observed power (1-β) = 1.00 (α = .05),further post-hoc analysis revealed significant differences between Blocks in all durations (all *p*'s < .013), see Figure 13. Block by Duration. There was also a significant Salience by Duration interaction, $F(6, 726) = 3.73$, $p = .001$, $\eta_p^2 = .030$, with observed power (1-β) = 0.96 (α = .05),further post-hoc analysis revealed significant differences between Salient and Neutral stimuli at 400, 600, and 800ms (all *p*'s < .04), see Figure 14. There was also a four- way interaction of Session x Image x Duration x Group, $F(12, 726) = 1.86$, $p = .036$, $\eta_p^2 = .030$, with observed power (1-β) = 0.90 (α = .05),however, post-hoc analysis did not reveal any significant simple effects (all *p*'s > .1).

[4] Participants with BP values outside the range of 400ms and 1600ms were excluded from the analysis. In this case, this led to the removal of 13 participants, resulting in 124 valid participants.

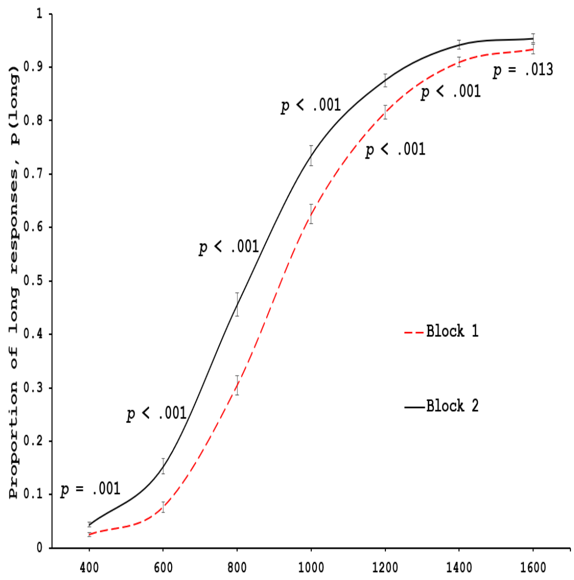


Figure 13. Block by Duration interaction for p(long) values

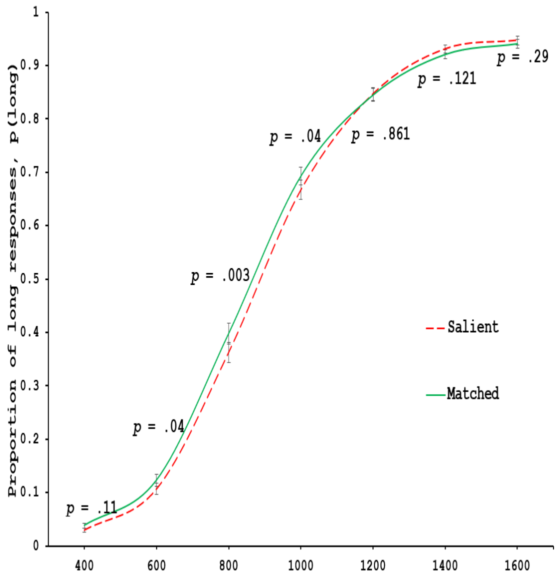


Figure 14. Salience by Duration interaction for p(long) values

BP Analysis

A four-way ANOVA for BP including Group(2), Image(2), Salience(2), and Block(2) was carried out. There was a significant main effect of Block, $F(1, 121) = 81.27$, $p < .001$, $\eta_p^2 = .402$, with observed power (1-β) = 1.00 (α = .05), with BP increasing from Block 1 ($M = 967.01$) to Block 2 ($M = 870.03$) indicating an overestimation of time for Block 2 compared to Block 1. There was also a main effect of Salience, $F(1, 121) = 5.10$, $p = .026$, $\eta_p^2 = .040$, with observed power (1-β) = 0.61 (α = .05), revealing an underestimation of time for Salient stimuli ($M = 925.24$) compared to Neutral stimuli ($M = 911.79$). There were no other significant main effects or interactions (all *F*'s < 2 and *p*'s > .1).

WR Analysis

A four-way ANOVA for WR including Group(2), Image(2), Salience(2), and Block(2) was carried out. There was a significant main effect of Salience, $F(1, 121) = 8.35$, $p = .005$, $\eta_p^2 = .065$, with observed power (1-β) = 0.82 (α = .05),with lower WR mean values for Salient stimuli ($M = .174$) compared to Neutral stimuli ($M = .192$), indicating a better discriminability of time for Salient stimuli. There was also a marginally significant Salience by Block interaction, $F(1, 121) = 3.72$, $p = .056$, $\eta_p^2 =$

.030, with observed power (1-β) = 0.48 (α = .05). Post-hoc analysis revealed significant differences between Salient and Neutral stimuli in Block 2 ($p < .001$) but not in Block 1. There were no other significant main effects or interactions (all *F*'s < 2 and *p*'s > .1).

YIAT Score and Correlations

The YIAT scores varied from 6 to 62 ($M_{YIAT} = 29.61$, $SD_{YIAT} = 13.27$). Fifty-two participants had scores between 30 and 49 and were classified as average online users, 8 had scores between 50 and 79 and were classified as online users with frequent problems due to Internet use. There were no participants with scores higher than 80 that would indicate significant problems due to use of Internet (Young, 1998). Furthermore, we ran correlational analysis between the YIAT scores and the attentional bias scores (*salient –matched)* in BP and WR for each image type in each block. All correlations were non-significant (*r*'s < .124, *p*'s > .169).

Experiment 7: Discussion

With the current experiment we aimed at addressing the lack of controlled conditions in Experiment 6. We therefore included two additional groups, one using the Internet to access and read a paper and one reading a printed version of the same paper. This was done in order to answer the question whether the results in Experiment 6 were driven by the intrinsic nature of accessing Facebook or whether they were driven by the fact that participants were allowed a controlled break that added to their fatigue. Our results indicate that there were no significant effects of group suggesting that the differences observed were not associated to accessing Facebook itself. Instead, we observed familiar block effects indicating that participants overall underestimated durations for block 1 compared to block 2.

Furthermore, there were significant main effects of salience both in terms of BP and WR in a consistent manner to Experiments and 5, to some extent. Again, salient stimuli were associated with underestimation of durations compared to neutral stimuli. This provided further support to our claims that salient stimuli can cause intrusive thoughts that initiate a cycle of craving resulting in attentional bias effects as predicted by Franken (2003) and Kavanagh et al., (2005). In addition, the

WR results indicated that there were also familiar to previous experiments arousal effects that led to better discriminability for salient stimuli compared to neutrals ones. This was also in line with the predictions discussed above.

Experiment 8: Introduction

In the previous three experiments we have consistently observed temporal distortions both in the terms of BP and WR and we have interpreted these effects as results of emotional and arousing addiction related content of the stimuli. However, we cannot at this stage eliminate the scenario that these effects are merely familiarity effects. In order to answer the question whether addiction related content or familiarity drive these effects we will use a modified temporal bisection task with associated non-words instead of images.

Richards and Blanchette (2004) used a modified emotional Stroop paradigm where participants first associated non-words with emotional and neutral images. They then carried out the Stroop task using the associated non-words. Analysis showed that high anxious participants were slower at responding the colour of the emotional words compared to the neutral ones. Similar finding were also reported by Sharma & Money (2010) where participants learnt associations between non-words with addiction related and neutral stimuli. The results were similar to Richards and Blanchette's findings. Drug users were slower are responding the colours of cocaine associated non-words compared to non-drug associated non-words.

These two studies provided evidence that the Stroop interference from addiction related stimuli is due to addiction related content and not to visual confounds. Therefore, we hypothesised that if the observed temporal distortions were due to addiction related content we should be able to observe similar distortions for the Facebook associated non-words and not for the neutral associated non-words.

Experiment 8: Method

Participants

Ninety-five psychology students (80 females, 15 males) were recruited via the Kent Psychology RPS website for course credit. The mean age was 19.49 with a standard deviation of 2.64 (age ranged from 18 to 41). Participants had to be over 18 years old and have a Facebook® account in order to participate.

Design

The experiment employed a 3x7 within-subjects design. *Word* (Salient, Neutral Familiar, Neutral Unfamiliar) x *Duration* (400, 600, 800, 1000, 1200, 1400, 1600ms) were the within-subjects IVs. The dependent measures for the Temporal Bisection task were the mean proportion of “long” responses p(long), the Bisection Point (BP), and the Weber’s Ratio (WR). The dependent variables for the recognition task were accuracy (*Hit rates, False alarm rates*) and confidence ratings.

Materials

Visual Stimuli. The same 20 images from *Experiment 5* were used during the memory association task. Furthermore, 21 non-words (non-existing, made-up words) were generated from The English Lexicon Project website (Balota et al., 2007). The criteria were: Mean Length = 6, and Ortho_N = 0 (Orthographic Neighborhood: the number of words that be produced if one character in the given word changes to another character, for example the word ‘CAT’ can give the word ‘BAT’. In order to minimise the chances of activating existing words during the experiment the criterion of zero was adopted. The actual characteristics of the generated non-words were: Mean Length = 5.95, and Ortho_N = 0.3, see Appendix I.

Questionnaires The CIUS (Meerkerk et al., 2009) and the YIAT were used in this experiment and were presented online using the Qualtrics website (Qualtrics ©, http://www.qualtrics.com, 2015). For more information on both, see Chapter 2, Exp 2 or Appendices D and C.

Procedure

Participants were briefed and provided signed consent before entering an individual cubicle to complete the computerised tasks. The order of the tasks was *memory association task, temporal bisection task*, *recognition task*, and finally the completion of questionnaires.

Memory Association Task. During this task participants had to learn associations between the non-words and the selected images. The task was completed in three thematic blocks, presented in random order. One block included

Facebook related associations of five Facebook salient images with five non-words. A second block included Internet related association of five Internet salient images with five non-words. Finally, a third block included neutral associations of five neutral images with five non-words, these 15 words were characterised as *Old*. Five non-words were not presented at all in this task and were left for the memory recognition task, they were characterised as *New*. Before each block participants received specific instruactions, "*An Internet (*Facebook or neutral for the other blocks) *related picture will first come on the screen. A made-up word (non-word) will then appear at the center of the screen. Pay close attention to both the picture and the word that will be presented."*. In each block they saw twice all possible combinations of the five images and five non-words (25 combinations). First the image would come on the screen and after 500ms the word would follow for an additional 1500ms, there was also an inter-trial duration of 1000ms, this resulted in 50 trials per block with a total duration of 150sec. Every block lasted exactly 150sec to avoid differences in the duration of learning association that could impact memory performance.

Temporal Bisection Task. The temporal bisection task in structure and timings was identical to the one in Experiment 5 (two training tasks and one main task). The key difference here was that the stimuli were non-words and not images. In order to stay consistent with the training tasks in Experiment 5 where one neutral stimulus was used throughout, the non-word "*tryles"* was selected to be the training stimulus. During the main task participants would see one non-word at a time on the screen for durations of 400 to 1600ms and they had to respond whether that duration felt *"short*" *or* "*long*".

Recognition Task. During this task all 20 non-words were presented at the screen one at time and the participant had to respond whether the non-word was presented during the Facebook, Internet, or neutral association, or whether it was new never seen before non-word. Once they gave a response, they had to also record how confident they felt about the answer 1, *Not confident at all* to 5, *Very confident*. For both questions there was no time pressure.

Questionnaires. When all the above tasks were completed, participants completed the CIUS and Facebook modified CIUS questionnaires, see Appendices D and E.

