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An investigation of eye movements within a food-related dot probe paradigm

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1. Introduction

In recent years, the visual probe task has successfully been used to demonstrate an attentional bias for drug-related cues among, for example, smokers, alcoholics and users of heroin or cannabis (e.g., Ehrmann et al., 2002; Field, Mogg, & Bradley, 2004a; Townshend & Duka, 2001). Apart from addiction-related stimuli, attentional biases have also been reported for food-related stimuli. More specifically, these biases have been demonstrated in restrained eaters (e.g., Papies, Stroebe, & Aarts, 2008), dieters (e.g., Cooper & Fairburn, 1992), external eaters (e.g., Brignell, Griffiths, Bradley, & Mogg, 2009), eating disorder individuals (for reviews see: Faunce, 2002; Shafran, Lee, Cooper, Palmer, & Fairburn, 2007), people who are food deprived (Channon & Hayward, 1990) and hungry (Mogg, Bradley, Hyare, & Lee, 1998; Piech, Pastorino, & Zald, 2010).

Attentional biases have been investigated using different reaction time measures, for example, the stroop task and the dot probe task. Focussing on the dot probe task in this thesis, its reliability and different versions of the dot probe task are described in the next chapter. The main weakness of the previous research about attentional biases is that measuring reaction times consider only information about the stimulus the attention is directed to during the offset of the stimuli which is seen as an indirect measure of attention. Some studies varied the presentation duration (short and long periods) of the stimuli which led to different results. There could be a relation to some attentional mechanisms called initial orientation, sustained attention or delayed disengagement, which are described in detail in the following chapter.

Another weakness of the previous research about attentional biases in dependence is the lack of a theoretical distinction between these mechanisms. Further, the “traditional” methodology of the dot probe task (indirect measurement of attentional biases through short or long reaction times on the target that appears after the stimuli offset) is not always well-suited to discover these different components of selective attention. Simultaneous monitoring of eye movements, a more definite and direct measure of attention than measuring reaction times, sheds more light on the attentional process, because eye movements offer the opportunity to measure the attention during the whole presentation duration of the stimuli.

The development of eye tracking over time, its applications and different kinds of measuring eye movements are described in detail in the following chapter. Eye movements are a well-suited methodology to measure attention, for example, as an adaption to the dot probe task.

In this diploma thesis, an attentional bias for food-related stimuli was examined by recording the eye movements during the use of a pictorial dot probe paradigm. This investigation was based on the study from Tapper, Pothos, and Lawrence (2010). They used a modified visual probe task to examine the influence of hunger and trait reward drive on food-related attentional bias. Tapper et al. (2010) found effects of hunger for both bland and appetizing foods while effects of reward drive were restricted to appetizing foods.

The basic elements were replicated, but the study was also extended in several ways. First, a distinction between low levels and high levels of hunger was also conducted to measure its effects on attentional biases. Second, rather than words, more salient picture stimuli were also used and third, the stimuli presentations were replicated (100 ms, 500 ms, 2000 ms). Third, attentional biases to palatable and bland foods (e.g., cake vs. lettuce) were examined separately. Finally, the same questionnaires were used, the Grand hunger scale (Grand, 1968) and the BAS-D(rive) scale (Carver & White, 1994). Additionally in this study, participants had to evaluate the food stimuli concerning appetite, preference, healthiness and saturation afterwards.

Compared to the study of Tapper et al. (2010), the most important extensions in this study included a simultaneous recording of the eye movements during the dot probe task to reveal the different mechanisms of attentional biases. Moreover, to assess possible differences between the common method of the dot probe task (involving button pressing, called “gamepad version” in this study) and another hopefully improved one, a new version of the dot probe task (called “eye version” in this study) had been developed. This new version did not use button pressing, but rather a 50 ms eye fixation on the target (in contrast to button pressing) to assess reaction times. This was intended to confirm that the participants’ attention was explicitly on the dot and they were not detecting the dot in their peripheral view (which was suspected to happen in the gamepad version). Eye movements were recorded during both versions of the dot probe task.

2. Background

2.1 Attentional bias

An attentional bias is defined as the tendency to selectively attend to personally relevant information over neutral information (Mathews & MacLeod, 2005). The variety of this information is very different, for example, it could be fear-related like spiders vs. neutral information, food-related like cake or lettuce vs. neutral information, alcohol-related like beer or vodka vs. neutral information and smoking-related like cigarettes or ash-trays vs. neutral information.

2.1.1 Attentional bias mechanisms

In the following section the different attentional bias mechanisms namely stimulus onset asynchrony, initial orientation, delayed disengagement and sustained attention are described.

2.1.1.1 Stimulus onset asynchrony (SOA)

The Stimulus onset asynchrony (SOA) describes the time delay between the onset of the first stimuli presentation and a) the onset of a second stimuli presentation or b) the onset of a target (Field & Cox, 2008). In the dot probe task the stimulus onset asynchrony (SOA) describes the time delay between the onset of the stimuli and the onset of the target (the dot), this happens simultaneously with the offset of the stimuli presentation.

The interpretation of the results from the visual dot probe paradigm and its use in general are hindered by multiple reasons, for example, the fact that the measured reaction time only provides information about the stimulus to which the participants' attention was allocated at the time of stimulus offset (Bradley, Field, Mogg, & De Houwer, 2004; Field et al., 2004a). If participants react quickly, it is assumed that they have their attention on the personally relevant information. If they are not reacting quickly, they might be attending the neutral information. The problem here is that the measured reaction time delivers no information about the participants' attention before stimulus offset and since there are various stages in attention like initial orientation, sustained attention or delayed disengagement, knowing more about the entire course of attention would be important as well.