Experiment 8: Results

P(long) Analysis

The p(long) values were entered into a two-way analysis of variance including Word and Duration. There was a main effect of Word, $F(1, 92) = 5.297$, $p = .024$, $\eta_p^2 = .054$, with observed power (1-β) = 0.63 (α = .05).Further pairwise comparisons revealed that p(long) values for Salient words was significantly lower to the p(long) values of Neutral words ($p < .001$), no difference was observed between Neutral Familiar and Neutral unfamiliar (Respective means: $M_{sal} = .550$, $M_{NF} = .563$, $M_{NUnf} = .564$). These results indicate that participants underestimated durations for *Salient* words only. Furthermore, there was a main effect of Duration, $F(6, 552) = 1941.4$, $p < .001$, $\eta_p^2 = .910$, with observed power (1-β) = 1.00 (α = .05), showing that the p(long) values would increase as the time duration increased (respective means for 400 to 1600ms: .034, .101, .377, .670, .856, .906, and .944). No significant interaction of Word by Duration was observed, $F(12, 1104) = 0.740$, $p = .713$, $\eta_p^2 = .008$, with observed power (1-β) = 0.11 (α = .05).

BP Analysis

The BP values were entered into a one-way ANOVA with Word as the IV. There was a significant main effect, $F(2, 184) = 81.27$, $p = .016$, $\eta_p^2 = .062$, with observed power (1-β) = 0.68 (α = .05). Similarly, with the p(long) analysis, pairwise comparisons revealed significant differences in the BP values between Salient and Neutral words ($p < .001$) but not between Neutral Familiar and Neutral Unfamiliar words (Respective means: $M_{sal} = 933.89$, $M_{NF} = 914.49$, $M_{NUnf} = 916.12$). This again indicates that participants underestimated durations for Salient words compared to Neutral words.

WR Analysis

The WR values were entered into a one-way ANOVA with Word as the IV. There was no significant main effect, $F(2, 184) = 0.106$, $p = .899$, $\eta_p^2 = .001$, with observed power (1-β) = 0.07 (α = .05). This indicated no differences in temporal discriminability between *Salient* and *Neutral* words (Respective means: $M_{sal} = 0.204$,

M_{NF} = 0.198, M_{NUnf} = 0.200). A possible explanation for this finding could be that the associated words could elicit attentional effects (differences in BP values) but not arousal effects, hence no differences in WR values.

CIUS and Facebook modified CIUS correlations

The differences between each type of word were calculated for both BP and WR values. A correlational analysis was then carried out with the said differences and the CIUS and F/CIUS scores. CIUS and F/CIUS were highly correlated, $r = .608$, $p < .001$. No other significant correlations were discovered.

Experiment 8: Discussion

One remaining criticism for Experiments 5-7 had to with the fact that participants could have been more familiar with the Internet and Facebook stimuli compared to the neutral matched ones that were entirely novel. This posed the question whether the results were driven by familiarity and not addiction related salience per se. In order to address this question, we designed a novel memory association modified temporal bisection task where participants learned associations of non-words with different types of stimuli and then performed the temporal bisection task with the learnt non-words.

Our results indicated that familiarity was not driving the distorted time perception effects since there were no significant differences between familiar and unfamiliar non-words. The differences observed between Facebook associated and neutral associated non-words suggest that emotional content rather than familiarity of the Facebook stimuli is driving the temporal distortion as a result of preferential allocation of attentional resources. These findings are in line with previous findings of memory associated Stroop tasks using emotional or addiction related stimuli (Richards & Blanchette, 2004; Sharma & Money, 2010). Participants demonstrated attentional bias effects for the non-words associated with emotional and addiction related stimuli respectively. We can therefore safely conclude that Internet and Facebook related stimuli can distort our time perception as a result of attention and arousal effects elicited by their emotional content and not by our familiarity with them.

Chapter Conclusion

In conclusion, we believe that time perception in general, and the temporal bisection task specifically, can be a valuable tool in the study of addiction, substance-related or not at both theoretical and methodological levels. The overall findings of chapter 4 show clearly that the temporal bisection task can be used to demonstrate intrusive cognitions from *addiction* related stimuli. Furthermore, applying the *internal clock* model allows us to distinguish between attentional effects (*mode switch*) and arousal effects (*pacemaker*). This provides an advantage over other implicit tasks used in addiction research (e.g., dot-probe, Stroop) where intrusive cognitions can be detected but not distinguished between attention and arousal effects. Furthermore, in the case of IA, investigating time perception is even more important as one of the side-effects could be the time lost in the *net*. The current chapter also identified the need for further investigation on the differences in different types of IA. It would also be valuable to employ different paradigms from the time perception research (e.g. time production) and attempt to further distinguish the individual roles of attention and arousal. Finally, the role of memory was not examined at all in this chapter and it would be interesting to investigate how memory can interact with both attention and arousal under the predictions of the *internal clock* model and what the effects would be on time perception.

Chapter 5 : MEMORY LOAD

In the previous chapters, we explored the role of salient stimuli on time perception. We consistently reported that Gambling, Facebook or Internet related stimuli can lead to distorted time perception either due to attentional or arousal effects. As described earlier the internal clock also consists of a decision-making component that compares the perceived duration of a current event to the stored duration of the two standard events, short and long. It is apparent that this component heavily relies on working memory capacity for both storing durations and retrieving the standards durations. In this chapter, we will explore whether manipulating working memory capacity can affect the impact that salient stimuli have on time perception.

Experiment 9 *N-back*: Introduction

Previous research in time perception has established what is known as the interference effect (Brown, 1997a). In general, participants demonstrate distorted time perception when asked to perform demanding cognitive tasks together with temporal estimation or production (Block, Hancock, & Zakay, 2010b). One explanation is the effect manifests as an underestimation of the perceived duration due to the attentional *gate* being switched-off (*distraction*), while we attend to non-temporal tasks. Hence, this divided attention causes the temporal underestimation. A second, more holistic explanation, is the interference effect is due to increased *cognitive load*, either attentional or memory related. Theoretical support for such an interference effect comes from an attentional allocation model, as proposed by many researchers, which argues that attention is as a multi-dimensional system that shares resources with other cognitive functions (Block & Zakay, 1997; Brown, 1997b; L. Casini, Macar, & Grondin, 1992; Fortin, Rousseau, Bourque, & Kirouac, 1993; Grondin, 2010; Posner, 2012; Tsal, Shalev, & Mevorach, 2005; Dan Zakay & Block, 1996, 2004).

This dual approach of *distraction* or *cognitive load* has been supported by a number of studies (for a review see Block et al., 2010). However, Fortin et al., (1993) were among the first to argue that this interference affect is not a mere result of *distraction* or limited available *cognitive resources.* They proposed that the limited *cognitive resources* left for time keeping were not a result of complexity or difficulty but a result of *short-term memory* involvement. They conducted four experiments in total, with experiments 1 and 2 involving visual search and short-term memory and experiments 3 and 4 involving visual search but not short-term memory. In experiment one participants had to produce temporal intervals of 2-sec while performing a visual search of a target comparing it to a set of memorised items. The target could either be present or absent in each trial and the memory set could vary from one to six items. Results indicated that the temporal interval was lengthen as the memory set increased in items. In experiment two, the memory set was restricted to one item but the visual search presented stimuli would vary from one to five. The results were similar to experiment one. In the final two experiments, there was no short-memory component and no lengthening of the interval production was observed. This provided an initial support to the claim that restricting short-term memory related attentional resources could affect time perception. Furthermore, attentional load that is not related to short-term memory does not have a similar effect.

Despite the fact that temporal perception performance in dual-task paradigms has been investigated for the 30 years memory load is still relatively under-researched compared to other cognitive load dual-tasks (Block et al., 2010b). Furthermore, of the little research that has been published very few publications used emotional stimuli in the temporal processing task in dual-task paradigms and to the knowledge of the author there is no research that investigated how memory load would affect time perception when the temporal task includes addiction-related stimuli. This is despite the fact that dual-task paradigms have been used in experimental paradigms with addiction related stimuli both with healthy and clinical populations (e.g., Christiansen, Schoenmakers, & Field, 2015; Cox, Fadardi, Intriligator, & Klinger, 2018; Cox et al., 2006; Field, Marhe, & Spectrums, 2014; Matt Field & Cox, 2008).

Non-substance addiction theories such as Franken’s (2003), Kavanagh et al., 2005), Tiffany's cognitive model on drug urges (1990), Griffiths' (2005) argue that attentional bias towards addiction related stimuli is an automatic process that relies on salience of said stimuli. This salience activates a process of elaborate intrusive thoughts that can distract participants from the given task. It is therefore valuable to investigate how memory related cognitive load would affect this salience effect.

Previous research has demonstrated that in Stroop tasks increased working memory load resulted in greater distractor interference (de Fockert, Rees, Frith, & Lavie, 2001; Konstantinou, Beal, King, & Lavie, 2014; Lavie, Beck, & Konstantinou, 2014.; Lavie & De Fockert, 2005). Lavie and de Fockert (2005) conducted a series of experiments where they manipulated the working memory load in a visual search task. Participants had to look for a diamond shape among circles and report the orientation of a line inside it. Furthermore, some trials included a coloured singleton as a distractor. At the beginning of each trial, a number of digits had to be memorised and at the end of the visual search a single digit was presented. Participants had to recall the digit that followed the probe in the learnt sequence. Results indicated that the singleton distractor effect was greater under increased memory load. Lavie's load theory of attention (2005) proposed a cognitive control model where distractors have reduced interference effects when cognitive resources are available to be allocated to the task at hand. In other words, low cognitive load should result in lesser distractor interference compared to high cognitive load.

Since then large volume of research has mainly reported findings that support Lavie's model (for review and historical context see Konstantinou et al., 2014; Lavie et al., 2013.). There are however instances where findings pointed to exact opposite direction. Berggren, Richards, Taylor, and Derakshan (2013) conducted an experiment where participants had to perform an antisaccade task under cognitive load. The antisaccade task involved seeing expressions of angry, happy, or neutral faces and the load task involved recognising auditory tones. Their findings indicated that under low load there were differences in performance depending on the emotion of the face and that these differences disappeared in increased load. Specifically, participants demonstrated slower saccade latencies under high load compared to low load. Furthermore, post-hoc analysis indicated that there were no expression differences for high load whereas for low load participants demonstrated higher latencies for angry faces and lower latencies for happy faces. These results provided support for Dillen and Koole's proposition (2009) that vigilance towards emotional content is not automatic but rather a top-down process that is controlled by working memory. Therefore, it is crucial that the effect of salient distractors in our time perception is investigated under high and low cognitive load.

The current experiment aimed at investigating the effects of memory load on salience effects in a temporal bisection task. Given the conflicting findings proposed by two distinct models (Lavie's and Dillen and Koole's) this exploration will also provide more support on whether memory load facilitates or inhibits distractors' interference effects. We manipulated the memory load by utilising the N-back task. Specifically, we used 1-back for low memory load and 2-back for high memory load interleaved with Facebook and Internet modified temporal bisection trials as described in the previous two chapters.

Experiment 9 *N-back*: Method

Participants

In total, 81 participants were recruited for this experiment (10 males and 71 females) via the RPS website. All participants were students at the University of Kent aged between 18 and 31 (M = 18.92, SD = 1.68). Participants were required to have an active Facebook account in order to be allowed to complete the experiment.

Design

This was a mixed-design experiment with Image (Facebook, Internet), Salience (Salient, Neutral), Duration (400, 600, 800, 1000, 1200, 1400, 1600ms), Difficulty (1-back, 2-back) being within-subjects factors and Order (1-back First, 2-back First) being a between-subjects factor. Participants had to report the duration of presented events as either *long* or *short*. These responses were used to calculate the dependent variable of *p(long)* as the proportion of *long* responses over the total number of trials. The *p(long)* responses were further used to obtain the Bisection Point (BP) and the Weber's Ratio (WR) psychometrics. Furthermore, for the N-back task they had to report whether the current trial was matching a previous trial. These responses were used to calculate the average of correct responses.

Materials

This experiment employed a dual task combining the TB task used in previous experiments (e.g., Exp 5, Chapter 4) and a 1-back and 2-back tasks. As such, the materials used for the TB trials were as mentioned in the previous experiments (140 trials). For both the 1-back and 2-back tasks single digit numbers were used and were presented in pseudo-randomised order with 40% matched trials and 60% non-matched trials (140 trials). Participants were instructed that they had up to three seconds to respond and they should try to do so as fast and as accurate as they can. Furthermore, Young's YIAT was used as in previous experiments. For a snapshot of Experiment 9 see Figure 15

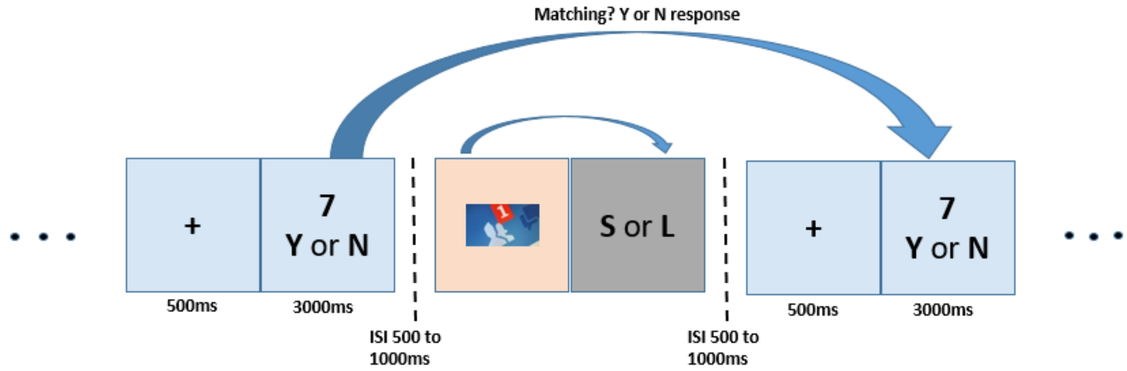


Figure 15. Snapshot of the dual task showing a matching 1-back trial and a temporal bisection trial

Procedure

After being briefed and providing consent, each participant completed the experiment in individual cubicles. The experiment was comprised of two separate phases of the dual task with *low difficulty* (1-back) and *high difficulty* (2-back). Participants would first complete the *low difficulty* or *high difficulty* depending on the level of *Order* that they were randomly assigned at. Each phase included a training block for the relevant N-back task, 15 trials (33% matched, 67% non-matched), and then training blocks for the TB task as described in earlier experiments. Following that, they would complete the dual task, including the relevant N-back task. Upon completing one phase participants would then proceed to complete the other *difficulty* phase. Finally, all participants would complete Young's YIAT. They would then be thanked for their participation and reminded them of their rights as participants.

Experiment 9: Results

Data Preparation

For each participant the mean correct responses were calculated for the 1-back and 2-back trials. Furthermore, for the TB trials the *p(long)* was calculated per Image, Salience, and Duration. Furthermore, the BP and WR scores were calculated per Image and Salience. Any participant with N-back mean below 60% and BP outside the 400 and 1600ms was excluded from the analysis. This resulted in dropping 16 participants.

N-back Analysis

The mean correct responses were entered into a two-way ANOVA with Difficulty (low, high) and Order (1-back first, 2-back first). There was a main effect of Difficulty, $F(1, 63) = 175.68$, $p < .001$, $\eta_p^2 = .736$. This indicated that performance was significantly worse for the 2-back task ($M_{2\text{-back}} = .77$, $SD_{2\text{-back}} = .083$) compared to the 1-back task ($M_{1\text{-back}} = .90$, $SD_{2\text{-back}} = .057$). This was expected and was in line with previous research. There was no main effect of Order, $F(1, 63) = 2.46$, $p = .122$, $\eta_p^2 = .038$. Indicating there was no overall difference in participants' N-back accuracy depending on which task they did first ($M_1 = .85$, $SD_1 = .06$, $M_2 = .82$, $SD_2 = .07$. There was a significant interaction of Difficulty by Order, $F(1, 63) = 14.85$, $p < .001$, $\eta_p^2 = .191$. Further post-hoc analysis revealed a significant simple main effect of Order for the 2-back task ($p = .003$, $M_1 = .80$, $SD_1 = .05$, $M_2 = .74$, $SD_2 = .06$) but not for the 1-back task ($p = .280$, $M_1 = .89$, $SD_1 = .03$, $M_2 = .90$, $SD_2 = .05$). This indicated that participants found the 2-back task significantly more difficult when it was completed first, compared to when it was completed second. This could be due to participants becoming better at the task when they completed the easier task first.

P(long) Analysis

The *p(long)* values were entered into a 5-way ANOVA with Difficulty, Image, Salience, Duration as within-subjects factors, and Order as between-subjects factor. There was a main effect of Difficulty, $F(1, 63) = 15.377$, $p < .001$, $\eta_p^2 = .196$, with observed power $(1-\beta) = 0.97$ ($\alpha = .05$). This indicated that participants overestimated time in the *low* difficulty ($M_{\text{low}} = .61$, $SD_{low} = .06$) compared to the *high* difficulty ($M_{\text{high}} = .57$, $SD_{high} = .07$). This could be due to the easier task allowing more cognitive resources to be allocated to the time keeping compared to the more difficult task. Hence, increasing attention on the TB task, which has been found in the past to lead to time overestimation.

There was also a main effect of Duration, $F(6, 378) = 916.13$, $p < .001$, $\eta_p^2 = .936$, with observed power (1-β) = 1.00 (α = .05) (respective means for 400 to 1600ms: .066, .166, .451, .729, .853, .918, and .937). This was as expected and in line with all previous experiments and research. All other main effects were non-significant (all *F's < 2.14, p's > .14*)

There was a significant interaction of Image by Salience, $F(1, 63) = 4.79$, $p = .032$, $\eta_p^2 = .071$, with observed power (1-β) = 0.58 (α = .05) and a significant interaction of Image by Salience by Duration, $F(6, 378) = 4.61$, $p < .001$, $\eta_p^2 = .068$, with observed power (1-β) = 0.92 (α = .05). Following up post-hoc analysis revealed significant differences between Salient and Neutral Facebook images for the Durations of: 600ms, $p = .015$; 800ms, $p = .002$; 1000ms, $p = .002$, 1600ms, $p = .02$. Detailed comparisons between Image and Salience see Figure 16.

Finally, there was a significant Difficulty by Salience by Duration by Order interaction, $F(6, 378) = 2.23$, $p = .039$, $\eta_p^2 = .034$, with observed power (1-β) = 0.78 (α = .05). This included a number of two-way and three way-interactions that were significant (all *p*'s < .05, Difficulty by Order, Difficulty by Duration, Difficulty by Duration by Order, Salience by Duration, Salience by Duration by Order). Post-hoc analysis indicated that there were more durations that varied significantly between salient and neutral stimuli when the task was easier (1-back first, 2-back second) compared to when the task was more difficult (2-back first, 1-back second). For more details, including p-values see Figure 17.

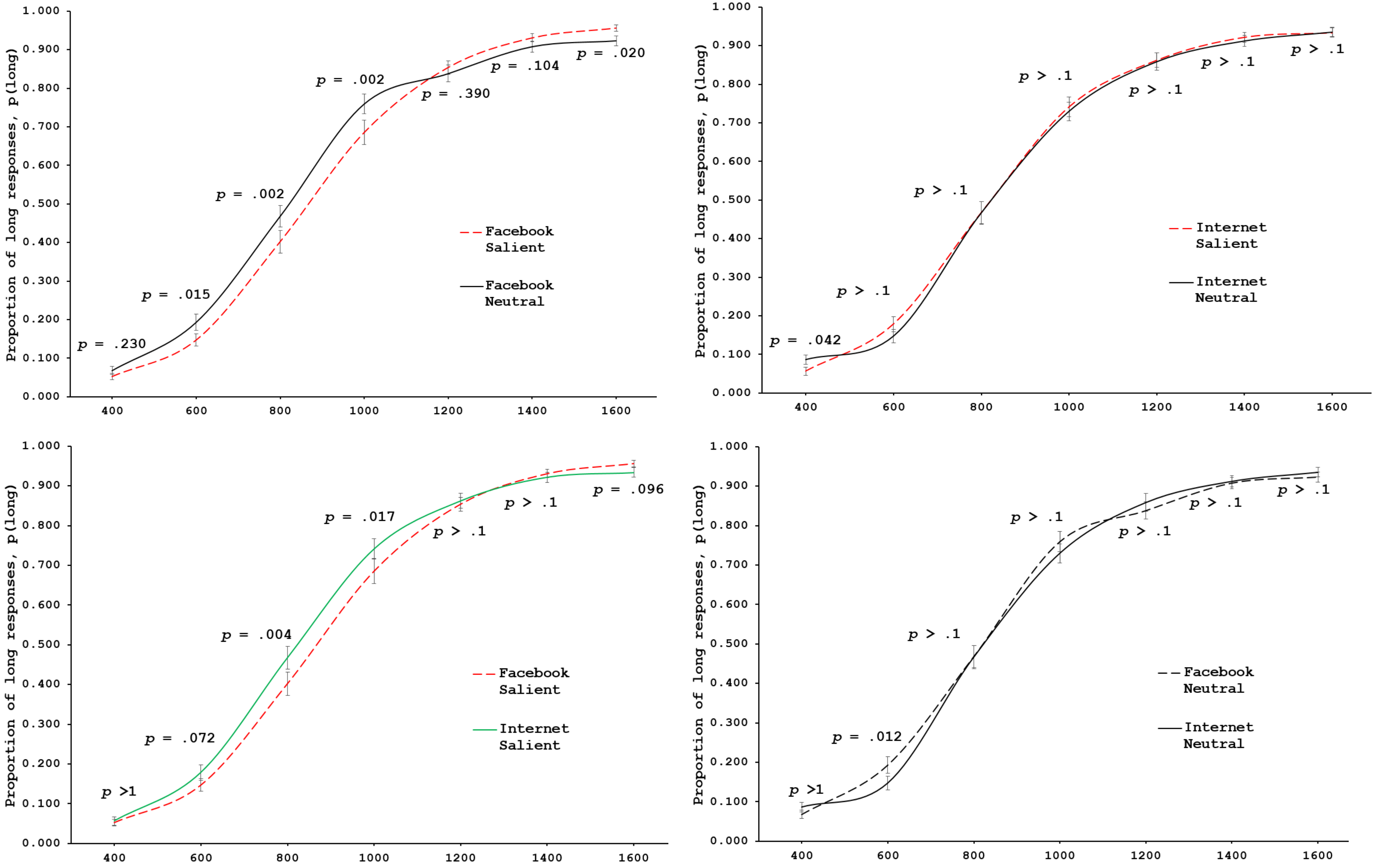


Figure 16 Image by Salience by Duration Interaction. Comparisons of Image and Salience per Duration