The measured reaction time cannot completely distinguish between those mechanisms for itself. By varying the time delay between the stimuli onset and the target onset (SOA) from very short (200 ms) to relatively long (500 - 2000 ms) in some studies (Bradley et al., 2004; Bradley, Mogg, Wright, & Field, 2003; Field, Eastwood, Bradley, & Mogg, 2006), different results have been obtained, because longer SOAs (200 ms or longer) provide the possibility to shift your attention multiple times between the stimuli (for details see the section 2.1.1.2 “initial orientation”) or to maintain on the stimulus where you first attended to (sustained attention), whereas a short SOA only allows one shift of attention (initial orientation). To clear the distinction between initial orientation, delayed disengagement and sustained attention is a challenge to face in these studies.

For example, Field et al. (2004a) found that heavy drinkers, compared to light social drinkers, showed an attentional bias for alcohol-related stimuli when the stimuli were presented for 500 or 2000 ms; however, both groups showed no attentional bias when stimuli were presented for 200 ms. On the contrary, Noel et al. (2006) found that abstinent alcohol abusers, relative to social drinkers, showed an attentional bias for alcohol-related stimuli presented for 50 ms, but showed no attentional bias when the stimuli were presented for 500 ms or 1250 ms. The attentional system is not unitary, and different cognitive mechanisms are thought to underlie the initial shifting of attention and the subsequent maintenance or disengagement of attention (Allport, 1989; LaBerge, 1995).

2.1.1.2 Initial orientation

The findings of Allport (1989) and LaBerge (1995) rely on the observation that when short exposure durations are used, a relatively fast automatic bias in the shifting of attention between two stimuli is measured, whereas in case of longer exposure durations a bias in the disengagement of attention occurs. The reason for these different biases is based on the fact that participants can only make one shift of attention towards one of the two stimuli during a short stimuli presentation (200 ms), so the attentional bias index is likely to reflect a bias in the initial orienting of attention. Instead during longer stimuli presentation it is possible to make multiple shifts of attention between the two stimuli, therefore the attentional bias index is likely to reflect delayed disengagement of attention. But what defines a “short” versus a “long” SOA?

Basic perceptual research with simple stimuli suggests that after presenting a simple visual cue, participants require about 50 ms to relocate their attention to the cue

(Duncan, Ward, & Shapiro, 1994). Moreover, participants typically need 150 ms to disengange their attention from one cue and divert it to a stimulus presented in another spatial location (Theeuwes, 2005). To conclude, these declarations indicate that when a pair of fairly complex stimuli are presented together (as in the trials of a visual probe task) for less than 200 ms, any observed attentional bias (based on reaction times to probes that replace one of the stimuli) have to be for the stimulus towards which participants initially directed their attention, because within a timeframe of 200 ms a second shift of attention is not possible.

2.1.1.3 Delayed disengagement

After describing studies with SOAs of 200 ms and 1000 ms, a SOA of 500 ms raises some interesting questions. This SOA has also been used in many published studies measuring attentional bias, but interpretation of the indices has been inconsistent across the studies. For example, Bradley et al. (2003) interpret a 500 ms SOA as indicating initial orienting, but Koster, Verschuere, Crombez, and Van Damme (2005) take this SOA as indicating delayed disengagement. Based on the research described above (Duncan et al., 1994; Theeuwes, 2005), it seems plausible that since there is only one shift possible before 200 ms, 500 ms provides the chance to perform multiple shifts of attention between two stimuli. Attentional bias that is observed with this SOA is likely to reflect delayed disengagement of attention. This interpretation is corroborated by findings from the anxiety literature in which reaction time with this SOA has been found to reflect disengagement of attention rather than the rapid orienting of attention (Koster, Crombez, Verschuere, & De Houwer, 2004; Koster et al., 2005).

2.1.1.4 Sustained attention

Sustained attention describes the maintenance of attention after the initial orientation. To measure this attentional mechanism, researchers usually use a SOA of 1000 ms or longer (e.g., Koster et al., 2005; Mogg, Bradley, De Bono, & Painter, 1997) to deviate biases in the maintenance of attention. According to the preceding descriptions, SOAs longer than about 200 ms are sufficient to allow multiple shifts in attention between two stimuli, therefore any attentional bias that is identifiable at stimulus offset is likely to reflect a bias in the maintenance of attention to that stimulus. This logic is supported by findings from two studies which demonstrated that the magnitude of attentional bias that cannabis users and heavy drinkers showed for substance-related cues when presented for 2000 ms was positively correlated with the amount of time that participants sustained their gaze on the substance-related cue (Field et al., 2006; Field et al., 2004a).

2.1.2 Attentional bias in addictive behaviours

A wealth of research from the past two decades approved that addictive behaviours are characterized by attentional biases for substance-related stimuli. Field and Cox (2008), reviewing the relevant evidence, established an integration of existing theoretical models to explain the development of addiction-related attentional biases. Various theories of addiction have argued that substance-related stimuli will capture the attention of people who use or abuse the addictive substance. Field and Cox (2008) suggested that the attentional bias develops partly as a consequence of classical conditioning where the substance-related stimuli causes the expectation in substance users of actually using the specific substance, which further causes substance craving and increases attention-grabbing properties of these cues. These processes have reciprocal effects on each other in form of a mutually excitatory positive feedback loop. Moreover, the processes appear to be mediated by substance users' impulsivity and impaired inhibitory control and their attempts to consciously suppress their craving and to avoid attending to substance cues (Field & Cox, 2008). Attentional bias has been measured in many different areas besides food (e.g., drug dependence, anxiety). Since it would go beyond the scope of this thesis to describe every topic in detail, two substantial research areas are picked as examples of attentional bias measures in other topics to capture more precisely: alcohol and nicotine abuse.