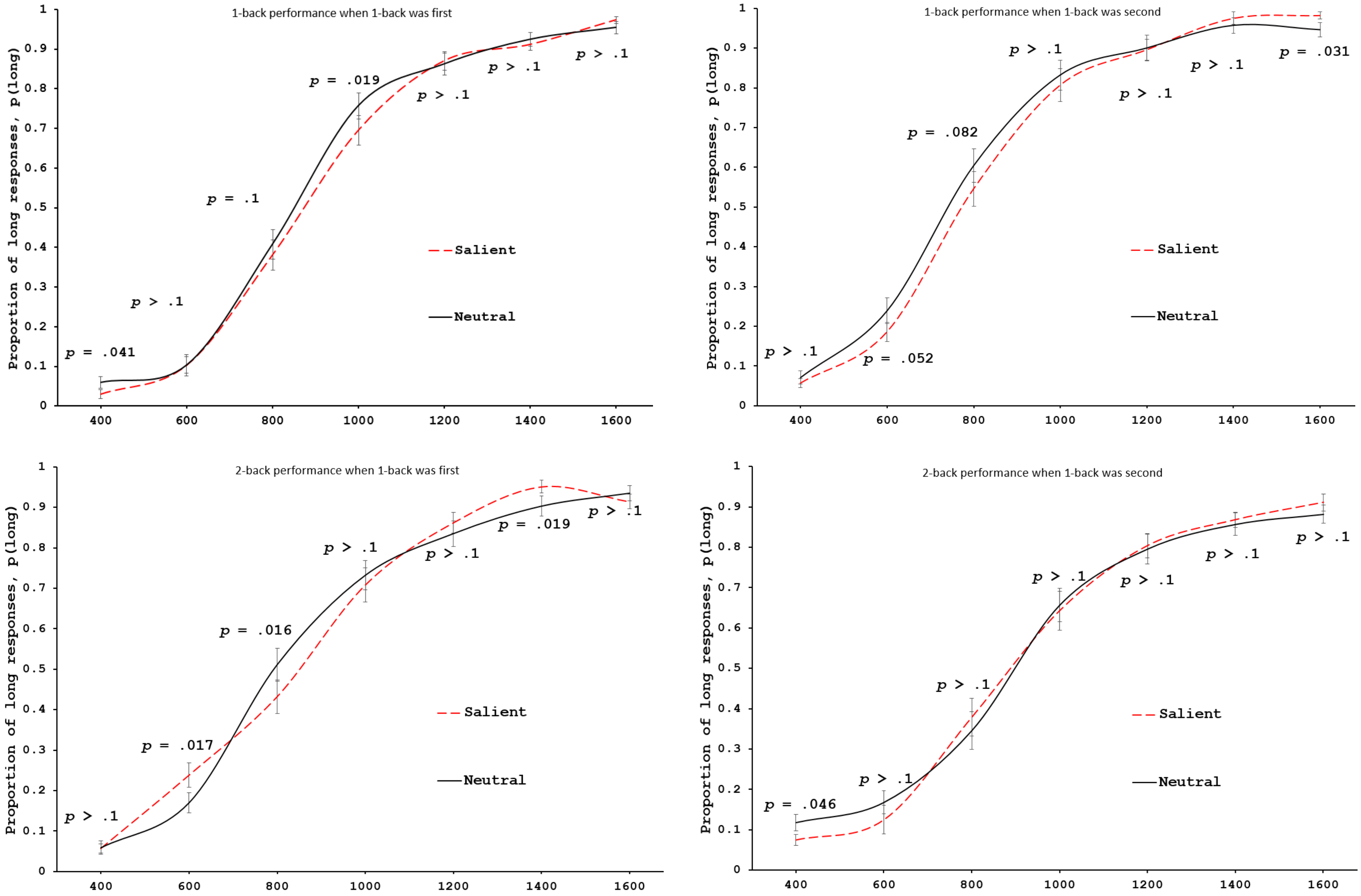


Figure 17 Difficulty by Salience by Duration Interaction presented by Order.

BP Analysis

The BP values were entered into a four-way Anova with Difficulty, Image, Duration, and Order as factors. There was a significant main effect of Difficulty, $F(1, 63) = 13.47$, $p = .001$, $\eta_p^2 = .176$, with observed power (1-β) = 0.95 (α = .05). This indicated that participants had lower BP value, hence overestimated time, for the *low* difficulty ($M_{\text{low}} = 847.54$, $SD_{low} = 138.77$) compared to the *high* difficulty ($M_{\text{high}} = 906.01$, $SD_{high} = 183.98$). This finding is in line with the *plong* analysis.

There was a also a significant Difficulty by Order interaction, $F(1, 63) = 28.90$, $p < .001$, $\eta_p^2 = .314$, with observed power (1-β) = 1.00 (α = .05) and a significant Difficulty by Image by Salience by Order interaction, , $F(1, 63) = 28.90$, $p = .043$, $\eta_p^2 = .098$, with observed power (1-β) = 0.83 (α = .05). Follow up post-hoc analysis revealed a significant simple main effect of Salience for the Facebook images during the 1-back task only when the 1-back task was presented second, $p = .016$ (respective means: $M_{\text{Sal}} = 820.06$, $SD_{Sal} = 203.11$; $M_{\text{Sal}} = 770.14$, $SD_{Sal} = 236.96$). All other pairwise comparisons were non-significant (all *p*'s > .05). Similarly, to the *plong* analysis, this finding suggests that we only observe salience effects in *low* difficulty and not in *high* difficulty. All other main effects and interactions were non-significant.

WR Analysis

The WR values were entered into a four-way Anova with Difficulty, Image, Duration, and Order as factors. There was a significant main effect of Difficulty, $F(1, 63) = 20.45$, $p < .001$, $\eta_p^2 = .245$, with observed power (1-β) = 0.99 (α = .05) . This indicates that participants had lower WR values for the *low* difficulty compared to the *high* difficulty, hence better temporal discriminability ($M_{\text{low}} = 0.200$, $SD_{low} = 0.08$; $M_{\text{high}} = .251$, $SD_{high} = 0.08$). According to (Gonidis & Sharma, 2017) lower WR values could be interpreted as evidence of increased arousal, indicating that emotional effects on participants were greater for the *low* difficulty.

There was also a main effect of Salience, $F(1, 63) = 12.98$, $p = .001$, $\eta_p^2 = .171$. This indicates that participants had lower WR values for the *salient* compared to *neutra*l stimuli, hence better temporal discriminability ($M_{\text{Sal}} = 0.213$, $SD_{Sal} = 0.07$; $M_{\text{Neut}} = .238$, $SD_{Neut} = 0.08$). Similarly, with the above this could be an indication that salient stimuli were associated with increased arousal compared to neutral stimuli.

Furthermore, the Salience by Order interaction was significant, $F(1, 63) = 6.11$, $p = .016$, $\eta_p^2 = .088$. Post-hoc analysis revealed that the WR differences between salient and neutral stimuli were greater when the 1-back task was presented second ($M_{\text{Sal}} = 0.212$, $SD_{Sal} = 0.09$; $M_{\text{Neut}} = .283$, $SD_{Neut} = 0.09$; $p < .001$) compared to when it was presented first ($M_{\text{Sal}} = 0.215$, $SD_{Sal} = 0.08$; $M_{\text{Neut}} = .222$, $SD_{Neut} = 0.08$; $p > .1$).

Finally, there was a marginally non-significant interaction of Image by Salience, $F(1, 63) = 3.88$, $p = .053$, $\eta_p^2 = .058$. Follow up analysis revealed that there was a significant simple main effect of Salience only for the Facebook images (Facebook: $M_{\text{Sal}} = 0.203$, $SD_{Sal} = 0.07$; $M_{\text{Neut}} = .247$, $SD_{Neut} = 0.08$; $p = .001$) and not the Internet images (Internet: $M_{\text{Sal}} = 0.223$, $SD_{Sal} = 0.08$; $M_{\text{Neut}} = .228$, $SD_{Neut} = 0.08$; $p = .693$). This again suggests Facebook stimuli seem to be driving the temporal distortion effects. All other main effects and interactions were non-significant.

YIAT Scores and Correlational Analysis

The YIAT scores varied from 4 to 74 ($M_{YIAT} = 34.91$, $SD_{YIAT} = 13.32$). Twenty-three participants had scores between 4 and 30, 36 had scores between 31 and 49, and five had scores between 50 and 79. There were no participants with scores higher than 80 that would indicate significant problems due to use of Internet (Young, 1998). Furthermore, we ran correlational analysis between the YIAT scores and the attentional bias scores (*salient –neutral)* in BP and WR for each image type and difficulty. All correlations were non-significant (r's < .173, p's > .090).

Experiment 9 N-back: Discussion

The aim of this experiment was to explore the impact of working memory load on time perception. On the effects of working memory load on time perception in general, previous research has consistently reported that increasing working memory load results in overall underestimation of durations. This finding was successfully replicated in the current experiment in terms of *p(long)* and BP values where increased difficulty resulted in underestimation of durations. This provides further support to the attentional allocation model and indeed supports the notion that attention is a multi-dimension system that shares a pool of resources with other cognitive functions (Block & Zakay, 1997; Brown, 1997b; L. Casini et al., 1992; Fortin et al., 1993; Grondin, 2010; Posner, 2012; Tsal et al., 2005; Dan Zakay & Block, 1996, 2004). Furthermore, participants exhibited lower WR values in *low difficulty* compared to *high difficulty.* Lower WR values are associated with better temporal discriminability. This finding provides further support to the argument of shared attentional resources as participants' discriminability deteriorates as difficulty increases.

The second aim of the study was to investigate the impact of increased working memory load on the interference of the salient stimuli on time perception. Previous research has provided support for either of the two conflicting approaches proposed by Lavie (2005) and Dillen and Koole (2009). Lavie proposed a model where effects of distractors increases when we are deprived of cognitive resources to suppress them. In other words, increased working memory load should result in increased interference of salient stimuli on time perception. On the other hand, Dillen and Koole proposed that the impact of emotional stimuli is not an automatic process and requires availability of working memory resources. In other words, restricting working memory related resources should result in reduced salient stimuli interference.

Our findings provide further support for the Dillen and Koole approach. Both *p(long)* and BP values indicated that salient interference on time perception was observed in *low difficulty* but not in *high difficulty*. Therefore, the availability of working memory resources is crucial for the manifestation of such effects. This also seems to support the conceptual Elaborated Intrusion Theory (EI, Kavanagh et al., 2005). Kavanagh proposed that in the presence of external cues, automatic processes initiate an activation of desire thoughts. These desire thoughts, relying on attentional and working memory mechanisms, activate addiction related thoughts and engage further with the external cues. The outcome of this process is a perpetual cycle where external cues activate desire thoughts and desire thoughts reinforce the impact of external cues. This experiment is the first to propose that when working memory resources are not available in the first instance the initial desire thought activation process does not escalate to a perpetual cycle. This can potentially have great implications on prevention of relapse in addiction. A preoccupied and engaged with other activities mind might be as crucial (or even more) as abstaining is.

Further support to the above argument as well as to the EI theory itself comes from our WR analysis. Participants overall demonstrated better discriminability when observing salient stimuli. This could be an indication that these external cues led to an activation of desire thoughts that in turn increased arousal. We have proposed in the past that lower WR values should be associated with increased arousal (Gonidis & Sharma, 2017). However, when the difficulty of the task increased the WR values also increased resulting in worse discriminability. This indicates, as above, that reduced availability of working memory resources prevented external cues from putting the perpetual cycle in motion.

Experiment 10 Sternberg: Introduction

With the previous experiment we attempted to provide supporting evidence for either of the conflicting approaches proposed by Lavie (2005) and Dillen and Koole (2009). The former proposed that reduced cognitive resources would enhance distractors effects as we lack the means to suppress their impact on our attention. The latter proposed that distractors need available cognitive resources in order to initiate a cycle of intrusive thoughts. Our results clearly supported the findings of Dillen and Koole (2009). However, since Experiment 9 was the first such experiment, to the best knowledge of the authors, that included memory load manipulation on an addiction modified temporal bisection task, it is vital that we replicate these findings.