2.1.2.1 Attentional bias in alcohol abuse

Alcohol-related stimuli are preferentially attended to by alcoholics and this is illustrated by results that have been gathered from research measuring attentional bias using alternative methods to the stroop task. Townshend and Duka (2001) examined differences in selective attention towards alcohol-related stimuli between heavy and occasional social drinkers using a dot probe detection task. Heavy social drinkers showed an attentional bias towards alcohol-related stimuli when compared to the occasional social drinkers. This study supports cognitive theories of addictive behaviour showing that the ability of alcohol-related stimuli to capture attention is meant to be playing an important role in substance dependence, craving and relapse. Field, Mogg, Zetteler, and Bradley (2004) conducted some research about initial orienting to - , and the maintenance of, attention on alcohol-related cues in heavy and light social drinkers using a visual dot probe task. To investigate the differences between initial orientation and maintenance of attention, they varied the presentation duration of the alcohol-related stimuli from 200 ms, 500 ms or 2000 ms.

Heavy social drinkers had an attentional bias for alcohol stimuli at the longer exposure durations (500 ms, 2000 ms), but not at the short duration (200 ms). They concluded that biases in visual orienting to alcohol-related cues in heavy social drinkers operate mainly in the processes involved in the maintenance of attention. Cox, Yeates, and Regan (1999) investigated the effects of alcohol-related visual cues vs. neutral cues on cognitive processing in heavy and light social drinkers with an emotional stroop task. They found that heavy drinkers, exposed to alcohol cues, had significantly slower reaction times than light drinkers. Alcohol cues can affect automatic cognitive processes and therefore cue reactivity. Longer latencies for emotionally and semantically valenced stimuli than neutral stimuli are consistent with previous research with the stroop task (MacLeod, 1991; Williams, Mathews, & MacLeod, 1996). Results indicated that the effects of alcohol cues on cognitive processes can be measured in dependent drinkers as well as in social drinkers. The study from Lusher, Chandler, and Ball (2004) evaluated alcohol abusers attentional bias towards alcohol-related stimuli within a computerized emotional (alcohol) stroop task including mood status in the analysis. Regardless of mood status, findings showed that alcoholics responded significantly slower to alcohol-related than to neutral words when compared to controls, the alcohol-related stimuli are distracting to heavy users of alcohol. If these findings could be measured for alcohol drinkers in general the results would have implications on the development and treatment of alcohol dependence, for example, a generic model for treating this aspect of the addiction process (Lusher et al., 2004).

2.1.2.2 Attentional bias in smokers

Much evidence documents that individuals with emotional and drug-use disorders demonstrate biased attention towards stimuli associated with their disorder. Recent theories of addiction assume that responses to drug cues maintain drug use and precipitate relapse. Waters, Shiffman, Bradley, and Mogg (2003) used a pictorial version of the visual probe task to evaluate whether deprived smokers had an attentional bias to smoking cues. They demonstrated that participants were faster (indicating an attentional bias) and more accurate in responding to a visual probe that replaced a smoking stimulus than to a probe replacing a neutral stimulus. The authors concluded that visual probe tasks can add useful information about attentional responses to drug cues. Mogg and Bradley (2002) used three different measures (for example a visual probe task) of processing bias for linguistic and pictorial smoking-related cues. Results were consistent with an attentional bias for smoking-related stimuli on the visual probe task which was most strongly predicted by a subjective measure of addiction, namely urge to smoke.

These findings provide strong evidence that self-reported urge to smoke is a key predictor of an index of attentional bias in smokers. Ehrmann et al. (2002) conducted two studies with the dot probe paradigm. Study 1 and 2 examined whether current cigarette smokers showed biased attention towards smoking-related images compared with non-smokers. Further, Study 2 investigated whether this bias is less pronounced in former smokers. In both studies, current smokers displayed significantly greater attentional bias towards cigarette stimuli than did non-smokers.

2.1.3 Attentional bias in eating behaviours

Over the past decades, extensive research has demonstrated attentional biases for craving-related stimuli (e.g., alcohol, drugs and cigarettes) in individuals for whom these stimuli are of particular interest. Apart from addiction-related stimuli, attentional biases have also been reported for food-related stimuli. More specifically, these biases have been demonstrated in restrained eaters (e.g., Papies et al., 2008), dieters (e.g., Cooper & Fairburn, 1992), external eaters (e.g., Brignell et al., 2009), obese individuals (e.g., Nijs, Muris, Euser, & Franken, 2010), people who are food deprived (e.g., Channon & Hayward, 1990) and hungry (e.g., Mogg et al., 1998; Piech et al., 2010) or craving food (Pelchat, 2002). In the following block a selection of studies concerning these topics will be presented.

2.1.3.1 Restrained eaters

In daily life we are surrounded by numerous temptations and cues that indicate the availability of all kinds of tasty treats, like inviting aroma smells of food or seeing other people eat. How do people who are on a diet constantly react to the continuous presence of such temptations? (Papies, Stroebe, & Aarts, 2007) Attempts to lose weight or to restrain food intake are supposed to lead to hyperattention for food stimuli. Evidence shows that it can otherwise lead to prolonged colour naming latency for food words in participants who restrain their food intake (Boon, Vogelzang, & Jansen, 2000). Papies et al. (2007) examined the impact of exposure to social food cues on the spontaneous activation of hedonic (i.e. desire) thoughts about food in restrained and unrestrained eaters in two experiments. The hypotheses was confirmed, restrained eaters, on the contrary to unrestrained eaters, spontaneously activated inspiring thoughts about food upon reading behaviour descriptions that involved a palatable food item. The authors also concluded that the abundance of food cues in our environment is likely to be harmful for the dieting goal of restrained eaters. The exposure of palatable food cues released the thoughts for desire in the mind of dieters and this process might trigger restrained eaters to seek consumption (Papies et al., 2007).

Another study from the same authors investigated the impact of food cues on restrained eaters' attention for food (Papies et al., 2008). As expected, the results revealed that restrained eaters who had been pre-exposed to food cues displayed an attentional bias for desirable food items. Also an interesting aspect of the study was that they were able to prevent the occurrence of the attentional bias when they confronted restrained eaters with their dieting goal. Measures with the stroop paradigm revealed no complete understanding of the pattern of restrained eaters' attention for food. Restrained eaters typically experience concern about high-fat (palatable food), so measured reaction time differences could also be due to increased concern with certain stimuli (instead of hedonic orientation towards it) which could as well lead to increased colour-naming latencies for these cues. Stroop effects for such stimuli cannot distinguish between an attentional bias that is driven by the goal to avoid this food or by a hedonic orientation towards it (Papies et al., 2008). The authors suggest that the visual probe paradigm (MacLeod, Mathews, & Tata, 1986) might be more compatible to measure a hedonically motivated attentional bias, since it assesses shifts of selective attention towards relevant cues. In conclusion, the accessibility of individuals' long term goals may be at first enough to leave the presence of attractive temptations beside, but repeated exposure to temptation cues in the environment can trigger an attentional bias for short-term rewards at the cost of the conflicting long-term goal. In the case of restrained eaters, once an attentional bias for palatable food cues has been triggered it becomes increasingly difficult to disengange from the attractive cues and this will serve to continuously stimulate hedonic thoughts about food which in turn will maintain biases in selective attention for tempting food (Papies et al., 2008). Boon et al. (2000) on the other hand conducted a study to examine whether the prolonged colour naming of food words in stroop tasks in restrained eaters is due to hyperattention to or avoidance of these food words. They found neither attention nor avoidance of food and weight/shape stimuli in the visual attention task. This results might be explained by Wegner's Ironic Process Theory (Wegner, 1994) which argues that in order to avoid certain thought contents, an individual needs to attend them first (in this study: first shift to the food words in the dot probe task). But only the examination of the eye movements of restrained and unrestrained eaters during the presentation of target and neutral stimuli could reveal the exact attention curve of restrained eaters. The hypothesis that restrained eaters selectively attend to food stimuli - a finding which has repeatedly been documented by means of the modified stroop test - had not been confirmed. Another reason for no significant results (neither hyperattention nor avoidance) could be that the subject sample was not a clinical group.

The authors suggested that the dot probe paradigm might not be sensitive enough for normal restrained eaters and that it might be a rewarding enterprise to replicate the study with eating disordered patients (Boon et al., 2000).

2.1.3.2 Food deprivation

"Hunger influences food intake through mechanisms beyond the mere desire to eat" (Piech et al., 2010, p. 581). Effects of hunger on cognitive processes are not as well established as the effects of hunger on motivation and food reward value. There might also be a strong impact on cognitive processes as well as on physiological and affective properties. Piech et al. (2010) have demonstrated that when participants are hungry, food stimuli consume a lot more of people's attention and distract them from target detection than when they are sated. This might be especially taken into account when the attending participants restrain their food intake. Previous studies showed that a hunger-related bias in selective attention for food-relevant stimuli seemed to have an adaptive value in helping a food-deprived individual locate and acquire food. Mogg et al. (1998) wanted to examine if an attentional bias is also found in non-emotional motivational state (such as hunger which appears to be a normal drive state) or if it is more likely to appear in emotional-motivational states such as anxiety. The modified stroop task does not provide a direct measure of attentional bias, because a number of different cognitive mechanisms might contribute to colour-naming interference effects (MacLeod, 1991), so Mogg et al. (1998) used a dot probe task which is a more direct measure of deployment of visual attention. They demonstrated that participants with a higher level of hunger showed a greater attentional bias for food-related words than those with a lower level of hunger. These results suggested that hunger was associated with selective attention (an attentional bias) for stimuli that were relevant to this specific state (in this case: food-related stimuli). Hunger and anxiety appear to play an important role in determining the allocation of selective attention to environmental stimuli (Mogg et al., 1998). Channon and Hayward (1990), and Lavy and van den Hout (1993) measured the effects of food deprivation on the selective processing of food-related information using a modified version of the stroop task. Both research parties found out that fasting participants were slower than non-fasting participants in colour-naming food-related words which was consistent with a hunger-related processing bias. Stewart and Samoluk (1997) investigated the selective processing of appetitive cues among food-deprived participants and restrained eaters using the modified stroop.

Results showed that chronic dietary restraint, but not short-term food deprivation, was associated with selective processing of appetitive cues. The study failed to demonstrate that short-term food deprivation leads to selective processing of food cues on the stroop task. According to this, the results contradict those of Channon and Hayward (1990) who found that food deprivation participants demonstrated selective processing of food words. One possible explanation for the discrepancy was that participants in the study of Channon and Hayward (1990) were food deprived for 24 hours. Hepworth, Mogg, Brignell, and Bradley (2010) found several novel and theoretically relevant results examining the effect of negative mood on attentional biases and self-reported hunger/urge to eat respectively. Results showed that negative mood increased both attentional bias for food cues and subjective appetite demonstrating that mood influences motivation to eat. This is consistent with psychological models (for example, the negative reinforcement model; Baker, Piper, McCarthy, Majeskie, & Fiore, 2004) which predicts that negative affect increases the reward value for food cues which in turn increases the urge to eat and attentional bias for food cues (link between negative mood and overeating). Attentional bias is also associated with trait eating style such as external and restrained eating, this may be important in determining behavioural responses to food cues and overeating. There are also suggestions concerning learning experiences that shape the development of the trait eating style of emotional eating. For instance, if a child always gets a sweet from their parents as a reward for engaging in an unpleasant activity such as going to the doctor, the child inappropriately learned to eat in response to a negative effect. Through operant conditioning, eating becomes a negatively reinforced coping strategy. The palatability results showed generally that participants had a greater attentional bias for foods that were rated as being more palatable. To examine this effect, a fully balanced design in order to calculate bias scores for separate subsets of food stimuli was required (each stimulus pair appeared in all different conditions, as a function of stimulus duration, stimulus location and probe location). But the food stimuli in this study were all selected to be palatable and therefore it might be informative to examine attentional responses to a wider selection of foods which vary more in palatability (Hepworth et al., 2010).

2.1.3.3 External eaters

Newman, O'Connor, and Conner (2008), using a stroop task, investigated the hypothesis that an attentional bias for food cues might be the core mechanism that external eaters increase snack intake when stressed which could be caused by an attentional shift towards food stimuli.