In Experiment 10, we employed the same temporal task and we manipulated the memory load utilising a Sternberg memory task that included a *low* and a *high* memory load block. In the *low* memory load (*low difficult*) participants had to memorise four consonants and in the *high* memory load (*low difficult*) eight consonants. *We* hypothesised, in line with previous research, that there would be an overall greater underestimation of temporal perception in high load compared to low load. Furthermore, based on the findings from Experiment 9, we hypothesised that as memory load increased the effects of salient stimuli on time perception would diminish. As such, we expected that in the *low* memory load participants would underestimate durations for salient stimuli compared to neutral ones and this underestimation would be reduced or even disappear altogether in the *high* memory load.

Experiment 10 Sternberg: Method

Participants

In total, 88 participants were recruited for this experiment (12 males and 76 females) via the RPS website. All participants were students at the University of Kent aged between 18 and 48 (M = 20.36, SD = 5.20). Participants were required to have an active Facebook account in order to be allowed to complete the experiment.

Design

This was a mixed-design experiment with Image (Facebook, Internet), Salience (Salient, Neutral), Duration (400, 600, 800, 1000, 1200, 1400, 1600ms), Difficulty (Low, High) being within-subjects factors and Order (Low First: 1, High First: 2) being a between-subjects factor. Participants had to report the duration of presented events as either *long* or *short*. These responses were used to calculate the dependent variable of *p(long)* as the proportion of *long* responses over the total number of trials. The *p(long)* responses were further used to obtain the Bisection Point (BP) and the Weber's Ratio (WR) psychometrics. Furthermore, for the Sternberg task participants had to report whether the presented letter was included in the learnt sequence of letters. These responses were used to calculate the ratio of correct responses over total number of trials.

Materials

This experiment employed a dual task similar to Experiment 9. However, instead of the n-back task the Sternberg task was used together with the TB task. The two difficulties of the Sternberg task involved participants having to memorise a sequence of either four (Low) or eight consonants (High). Participants were instructed that they had up to two seconds to respond and they should try to do so as fast and as accurate as they can. Furthermore, Young's YIAT was used as in previous experiments. For a snapshot of Experiment 10 see Figure 18

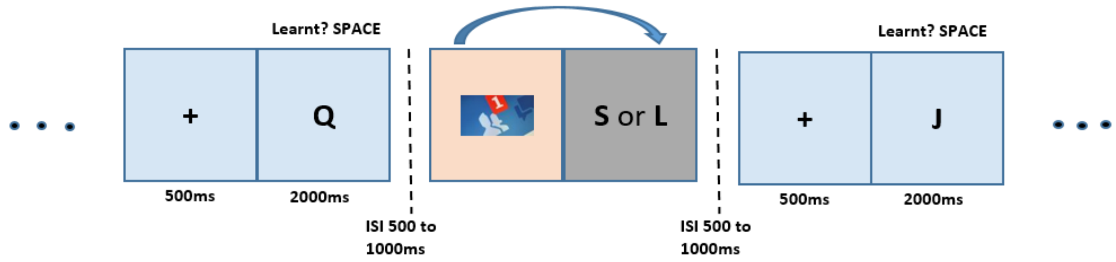


Figure 18 Snapshot of the Sternberg and TB dual task.

Procedure

After being briefed and providing consent, each participant completed the experiment in individual cubicles. The experiment was comprised of two separate phases of the dual task with *low difficulty* (four letters) and *high difficulty* (eight letters). Participants would first complete the *low difficulty* or *high difficulty* depending on the level of *Order* that they were randomly assigned at. Each phase included a training block for the relevant difficulty and then training blocks for the TB task. The training block for the Sternberg task comprised of 12 trials with 4 learnt and 8 non-learnt characters. Participants would also get feedback on whether their response was correct or not. Upon completing one phase, participants would then proceed to complete the other *difficulty* phase. Finally, all participants would complete Young's YIAT. They would then be thanked for their participation and reminded them of their rights as participants.

Experiment 10: Results

Data Preparation

For each participant the mean correct responses were calculated for the *low* and *high* difficulty. Furthermore, for the TB trials the *p(long)* was calculated per Image, Salience, and Duration. The BP and WR scores were calculated per Image and Salience. Any participant with Sternberg performance below 60% and BP outside the 400 and 1600ms was excluded from the analysis. This resulted in dropping 21 participants.

Sternberg Analysis

The mean correct responses were entered into a two-way ANOVA with Difficulty (low, high) and Order (Low First: 1, High First: 2). There was a main effect of Difficulty, $F(1, 82) = 240.03$, $p < .001$, $\eta_p^2 = .745$. This indicated that performance was significantly worse for the High Difficulty ($M_{High} = .79$, $SD_{High} = .046$) compared to the Low Difficulty ($M_{Low} = .97$, $SD_{Low} = .10$). This was expected and is in line with previous research and supports further the findings in Exp 9. There was no main effect of Order, $F(1, 82) = 1.21$, $p = .274$, $\eta_p^2 = .015$. Indicating there was no overall difference in participants' Sternberg performance depending on which task they performed first ($M_1 = .88$, $SD_1 = .08$, $M_2 = .87$, $SD_2 = .08$.

The interaction of Difficulty by Order was also significant, $F(1, 65) = 5.342$, $p = .023$, $\eta_p^2 = .061$. Further post-hoc analysis revealed significant simple main effects of Difficulty for the Low First Order ($p < .001$, $M_{Low} = .97$, $SD_{Low} = .06$, $M_{High} = .81$, $SD_{High} = .15$) and for High First Order ($p < .001$, $M_{Low} = .98$, $SD_{Low} = .05$, $M_{High} = .77$, $SD_{High} = .14$).

P(long) Analysis

The *p(long)* values were entered into a 5-way ANOVA with Difficulty, Image, Salience, Duration as within-subjects factors, and Order as between-subjects factor. There was a main effect of Difficulty, $F(1, 65) = 6.70$, $p = .012$, $\eta_p^2 = .093$, with observed power $(1-\beta) = 0.72$ ($\alpha = .05$). This indicated that participants overestimated time in the *low* difficulty ($M_{Low} = .553$, $SD_{Low} = .06$) compared to the *high* difficulty ($M_{High} = .531$, $SD_{High} = .07$). This again supports the notion that increasing the cognitive resources that available to time keeping can lead to overestimating temporal durations.

There was also a main effect of Duration, $F(6, 390) = 827.07$, $p < .001$, $\eta_p^2 = .927$, with observed power $(1-\beta) = 1.00$ ($\alpha = .05$) (respective means for 400 to 1600ms: .047, .096, .336, .646, .818, .907, and .945). This, similarly to Experiment 9, was expected and was in line with all previous experiments and research employing TB. All other main effects were non-significant (all $F\text{'s} < 3.4$, $p\text{'s} > .07$)

There was a significant interaction of Difficulty by Image, $F(1, 65) = 5.04$, $p = .028$, $\eta_p^2 = .072$, with observed power $(1-\beta) = .60$ ($\alpha = .05$). Following up post-hoc analysis revealed significant differences between low and high difficulty only for the Facebook images and not for the Internet images, p = .002.

There was also a significant interaction of Difficulty by Salience, $F(1, 65)$ = 4.65, p = .035, η_p^2 = .067, with observed power (1-β) = 0.57 (α = .05). Following up post-hoc analysis revealed significant differences between Salient and Neutral images in *low difficulty* (respective means: M_{Sal} = .545, SD_{Sal} = .013; M_{Neu} = .562, SD_{Neu}= .014, p = .023) but not in the *high difficulty* (respective means: M_{Sal} = .533, SD_{Sal} = .014; M_{Neu} = .529, SD_{Neu}= .016, p = .676). This was in line with the prediction that increasing difficulty would result in eliminating salience effects and replicated the Experiment 9 findings.

Finally, there was a significant Difficulty by Duration by Order interaction, $F(6, 390)$ = 3.86, p < .001, η_p^2 = .089. This also included a Difficulty by Duration interaction, p =.001. Post-hoc analysis indicated that there were durations that varied significantly depending on the Order that the Sternberg *difficulty* was presented.

BP Analysis

The BP values were entered into a four-way Anova with Difficulty, Image, Salience, and Order as factors. There was a significant main effect of Difficulty, $F(1, 65)$ = 7.05, p = .01, η_p^2 = .098, with observed power (1-β) = 0.74 (α = .05). This indicated that participants had lower BP value, hence overestimated time, for the *low* difficulty (M_{low} = 925.95, SD_{low}= 158.02) compared to the *high* difficulty (M_{high} = 962.37, SD_{high}= 181.95). This finding is in line with the *plong* analysis and provides further evidence that increased difficulty leads to underestimation of time.

There was a also a significant Difficulty by Order interaction, $F(1, 65)$ = 16.71, p < .001, η_p^2 = .204, with observed power (1-β) = 0.98 (α = .05). Follow up post-hoc analysis revealed a simple main effect of Difficulty only when *high difficulty* was presented first (p < *.001*; respective means: M_{low}= 959.54, SD_{low} = 231.66; M_{high} = 939.90, SD_{high}= 266.30) and not when *low difficulty* was presented first (p = *.332*; respective means: M_{low}= 892.37, SD_{low} = 214.97; M_{high} = 984.84, SD_{high}= 247.12). This seems to indicate that presenting *low difficulty* first gives enough practice to participants and reduces how challenging the find the following task. On the other hand, presenting the *high difficulty first* results in increased difficulty.

There was also a significant Difficulty by Image interaction, $F(1, 65)$ = 5.24, p

= .025, η_p^2 = .075, with observed power (1-β) = 0.62 (α = .05), with post-hoc analysis revealing significant differences between the two images only for *high difficulty*, *p = .017*. Finally, there was a significant Difficulty by Salience interaction, *F*(1, 65) = 5.24, *p* = .025, η_p^2 = .075, with observed power (1-β) = 0.62 (α = .05), with post-hoc analysis revealing significant differences between Salient and Neutral stimuli for *low difficulty* (*p* = .034) but not for *high difficulty* (*p* = .393). This again provides support that increased difficulty eliminates any salience interference in the temporal bisection task. All other main effects and interactions were non-significant (all *p's* > .05). In addition, four separate paired samples t-tests were carried out in order to acquire a more detailed view on the differences between types of images and salience per difficulty. We discovered that salient Facebook images differed from the neutral Facebook images only for the low difficulty, *t*(66) = 2.646, *p* = .01, *d* = 0.32, 95% CI[10.88, 77.80], indicating a small effect size. The three remaining t-tests were non-significant, all *p*'s > .217.

WR Analysis

The WR values were entered into a four-way Anova with Difficulty, Image, Salience, and Order as factors. There was a significant Difficulty by Group interaction, *F*(1, 65) = 8.07, *p* = .006, η_p^2 = .110, with observed power (1-β) = 0.80 (α = .05). Post-hoc analysis indicated a significant simple main effect of Difficulty only when *low difficulty* was presented first, (*p* = .006; respective means: M_{low}= .154, SD_{low} = .020; M_{high} = .205, SD_{high}= .014). This is supportive of previous finding that the order of presentation affects the perceived difficulty and when difficulty is lower, differences are observed. There were no other significant main effects nor interactions (all *p*'s > .1).