Their results found no straightforward support for the general hypothesis, but both high and low external eaters were found to demonstrate stroop interference for food words and this interference was largest in low external eaters in the no-stress condition. This paradigm has been criticized, because greater response latencies could also indicate avoidance of target stimuli. The dot probe task aims to counteract this problem by presenting neutral and target stimuli simultaneously, but has also been criticized for its influential processing priorities of stimuli by participants (e.g., Broschott, de Ruiter, & Kindt, 1999). Another experimental study examined whether individual differences in eating in response to external food cues (i.e. external eating) were predictive of the extent to which individuals preferentially allocated their attention to food cues. Johansson, Ghaderi, and Andersson (2004) investigated attentional biases for food stimuli in normal-weight external eaters. Surprisingly, the results suggested that high external eaters (i.e. high in responsiveness to external food cues/scoring high on the external eating behaviour scale of the DEBQ) showed a bias away from food words (suggesting cognitive avoidance) whereas low external eaters (i.e low in responsiveness to external food cues/scoring low on the external eating behaviour scale of the DEBQ) directed their attention towards food words on a dot probe task (suggesting attentional bias). But they also noted an important limitation of the study, namely that it used words as stimuli and that it would be preferable to investigate this issue further using pictorial stimuli as they have better ecological validity (Brignell et al., 2009; Johansson et al., 2004). Altogether, both studies (Johansson et al., 2004; Newman et al., 2008) have not yielded clear evidence for the idea that external eating is associated with an increased processing of food cues (Nijs, Franken, & Muris, 2009). Nijs et al. (2009) conducted a study that investigated differences in the processing of food-related stimuli between women with high and low scores on a scale of external eating. After the experiment, high external eaters reported significantly more food craving than low external eaters. This indicated that high external eaters displayed stronger subjective craving in response to the exposure to food cues as compared to low external eaters. This finding matches with the idea that in high external eaters the tendency to eat is more controlled by the exposure to external food-related cues than in low external eaters.

2.1.3.4 Food craving

Pelchat (2002) asked herself if it is more than a linguistic accident that the same term - “craving” - is used to describe intense desires for both foods and for a variety of drug abuse.

Indeed, there is strong evidence that most addictive drugs affect common neural pathways and, to be more specific, for animals (there has been less explicit work on this topic in humans) the presence of shared substrates for food and drug rewards has been indicated. Opioid peptides seem to influence food palatability in human beings, this indicates an amounting evidence for a consistency between drug/alcohol abuse and excessive craving or liking for sweets. The aim of the study from Smeets, Roefs, and Jansen (2009) was to induce chocolate craving (expose the participants to chocolates) in samples of high and low trait chocolate cravers and to examine the direct impact of this manipulation on the attentional processing of chocolate-related stimuli in a visual search paradigm. This study clearly showed a causal link between an elevated state of chocolate craving and a higher bias in the distraction component of attention than when they were not brought to this elevated state. This finding sheds more light on the factors that might cause or maintain a food-related attentional bias. In summary, chocoholics who were induced with chocolate craving showed a bias in increased distraction, whereas chocoholics who were not exposed showed a bias in speeded detection. Findings further articulated the importance of craving in explaining attentional biases for craving-related stimuli (Smeets et al., 2009).

2.1.3.5 Obese individuals

A study carried out by Nijs et al. (2010) examined differences in attention for food-related stimuli and food intake between overweight/obese and normal-weight, food-deprived and satiated females within a visual probe task (reaction times, stimuli of food items) and eye tracking (duration and gaze). An attentional bias towards food stimuli in all participants was found. Overweight/obese individuals, when food-deprived, appear to automatically direct their attention to a greater extent to food-related stimuli than normal-weight individuals. From an evolutionary perspective, this could have been expected: a selective detection of (palatable, appetizing) food seems to be one of the most adaptive characteristics of humans and animals (Nijs et al., 2010). Castellanos et al. (2009) combined a visual probe task with the monitoring of eye movements to examine food-related attention in obese and normal-weight individuals under conditions of hunger and satiety. Obese individuals were found to demonstrate a similar bias in attention to food stimuli during conditions of hunger and satiety whereas in normal-weight participants the food-related bias was clearly reduced (or even no longer existent) in a satiety, compared to a hunger state.

After describing different kinds of attentional biases in addictive and eating behaviours, the next topic of interest is focussing on how to measure attentional biases for these different kinds of behaviours. For that reason a selective number of methods that have been created to measure attentional biases are introduced in the next section.

2.2 Attentional (cognitive) bias measures

> Consuming and/or abstaining from a substance with a high reward value is often associated with cognitive biases for information relating to this substance (Pothos et al., 2008, p. 1).

Previous research is formulated about substance abuse and it is also the most common behaviour from which cognitive biases have been observed. Cognitive biases have been demonstrated with several paradigms, e.g., in an alcohol version of the stroop task (Cox, Fadardi, & Pothos, 2006), where an attentional bias for alcohol-related information was discovered in relation to the observation that alcohol abusers needed more time to name the ink colour of alcohol words compared to neutral ones. Pothos, Calitri, Tapper, Brunstrom, and Rogers (2008) examined cognitive biases for stimuli related to food. They compared five conceptually distinct measures of cognitive bias (dot probe, emotional stroop (see below), recognition, EAST, explicit attitudes) and found a weak relation and evidence only in certain subsets of the population sample (e.g., emotional, restrained and external eating characteristics of the participants).

An observation involving a wide range of substances (e.g., alcohol, heroin, marijuana, nicotine and certain foods – this is also the focus of this study (e.g., Brignell et al., 2009; Field et al., 2006; Field, Mogg, & Bradley, 2004b; Townshend & Duka, 2001) other types of addictive behaviour (e.g., gambling; Boyer & Dickerson, 2003), as well as other types of psychological problems (e.g., excessive anxiety; Mogg & Bradley, 1999; for reviews see Cox et al., 2006*)* has revealed the assumption that such cognitive biases are important since they may influence the controlling intake of the substance. Evidence of the arising of such biases for people who are particularly sensitive to the appetitive qualities of food (external eaters) and people who try to restrict their food intake (restrained eaters) was found.

> Methodologically, the emphasis on food stimuli is convenient. Cognitive biases relating to food stimuli are ubiquitous (Pothos et al., 2008, p. 2).

The DEBQ (Dutch Eating Behaviour Questionnaire; Van Strien, Frijters, Bergers, & Defares, 1986) is a widely used measure of three kinds of eating behaviours: emotional eating, restrained eating and external eating. Emotional eating is a measure of how likely an individual is (over)eating as a coping mechanism or in response to emotions like stress, anxiety and other similar negative emotions. A cognitive bias for food-related information might also been found in terms of a positive attitude towards food.

One way for measuring positive or negative attitude towards a particular theme such as "food" is the EAST (Extrinsic Affective Simon Task; De Houwer, 2003). The EAST is a simplified version of the better known IAT (Implicit Association Test, e.g., Greenwald, McGhee, & Schwartz, 1998). The EAST and the IAT have been advocated as implicit measures of attitudes.

Finally, an intuitive measure of eating behaviour is the BMI. The Body mass index (BMI) is defined as the individual's body weight divided by the square of his or her height. The formulae universally used in medicine produce a unit of measure of kg/m^2. High BMI can be a result of overeating which might arise because of the higher incentive salience of food-related cues. Furthermore, it can be associated with food cognitive biases (cf., Brunstrom, Rogers, Pothos, Calitri, & Tapper, 2008). Attentional bias measures are often derived from manual reaction times (RTs) and the direction of initial eye movements (EM).

2.2.1 The Stroop task

For being a prequel and pathfinder to the dot probe paradigm, which is used in the present investigation, the stroop task is also worth mentioning in this section. In 1935, J.R. Stroop published his fundamental article on attention and interference. Stroop had been engaged in studies of colour naming versus word reading and examined the effect of incompatible ink colours on reading words aloud (the word was incongruent with the ink colour).

Stroops two major questions were, what effect each dimension of the compound stimulus would have on trying to name the other dimension, and what effect practice would have on the observed interference (MacLeod, 1991). The stroop task takes advantage of our ability to read words more quickly and automatically than we can name colours.

If the ink colour and the colour that is actually named differ from each other; for example, if the word "**RED**" is written in **green ink** (as shown in Figure 1), participants will say the word "green" more readily and faster than they can name the color in which it is displayed, which in this case is "red". Otherwise, if participants should name the ink colour in which the word is printed they are interfered by the divergent content of the word and need longer for that.

Figure 1. Stimuli material of the stroop task.

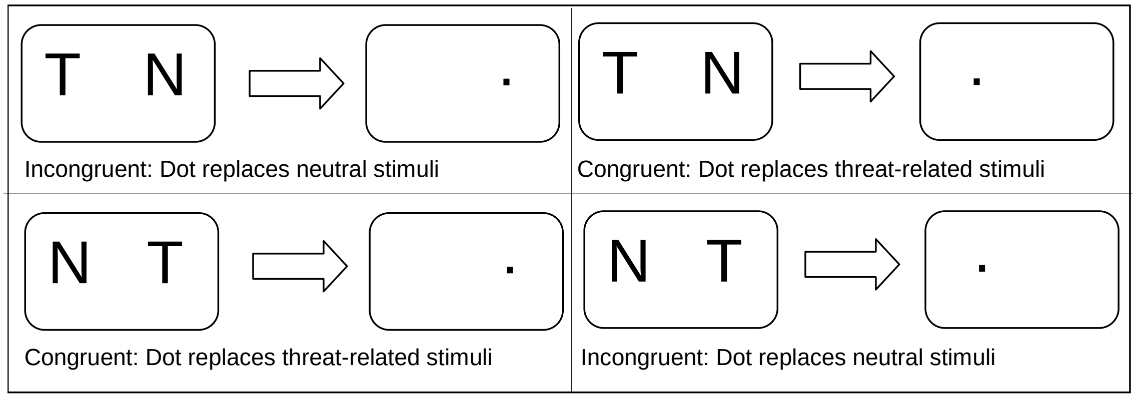
In a modified food version of the stroop task, participants see either food-related or neutral words and they have to name the ink colour of each word. The rationale is that the greater the attentional bias for food-related information, the longer it will take participants to disengage their attention from a food word and identify its ink colour relative to the time required for neutral words. The emotional stroop task (compared to the dot probe task) does not give the opportunity of an orientation bias as there are not multiple stimuli in different locations competing for attention. The content of the emotional word that causes response interference and capture attention could not only cause response latencies, but instead cause some other aspect of one's emotional reaction to the word's meaning (MacLeod et al., 1986). The methodology of the modified stroop task is not perfectly adequate to reveal the different components of selective attention, for example, initial orientation or sustained attention (Field et al., 2004a).

One paradigm, the dot probe task, offers improvement to the emotional stroop task in allowing multiple stimuli to compete for the engagement as well as for the orientation of attention (MacLeod et al., 1986). It also affords to verify the exposure times of the stimuli which provides a snap-shot view of attentional processes at the offset of the stimulus display. The exposure duration of 500 ms, for example, may be more likely to reflect initial orientating of attention whereas exposure times of, for example, 2000 ms or more may be more sensitive to the maintenance of attention (Field et al., 2004b).