YIAT Scores and Correlational Analysis

The YIAT scores varied from 0 to 70 (M_{YIAT} = 26.63, SD_{YIAT} =13.72). Forty-four participants had scores between 0 and 30, 18 had scores between 31 and 49, and five had scores between 50 and 79. There were no participants with scores higher than 80 that would indicate significant problems due to use of Internet (Young, 1998). Furthermore, we ran correlational analysis between the YIAT scores and the attentional bias scores (*salient –neutral)* in BP and WR for each image type and difficulty. All correlations were non-significant (*r*'s < .107, *p*'s > .146).

Experiment 10: Discussion

The main aim of this experiment was to replicate the findings of Experiment 9. Specifically, to provide more evidence on the effects of increased memory load on the temporal distortion caused by salient stimuli. Our findings were similar to the ones in Experiment 9 and provided further support for the Dillen and Koole findings (2009. Both *p(long)* and BP values indicated that salient interference on time perception was observed in *low difficulty* but not in *high difficulty*. Therefore, the availability of working memory resources is crucial for the manifestation of such effects. This also seems to support the conceptual Elaborated Intrusion Theory (EI, Kavanagh et al., 2005). Kavanagh proposed that in the presence of external cues, automatic processes initiate an activation of desire thoughts. These desire thoughts, relying on attentional and working memory mechanisms, activate addiction related thoughts and engage further with the external cues. The outcome of this process is a perpetual cycle where external cues activate desire thoughts and desire thoughts reinforce the impact of external cues. This experiment provided more evidence that when working memory resources are not available in the first instance the initial desire thought activation process does not escalate to a perpetual cycle.

Furthermore, consistent with previous research and Experiment 9, we found that increasing working memory load results in overall underestimation of durations (both in terms of BP and *p(long))*. This provides further support to the attentional allocation model that attention is a multi-dimension system that shares a pool of resources with other cognitive functions (e.g., Block & Zakay, 1997; Dan Zakay & Block, 1996, 2004).

Even though we mostly replicated the findings of Experiment 9 it is also vital to highlight that the two experiments besides similarities they also differed in terms of WR results. Indeed, in Experiment 10 we did not observe differences in the WR of salient stimuli across difficulties. A possible explanation of this could be that the Sternberg task is not as difficult as the *N-back* task. Therefore, even though the *high difficulty* in Experiment 10 was difficult enough to lead to BP changes perhaps it was not difficult enough to lead to WR changes. A possible future investigation should also use a more difficult version of the Sternberg (e.g, 4 digits vs 8 vs 12) task or even use both *N-back* and *Sternberg* task in the same experiment in order to shed more light on the similarities and difficulties of the two tasks.

Chapter Conclusion

In conclusion, the two experiments in this chapter successfully replicated previous research and at the same time added novel evidence. We have successfully replicated our previous findings that Internet and Facebook related stimuli could lead to distorted time perception and better discriminability of temporal durations. Furthermore, we provided more evidence that increasing working memory load results in overall underestimation of durations which supports the attentional allocation model that attention is a multi-dimension system that shares a pool of resources with other cognitive functions. Finally, we provided novel evidence that in a temporal bisection task, salient stimuli interference relies on the availability of working memory resources and once these are restricted, interference is eliminated.

Chapter 6 THESIS GENERAL DISCUSSION

Overview Across Chapters

The aim of this thesis was to investigate the potential effects of addiction related stimuli on our time perception. Specifically, since addiction models (e.g., EI) and ICM both account for attentional, arousal, and memory load effects we explored how these three factors can independently, or in conjunction, affect out time perception. In the chapter, I will provide a general overview of addiction theories that could account for the discovered attentional biases. I will also discuss SET and ICM outlining the roles of attentional switch and arousal. Furthermore, I will provide the rationale behind this investigation and highlight the novelty of my findings and the novel contribution they make to addiction models and ICM.

In chapter 2, I aimed to replicate previously established attentional biases in Poker players towards gambling related stimuli using a modified Stroop paradigm (Experiment 1). This was done in order to establish a point of reference for AB that I could later on build upon to explore for AB in time perception in the form of distorted temporal perceptions and discriminability. Then I aimed to expand these findings in to Facebook/Internet related stimuli in a general student population (Experiment 2). Even though, for the latter, the participants were not problematic Facebook/Internet users attentional bias towards *salient* stimuli was still discovered.

Focusing on Experiment 1, I observed two interesting findings. First, Poker players were overall faster in reporting the colours of all stimuli compared to the control group participants. This finding provides further support to the claim that salient stimuli can activate a dopaminergic cycle and therefore increase arousal that in turn could facilitate overall quicker responses (Franken, 2003; Robinson & Berridge, 1993). Second, the Poker players were slower in reporting the colour of gambling related stimuli compared to neutral stimuli. This supports the predictions made by Tiffany (1990) that addiction is guided by automatic processes and by EI that external cues can activate desire thoughts (Kavanagh et al., 2005). The *desire thoughts* conflicted with the task in hand and therefore slowed down responding the colour of the stimuli. This effect was further reinforced when two gambling related stimuli were presented in succession and when Poker players stared at a gambling related stimulus for longer. The prolonged exposure leading to stronger AB could be explained by EI as a result of maintaining the *subjective state of desire* for longer therefore, increasing the effect of associated intrusive thoughts.

In Experiment 2, Facebook users completed a novel Facebook/Internet modified Stroop and the AB effects were similar to Experiment 1. Participants were slower in responding the colour of *salient* stimuli compared to neutral stimuli. This was a novel finding that relevant literature had not explored yet. As discussed above, this AB is in line with both Tiffany's work and EI. Furthermore, *slow* Stroop effect also indicated that this AB increases when two *salient* stimuli are presented in succession. Overall, Experiment 1 and Experiment 2 highlighted similarities in AB between Poker players and Facebook users indicating that just frequent Facebook use can trigger AB. The results from Experiment 1 and Experiment 2 provided the foundations that gambling and Facebook/Internet related stimuli could elicit AB.

In chapter 3, using a novel experimental paradigm, I wanted to further explore these AB effects but also look at discriminating between attentional arousal effects. In Experiment 3, Poker players achieved lower WR scores compared to the control group, demonstrating a better temporal discriminability. Again, this is a novel finding associating gamblers with increased temporal discriminability. I proposed that this reduction in WR is a result of increased arousal as predicted by *incentive-sensitisation* theory (Robinson & Berridge, 1993) and EI (Kavanagh et al., 2005). Furthermore, I hypothesised that gambling related AB would also be manifested in the form of distorted temporal perception. Indeed, Poker players underestimated durations for gambling related stimuli compared to neutral stimuli, whereas the control group exhibited no differences. This novel finding has direct implications on time keeping when exposed to addiction related stimuli. According to ICM this underestimation could be due to *mode switch* opening due to attentional distraction, resulting in lost temporal pulses. The attentional distraction can be explain by EI and *intrusive thoughts* due activated *desire.* Furthermore, this is also supported by the positive correlation between the dBP and the overall GACS and the GACS *desire* subscale. Indicating that an increased difference in BP between *salient* and neutral stimuli was associated with increased *desire* score. This is one of the central claims of EI. External cues activate *desire* to use and while this *subjective state* stays activated, this *desire* is constantly increasing.

In Experiment 4, I wanted to further explore whether presenting positively or negatively loaded gambling related stimuli would produce different *temporal* *distortions*. Previous research has indicated that threatening stimuli can affect our time perception (e.g., Droit-Volet & Meck, 2007;; Tipples, 2008). I operationalised the concept of threat by presenting poker hands that would most probably lead to loss, contrary poker hands that would most probably lead to winning (positive stimuli). However, the only observed outcome, similarly to Experiment 3 was that Poker players had better temporal discriminability (reduced WR) compared to the control group. There were no differences, either due to arousal or attentional effects, between the positive, neutral, and negative stimuli.

A possible explanation for this would be that Poker players' attention was focused purely on the fact that the stimuli were gambling related and allocated no further cognitive resources on examining whether there would be potentially positive or negative outcome. This is despite the fact that Poker players were very good at estimating their winning and losing chances. Similar findings were reported by Atkins and Sharpe (in: Williams, Connolly, Wood, Currie, & Davis, 2004) were they observed no differences no differences in responding the colour between positive and negative words in a modified Stroop task. However, no manipulation was done in the past which involved positive and negative gambling stimuli. The novel findings from Experiment 4 suggest that gamblers ignore the negative of positive aspects and they focus purely on whether the content is gambling related or not. A possible explanation for this could be that gamblers could implicitly overestimate how lucky they can be despite explicitly knowing the actual chances of winning therefore, nullifying any potential negative thoughts associated with potential loss.

Similarly, to chapter 3, in chapter 4 I wanted to investigate for potential temporal perception distortions due to Facebook/Internet related stimuli. Therefore, I adopted a novel Facebook/Internet modified temporal bisection task. Furthermore, I wanted to see whether repetition would have additional effects. Thus, I included five blocks of the modified Temporal Bisection task. The findings from Experiment 5 expand on the ones from Experiment 3, from the gambling addiction to Facebook/Internet addiction related stimuli. Participants demonstrated an overall better discriminability for *salient* stimuli compared to *neutral* ones, consistent to the arousal effects as discussed above. Furthermore, there was a tendency to underestimate durations for Facebook related stimuli, indicating perhaps that Facebook related stimuli have greater emotional content than the Internet ones. This novel finding makes our predictions regarding temporal distortion due to addiction related stimuli even more confident. Furthermore, Experiment 2 and Experiment 5 were the first to provide experimental evidence that substance addiction theories such as Tiffany's (1990), *incentive-sensitisation* theory (Robinson & Berridge, 1993) and EI (Kavanagh et al., 2005) can be expanded to incorporate forms of Online addictions such as Social Media and Internet use.

Finally, regarding repetition, results indicated that the first two Blocks were significantly different to Blocks 3, 4, and 5. Participants tended to overestimate time from one block to the next but that overestimation reached a *floor effect* at Block 3 and after that BP slightly reduced in a non-significant manner. This pattern was also supported by the WR analysis where participants' discriminability deteriorated from Block 1 to 5. The results from Experiment 5 are in line with Experiment 4 and provide further support for the previously discussed addiction theories.

In Experiment 6, I wanted to replicate the fatigue results but also explore how priming could have an impact the effect of salient stimuli. Therefore, I employed the same task as in Experiment 5 but this time the first one-minute break only involved engagement with Facebook or all one-minutes breaks involved engagement with Facebook. Concerning fatigue, the exact same pattern was observed as in Experiment 5 when it came to BP, the first two Blocks significantly differed from 3,4, and 5. More interestingly, WR now significantly kept increasing across the five Blocks, indicating a constantly reducing arousal. Regarding *salience* effects, durations for Facebook related stimuli were significantly underestimated compared to their neutral ones. Furthermore, durations for Internet related stimuli were underestimated compared to their neutral ones. This seemed to provide more support to our claim that Facebook and Internet stimuli could be treated differently by participants, possibly due to different associations made between Facebook and Internet.

Wanting to explore this potential difference between Facebook and Internet, in Experiment 7 we focused on running a study with only two Blocks and this time modify the priming task. Indeed, we had three conditions with participants using Facebook, Internet, or read a printed-paper, hoping that the first two task would reinforce the AB triggered by the corresponding stimuli. Similarly, with the previous two experiments there was an overall difference between Block 1 and 2 in terms of BP but WR. Participants overestimated time in Block 2 compared to Block 1. Furthermore, in relation to *salience* effects, participants underestimated time and displayed better temporal discriminability for *salient* stimuli compared to *neutral* ones. However, no between groups differences were detected suggesting that AB effects were unaffected by the priming tasks. A possible explanation for this could that these AB effects had already reached a *ceiling effect* and could not be enhance further. It would be perhaps interesting to replicate this study comparing healthy and pathological Facebook/Internet users and investigate for potential difference in this *ceiling effect*.