2.2.2 The Dot probe paradigm

The dot probe task, also referred to as attentional probe task, attentional deployment task, or visual probe paradigm (Schmukle, 2005) was originally developed by MacLeod et al. (1986). This novel paradigm that enables direct measurement of how visual attention is distributed, enforces participants to make neutral responses (button press) to neutral stimuli (visual dot probe). "*The dot probe task has been used in at least 100 studies so far*" (Bar-Haim et al., 2007, as cited in Staugaard, 2009, p. 342) and its influence in shaping our current knowledge of attentional bias in a variety of disorders can hardly be underestimated. The dot probe task is an objective measure, because it is independent from the investigator and comprises a standardized presentation and analysis on a computer. In the original dot probe task, developed by MacLeod et al. (1986), a trial starts with a fixation cross, after which two words are displayed which can either be threat-related or neutral in content and which are simultaneously displayed in two areas of the display screen (up and down, or left and right). Immediately after the offset, a small dot (visual dot probe) appears on the screen whose position is manipulated relative to the visually displayed words. The ensuing distribution of visual attention is measured by the detection of the visual probe, which could appear in the spatial location of either word. Participants are required to press a hand-held button immediately when they detect the dot. Probe detection latency data is used to determine the impact of threat-related stimuli on the distribution of visual attention. The critical trials (which provide the data of interest) are those in which one of the two words is an emotionally threatening term. Clinically anxious participants consistently shift attention towards threat words whereas normal control participants tend to shift attention away from such material.

There are four kinds of critical trials that are distinguished in "congruent" and "incongruent" trials (see Figure 2). In a congruent trial, if the attention is directed towards the threat-related stimuli, the reaction time is expected to be shorter. If the attention is directed towards the neutral stimuli, the reaction time is expected to be longer. In an incongruent trial, if the attention is direction towards the threat-related stimuli, the reaction time is expected to be longer. If the attention is directed towards the neutral stimuli, the reaction time is expected to be shorter.



Note. T = threat-related stimulus, N = neutral stimulus.

Figure 2. Four critical trials within the dot probe paradigm.

2.2.2.1 Different versions of the dot probe paradigm

Until this day, a multitude of different versions of the dot probe task has been developed and used. In the original version of MacLeod et al. (1986) pairs of words were presented for 500 ms and participants needed to read the upper word aloud. Only 16,6% (48 out of 288 trials) of the trials comprised a threat-related word simultaneously with a neutral one (and were also followed by a dot). This version was hence less economic, because a lot of neutral (analysis irrelevant) word pairs needed to be presented. Beyond that, a dot hardly ever followed after neutral word pairs which classified another economic problem. There was evidence that some participants identified this connection and directed their attention more likely towards threat-related cues, where they expected the dot after every trial. This was actually the case with some participants in the study of Mogg and Bradley (1998). Dealing with these problems, a dot was presented after every word pair in later studies. The amount of critical trials (trials with a threat-related and a neutral word) was considerably raised too. Both changes led to a significant better economy compared to the original version of the dot probe task. It could still be a problem if participants develop the strategy to look consequently only on one side and if the dot is not showing up on this side, they conclude that the dot must be presented on the other side of the screen (Schmukle, 2003). Therefore Bradley, Mogg, Falla, and Hamilton (1998) developed an improved version, where after every pair of words a pair of dots is presented either vertically (:) or horizontally (..). Participants had to react with a button press which pair of dots was shown. But it had to be considered that this way additional time for identification of the pair of dots and choosing the right button is required, which incorporated the measured reaction time.

Hock (1999) modified a further version that avoided the different problems of the three so far illustrated kinds of dot exhibition and presented a dot during only 50% of the trials, independently of which trial was shown (also with neutral stimuli). As a consequence of this approach, it was necessary to double the number of trials that included a threat-related word to get the same amount of critical trials. Further variations between the versions persisted in the stimulus presentation duration. Mogg et al. (1997) realized three different presentation durations, 100 ms, 500 ms and 1500 ms, to measure the attentional allocation to varied points in time.

Regarding the assessment of attentional bias, there are three different versions of a visual probe task that can be used: a probe-position task ("where is the probe?"), a probe-classification ("what is the probe?") and a probe-detection ("is there a probe?"). Each version has advantages and disadvantages. For example, the probe position task is very simple (which is an advantage when testing children or clinical samples), consequently little data is lost due to errors or outliers. The probe-classification task may encourage even more monitoring of both sides of the display, but produces more errors and reaction time variance. Despite such apparent differences, the probe-position and the probe-classification tasks seem to produce similar results as comparison of data from these tasks indicate similar patterns of bias in monitoring strategy and similar sensitivity to attentional biases (Mogg & Bradley, 1999). Originally words were used as stimuli exclusively, but during the last years taking picture material instead of words has been increasing in the dot probe paradigm. The researchers of experimental cognitive psychology indicate that stimuli correlate to a greater amount with affective information than words, because stimuli and images have a "privileged access" to a system where affective information is processed and saved (Glaser & Glaser, 1989). Picture material functions directly since it need not be semantically processed and, for example, in case of measuring anxiety it owns a stronger threat factor (Schmukle, 2003). Mogg et al. (2000) also suggest that the use of pictures as stimuli might lead to better results, because they are more salient and threatening. They claimed that the dot probe task indicated a relatively fragile anxiety-related attentional bias in non-clinical studies, although results are inconsistent as well.

2.2.2.2 Reliability of the dot probe paradigm

By working with the dot probe paradigm, leading investigators explicitly point out the importance of reliable measures in this research field. *"It is clearly essential, in order to facilitate the investigation of cognitive bias in anxiety, to develop reliable, robust and sensitive tasks"* (Mogg & Bradley, 1999, p. 603). Staugaard (2009) actually announced considerably that *"it is thought provoking though that the reliability of the task was not tested more thoroughly before it was so widely applied" (*p. 342). Schmukle (2005) found the common denominator: *"Sufficient reliability of a measure is a prerequisite for research that is concerned with interindividual differences"* (p. 596).

Why is the reliability of a test so important? For example, if a test measures only error variance it does not lead to substantial and replicable effects. Inter-individual differences found in this test are only due to this measurement error. Possible effects are found only by chance and low reliability would explain the inconsistent results during the studies.