In Experiment 8, I wanted to provide an answer to a potential criticism that these AB effects could be due to the *salient* visual stimuli being familiar to participants compared to the neutral ones that were novel. For this reason, I replaced the images in the Temporal Bisection task with associated *non-words*. Results indicated that participants underestimated time for salience associated *non-words* compared to neutral associated *non-words*. Furthermore, no differences were observed between familiar and unfamiliar neutral *non*-words. These novel findings, in terms of addiction associated non-words in time perception, provided further support that our overall findings were due to emotional or addiction related content and not due to visual familiarity. This enhances our confidence that the observed AB are due to attentional switch triggered by *intrusive thoughts* as proposed by EI, and/or arousal effects due to dopaminergic activation as proposed by *incentive-sensitisation* theory.

Finally, in chapter 5 I wanted to explore the impact of memory load in time perception in conjunction with *intrusive thoughts* caused by *salient* stimuli. In Experiment 9, I employed a dual-task combining the Temporal Bisection and the N-back tasks. Results indicated that as difficulty increased participants underestimated time more. Furthermore, low difficulty resulted in better temporal discriminability compared to the high difficulty. These two results provide support to the claim that limiting temporal resources results in underestimation of time and deteriorates performance in time perception tasks (Block & Gruber, 2014; Block et al., 2010a). More interestingly, as difficulty increased any AB effects due to *salience* disappeared. Indeed, participants had better discriminability for *salient stimuli* compared to the neutral stimuli, in the low difficulty only. The same was observed in the BP where differences between *salient* Facebook images and neutral ones were only observed in the low difficulty task.

These novel findings seem to provide further support to Dillen and Koole

(2009) and reject the claims by Lavie (2005) that with increased memory load we should observed increased distractors effects. Indeed, Dillen and Koole (2009) observed reduced distractor effects when memory load was increased. However, no one has investigated before how memory load could affect how addiction related distractors impact ICM. Our findings support the EI theory, since working memory allocation is essential for the external cues to activate *intrusive thoughts*. When these limited memory resources are already allocated to memory demanding tasks this results to external cues being deprived of the fertile conditions to activate *intrusive thoughts* therefore, preventing any AB effects.

Further evidence for this claim came from Experiment 10 where the dual task this time involved a combination of Temporal Bisection and Sternberg tasks. Again, results indicated that as difficulty increased, participants underestimated time more. Furthermore, low difficulty resulted in better temporal discriminability compared to the high difficulty. When it came to *salience* effects, there was a significant difference between *salient* and neutral stimuli only in low difficulty, no such difference was observed in high difficulty. This is supportive of the claim that salient external *cues* require memory resources to activate *intrusive thoughts* that can in turn lead to distorted time perception.

Theoretical Implications

This novel investigation highlights a number of implications for the research in addiction and time perception. The consistent temporal underestimation effects due to *salient* stimuli provide support to relevant addiction theories that addiction related *cues* could cause AB. Indeed, both EI (Kavanagh et al., 2005) and *current concerns* (Cox & Klinger, 2004) theories highlight such effects. EI proposes that external *cues* can activate *intrusive thoughts* that can elicit AB. *Current concerns* imply that when we are motivated to use a process is activated in order to notice and act upon relevant external *cues*, this could result in a preferential treatment of addiction related stimuli. Furthermore, even if not directly relevant to non-substance addiction, Franken (2003) proposed that AB could be the result of a conditioning process that attributes *salience* to addiction related stimuli and therefore make them *attractive* to our attention.

The above provide further support to the role or *attention* in *internal clock* *model* (ICM). Indeed, ICM includes a *mode switch* that opens, when our attention is divided, resulting in temporal underestimations. The findings across this thesis consistently provided support for the existence of such a *mode switch* as argued by (Dan Zakay & Block, 1996) and highlighted its importance in the novel investigation of time perception when exposed to *addiction* related stimuli.

Further to the role of attention, this thesis also provided consistent novel evidence that *arousal* is also a contributing factor of distorted time perception in addiction. *Incentive-sensitisation* theory (Robinson & Berridge, 1993) clearly highlights the role of arousal as a result of increased dopamine levels. This increased arousal accelerates the *pacemaker*, which would normally result in temporal overestimation if all other factors were eliminated (e.g., no attentional effect on *mode switch*). However, as it was clearly stated above attentional effects also occurred. This conflicting combining effect between accelerated *pacemaker* and open *mode switch* could complicate the time perception investigations.

This thesis proposed that we could disentangle this combined effect and distinctly investigate for attention and arousal effects by focusing on two separate psychometrics, the BP and WR. Where BP should be mainly associated with *attentional* effects and WR mainly associated with *arousal* effect. We say “mainly”, because BP is included in the WR calculation. However, when we have underestimation only due to attention this would result in increased BP values and unaffected WR values. When we have overestimation, only due to arousal effects, we should have a greater sensitivity to time and therefore, lower WR values. In other words, this increased arousal produces steeper p(long) curves that are associated with lower WR values (J. Wearden, 2016). When we have combined effects of the two then we should observe both increased BP values and decreased WR values.

A further implication that is more relevant to addiction theories comes from our novel from the memory load results. There was a clear indication that as memory load increased *salience* effects disappeared, both in terms of BP and WR. This can have implications for the study of addiction, specifically supporting EI theory and implying that, *intrusive thoughts* require memory availability to flourish. This finding was replicated across two separate memory load paradigms and a temporal bisection task and is directly opposing previous research using a Stroop paradigm where distractors effects increased with increased cognitive load (e.g., de Fockert, Rees, Frith, & Lavie, 2001). This could have also implications for ICM, implying that as the Stroop effect is guided by automatic processes, the temporal bisection task does not, at least not to the same extent. This is something that future research can address, especially looking more at the *decision making* stage and whether this is guided more by automatic processes or not.

Limitations and Future Research

This thesis explored how gambling and Facebook/Internet related stimuli could cause AB and affect time perception. However, the participants involved with this research were mostly recruited from the general University student population. Regarding, gambling recruiting from the University of Kent Poker society allowed us to have participants that were gambling frequently, and we could measure this using validated questionnaires such as PGSI, and compare them to participants who were not gambling. Despite this comparison, the limitation of the sample comprised of students who might be gambling recreationally remains. It is therefore vital that the present work should also be tested with participants that have been identified as pathological gamblers in order to replicate the findings in verified addiction sample.

However, regarding the Facebook/Internet experiments such manipulation was not possible. At the time of the research, there were no validated measurements that could assess severity in the use of Facebook or social media. Furthermore, even though it was attempted, it was practically impossible to include a condition of participants who never used the Internet or Facebook. As above, this limitation should be addressed in future research by trying to recruit participants that have been identified as excessive users of the Internet and the social media.

A further limitation of the work reported in this thesis has to do with the established addiction rehabilitation and relapse prevention approaches and to what extent our findings can inform their practice. Current successful practices follow a holistic approach that include behavioural therapy that helps addicts, and especially gamblers, to modify their attitudes towards gambling and retrain them to process gambling related cues with a different state of mind that would allow them to abstain from gambling. This means the addict is actively encouraged to process his addiction thoughts and to try to create news associations with healthier habits and even discover what drives their need to gamble.

One of our main findings was that increasing our cognitive load prevents intrusive thoughts from triggering attentional bias effects. One could argue that this could be generalised and applied as a separate approach to treatment where patients do not actively process their addiction thoughts and reshape their cognitions but instead, they keep their mind busy preventing intrusive thoughts from finding "space" to grow. Up to a certain extent this already applies as it is common guideline to encourage addicts to stay productive in society and be pro-active in maintaining social bonds with their families and peers. However, we should be mindful that our findings come from researching temporal perception in the range of milliseconds up to only a few seconds. Moreover, these are novel findings that have not been tested thoroughly with special populations and in treatment settings. It is therefore possible that they may not extend to different types of addiction or may not be plausible to be used in treatment settings.

Conclusion

The main aim of this thesis was to examine the effects of addiction related stimuli on time perception. For this purpose, two modified temporal bisection tasks were used; a gambling and a Facebook/Internet one (Experiment 3 and Experiment 5). Findings suggested that gambling related stimuli can affect the time perception of Poker players and Facebook/Internet related stimuli can affect the time perception of Facebook users. One interesting aspect of these findings was that they manifested in non-pathological users. Furthermore, this thesis provided evidence that said distorted time perceptions were due to the addiction related content of the stimuli and not to other visual confounds (Experiment 8). Moreover, increasing the memory seemed to counteract the mechanisms that provide fertile ground for *intrusive thoughts* to develop into *attentional bias* (Experiment 9 and Experiment 10). This thesis makes the novel suggestion that time perception can be used in the investigation of addiction and can provide insights into addiction theories and automatic processes that drive addiction craving and need to use. Therefore, it is crucial that future research will employ temporal perception tasks across a spectrum of addictive behaviours in order to further explore the roles of *arousal*, *attention*, *and memory* in such behaviours.

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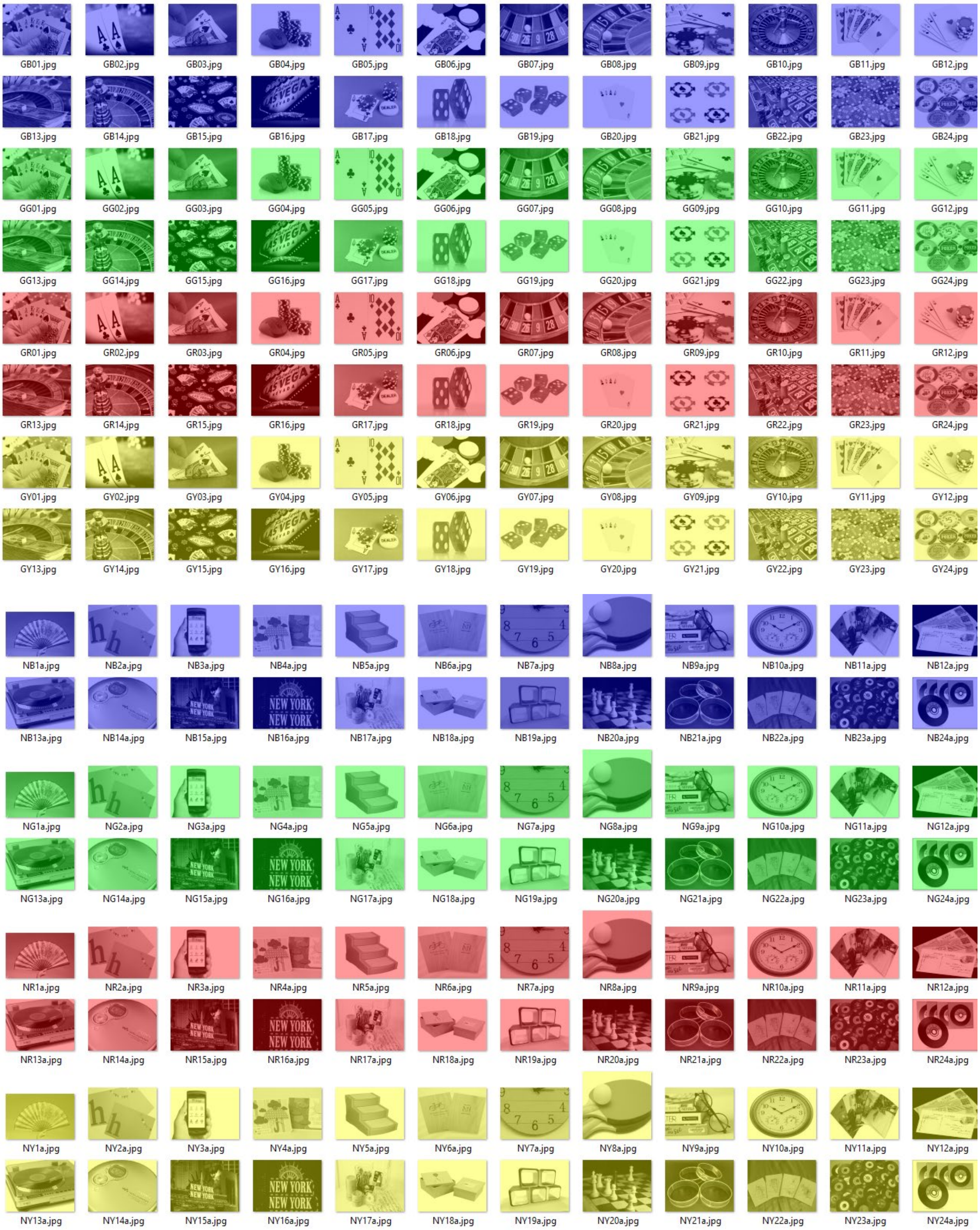
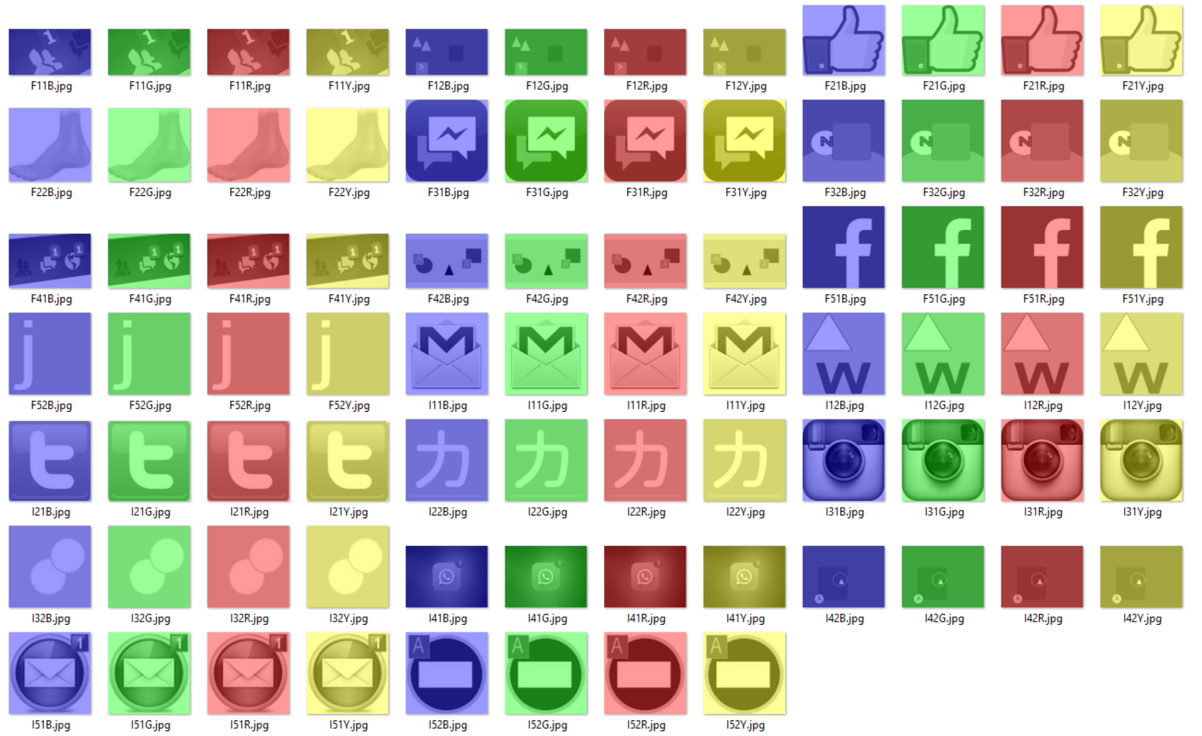
Appendix A: GAMBLING STROOP STIMULI



APPENDIX B: FACEBOOK STROOP STIMULI



APPENDIX B: YOUNG'S INTERNET ADDICTION TEST (YIAT)

Item1 Do you feel that you stay online longer than you intend?
Item2 Do you neglect household chores to spend more time online?
Item3 Do you prefer excitement of the internet to intimacy with your partner?
Item4 Do you form new relationships with fellow online users?
Item5 Do others in your life complain to you about the amount of time you spend online?
Item6 Does your work suffer because of the amount of time you spend online?
Item7 Do you check your e-mail before something else that you need to do?
Item8 Does your job performance or productivity suffer because of the internet?
Item9 Do you become defensive or secretive when someone asks what you do online?
Item10 Do you block disturbing thoughts about your life with soothing thoughts of the internet?
Item11 Do you find yourself anticipating when you go online again?
Item12 Do you feel that life without the Internet would be boring, empty and joyless?
Item13 Do you snap, yell, or act annoyed if someone bothers you while you are online?
Item14 Do you lose sleep due to late night log-ins?
Item15 Do you feel preoccupied with the Internet when off-line or fantasise about being online?
Item16 Do you find yourself saying "just a few more minutes" when online?
Item17 Do you try to cut down the amount of time you spend online and fail?
Item18 Do you try to hide how long you've been online?
Item19 Do you choose to spend more time online over going out with others?
Item20 Do you feel depressed, moody, or nervous when you are offline, which goes away once you are back online?

All the above items were presented each with the following options:

- ◯ Does not apply
- ◯ Rarely
- ◯ Occasionally
- ◯ Frequently
- ◯ Often
- ◯ Always

APPENDIX C: THE COMPULSIVE INTERNET USE SCALE (CIUS)

The following questions should be answered about your use of the internet for private purposes.
Answers can be given on a 5-point scale:
(0) Never, (1) Seldom, (2) Sometimes, (3) Often, (4) Very often.

How often . . .

	0 *never*	1 *seldom*	2 *sometimes*	3 *often*	4 *very often*
1. do you find it difficult to stop using the Internet when you are online?	○	○	○	○	○
2. do you continue to use the Internet despite your intention to stop?	○	○	○	○	○
3. do others (e.g., partner, children, parents) say you should use the Internet less?	○	○	○	○	○
4. do you prefer to use the Internet instead of spending time with others (e.g., partner, children, parents)?	○	○	○	○	○
5. are you short of sleep because of the Internet?	○	○	○	○	○
6. do you think about the Internet, even when not online?	○	○	○	○	○
7. do you look forward to your next Internet session?	○	○	○	○	○
8. do you think you should use the Internet less often?	○	○	○	○	○
9. have you unsuccessfully tried to spend less time on the Internet?	○	○	○	○	○
10. do you rush through your (home) work in order to go on the Internet?	○	○	○	○	○
11. do you neglect your daily obligations (work, school, or family life) because you prefer to go on the internet?	○	○	○	○	○
12. do you go on the Internet when you are feeling down?	○	○	○	○	○
13. do you use the Internet to escape from your sorrows or get relief from negative feelings	○	○	○	○	○
14. do you feel restless, frustrated, or irritated when you cannot use the Internet?	○	○	○	○	○

APPENDIX D: FACEBOOK MODIFIED CIUS

The following questions should be answered about your use of the internet for private purposes. Answers can be given on a 5-point scale: (0) Never, (1) Seldom, (2) Sometimes, (3) Often, (4) Very often.

How often . . .

	0 *ever*	1 *seldom*	2 *sometimes*	3 *often*	4 *very often*
1. do you find it difficult to stop using Facebook when you are online?	○	○	○	○	○
2. do you continue to use Facebook despite your intention to stop?	○	○	○	○	○
3. do others (e.g., partner, children, parents) say you should use Facebook less?	○	○	○	○	○
4. do you prefer to use Facebook instead of spending time with others (e.g., partner, children, parents)?	○	○	○	○	○
5. are you short of sleep because of using Facebook?	○	○	○	○	○
6. do you think about Facebook, even when not online?	○	○	○	○	○
7. do you look forward to your next Facebook session?	○	○	○	○	○
8. do you think you should use Facebook less often?	○	○	○	○	○
9. have you unsuccessfully tried to spend less time on Facebook?	○	○	○	○	○
10. do you rush through your (home) work in order to go on Facebook?	○	○	○	○	○
11. do you neglect your daily obligations (work, school, or family life) because you prefer to go on Facebook?	○	○	○	○	○
12. do you go on Facebook when you are feeling down?	○	○	○	○	○
13. do you use Facebook to escape from your sorrows or get relief from negative feelings	○	○	○	○	○
14. do you feel restless, frustrated, or irritated when you cannot use Facebook?	○	○	○	○	○

APPENDIX E: GAMBLING DSM-IV

Please answer the following statements by choosing the responds that describes you most accurately.
In the last 12 months...

When you gamble, how often do you go back another day to win back money you lost?

How often have you found yourself thinking about gambling?

Have you needed to gamble with more and more money to get the excitement you are looking for?

Have you needed to gamble with more and more money to get the excitement you are looking for?

Have you gambled to escape from problems or when you are feeling depressed, anxious or bad about yourself?

Have you lied to your family, or others, to hide the extent of your gambling?

Have you made unsuccessful attempts to control, cut back or stop gambling?

Have you committed a crime in order to finance gambling or to pay gambling debts?

Have you risked or lost an important relationship, job, educational or work opportunity because of gambling?

Have you asked others to provide money to help with a desperate financial situation caused by gambling?

Options first item only

- ○ Every time I lost
- ○ Most of the time I lost
- ○ Some of the time I lost
- ○ Never

Options for the rest of the items

- ○ Very often
- ○ Fairly often
- ○ Occasionally
- ○ Never

APPENDIX F: PATHOLOGICAL GAMBLING SEVERITY INDEX (PGSI)

In the last 12 months how often...

Have you bet more than you could really afford to lose?

Have you needed to gamble with larger amounts of money to get the same excitement?

Have you gone back to try to win back the money you'd lost?

Have you borrowed money or sold anything to get money to gamble?

Have you felt that you might have a problem with gambling?

Have you felt that gambling has caused you any health problems, including stress or anxiety?

Have people critised your betting, or told you that you have a gambling problem, whether or not you thought it is true?

Have you felt your gambling has caused financial problems for you or your household?

Have you felt guilty about the way you gamble or what happens when you gamble?

The options presented for all items were:

- ○ Almost always
- ○ Most of the time
- ○ Some of the time
- ○ Never

APPENDIX H: GAMBLING CRAVING SCALE (GACS)

Please answer the following statement with the choice that expresses you at this moment.

Gambling would be more fun right now

If I had an opportunity to gamble right now, I probably would take it

I would not enjoy gambling right now

I crave gambling right now

I need to gamble right now

I have an urge to gamble

If I were gambling right now, I could think more clearly

I could control things better right now if I could gamble

Gambling would make me less depressed

All items were presented with the following options

- Strongly Agree
- Agree
- Agree somewhat
- Undecided
- Disagree somewhat
- Disagree

APPENDIX I: COLLECTION OF *NON-WORDS* USED IN EXP8

Word	Length	Ortho_N
athuct	6	0
athuct	6	0
clowzy	6	0
dratty	6	0
essigy	6	0
fluash	6	0
glours	6	0
houger	6	0
kleedy	6	0
laared	6	0
marpan	6	0
oppult	6	0
parung	6	0
rejele	6	0
schays	6	0
threme	6	0
unlund	6	0
vespol	6	0
worghs	6	0
yeots	5	0

Source: English Lexicon Project Web Site

http://elexicon.wustl.edu/NonWordStart.asp