For example, the American Psychological Association (1954) set the standard for publications of psychological tests to report the reliability coefficients what has usually not been done for the dot probe task. Byrne and Holocomb (1962) criticized already nearly 50 years ago that every study should include a report of the reliability of its response measures to avoid disappointing results in cross-validation studies with the dot probe paradigm. Schmukle (2005) added that the reliability of a task should be analysed first, before it can be used as a measure of inter-individual differences, even if the task has shown that it can discriminate between groups like clinical and non-clinical samples. The reliability of the dot probe task was not investigated until 2003, although the paradigm has been used by researchers since it has been developed (1986). Schmukle (2003, 2005) rectified this neglect and reviewed two versions of the dot probe task, one using words and the other using situational images as stimuli. Results showed very poor reliability. Both versions were unreliable and therefore not adequate for research of individual differences in non-clinical samples. This unreliability might explain the inconsistent findings for the dot probe task as reported in the literature. Although the dot probe task might be used in studies that compare different samples, the results from the study of Schmukle (2005) are not applicable to studies comparing clinical and non-clinical samples. Staugaard (2009) suggested that one explanation for the negative results could be that the dot probe task is not sensitive enough to reveal consistent responses within non-anxious groups. While this would ultimately entail that the task cannot be used to test individual differences in non-anxious groups, between-subject effects can still be obtained if control groups consistently show no attentional bias or at least in the same direction (i.e. consistent with either avoidance or vigilance; Staugaard, 2009). This inconsistency is problematic for between-subject designs. Therefore, examining the reliability of the dot-probe task with facial stimuli in a non-anxious population is important (Staugaard, 2009).

Bradley, Mogg, and Millar (2000) conducted a study that simultaneously used an eye-tracking apparatus which revealed a tendency of some participants to ignore the initial stimuli (faces) and initiate their search only when the probe appeared. The problem with this behaviour was that if participants did not shift their attention, attentional bias might be reduced as a consequence. The eye movement monitoring in this study suggested that the (reaction time) bias in covert attention did not depend on overt shifts of attention (i.e., shifts in gaze) as many people only made a few eye movements. Instead, those who looked frequently at the stimuli showed conformity between the reaction times and eye movement bias measures.

One possible way of assuring that participants actively attend to the stimuli is to retain them within the visual field after onset of the probe (typically the faces disappear the moment the probe appears). When the offset of the faces no longer serves as a cue for probe onset, participants may be forced to initiate their search while the faces are visible (Staugaard, 2009). Indeed, under normal viewing conditions, shifts in gaze (overt orienting) closely follow, and are directed by, shifts in covert orienting of attention (Klein, Kingstone, & Pontefract, 1995; Kowler, 1995), although dissociation between overt and covert attention can occur. Staugaard (2009) concluded from the study that the dot probe design with photographic faces was not reliable. No coherent relationship between attentional bias scores for individual participants between the two testing sessions was found and concerning generalizability, the findings did replicate and extended those of Schmukle (2005). It was therefore recommended that until reliability has been firmly established, any results regarding individual differences originating from the dot probe task should be interpreted with caution (Staugaard, 2009). Although, Posner (1980) developed the cueing paradigm, an improved reaction time measure to better differentiate components of attention, many researchers have turned to eye tracking technology to overcome the limitations inherent in manual reaction time measures.

2.3 Eye tracking technology

Eye tracking systems continuously measure eye movements, which are a direct indicator of overt attention. This way a highly direct measure of visual attention is possible (Armstrong & Olatunji, 2009). Eye movement measures have several advantages over other methods of assessing attentional biases. For example, they are directly observable and ecologically valid measures of attentional allocation (Jonides, 1981).

2.3.1 The four eras of eye tracking technology

Many studies using eye movements to investigate cognitive processes have been conducted over the last two decades. A lot of them appeared in released books. The quality of such research is somewhat varying, therefore, the focus of the review from Rayner (1998) is on studies that have appeared in peer-reviewed journals. This review about 20 years of eye movement research begins with the assumption that there have been three eras of eye movement research.

The first era (1879-1920) was defined by the discovery of many basic effects about eye movements in reading such as saccadic supression (perceiving no information during an eye movement), saccade latency (initiation time of eye movements) and the size of the perceptual span (the region of effective vision). The second era was characterized by a more applied focus, coinciding with the behaviourist movement in experimental psychology and most of the work seems to have focused on the eye movements per se (Rayner, 1998). Tinker's (1958) review suggested that almost everything that could be learned from eye movements (under the restriction of the advanced technology at that time) in reading has been discovered. This widely held opinion might be the reason why between the late 1950s and the mid-1970s (when the third era began) only little research with eye movements was undertaken. The third era has been marked by improvements in eye movement recording systems, facilitating increasingly accurate and easily obtained measurements. The third era has generated enormous technological advances so that it became possible to interface laboratory computers with eye-tracking systems so that large amounts of data can be collected and analyzed. Because of the new technology it was also possible to develop innovative techniques in which the visual display can be changed contingent on the eye position.

The success of each era depends on researchers designing interesting and informative studies (Rayner, 1998). Rayner (1998) and Duchowski (2002) concluded in both of their reviews that eye movement data seems to be very valuable in diagnostic studies of reading and other information processing tasks, because they are able to provide a quantitative measure of real-time overt attention. Although much has been learned about the characteristics of eye movements in varying explored tasks, it is generally not appropriate to make generalizations between different tasks about the underlying cognitive processes that observing eye movements might reveal (Rayner, 1998).

2.3.2 Different kinds of monitoring eye movements

Current eye tracking systems rely on a variety of approaches and technologies, so eye movements can be monitored in many different ways. In general, the different methods range from (a) surface electrodes (which are fairly good at measuring saccade latency, but not good at measuring location) to (b) infrared corneal reflections and (c) video-based pupil monitoring as well as (d) infrared Purkinje image tracking and finally (e) search coils attached like contact lenses to the surface of the eyes (Rayner, 1998).

Although the measurement of eye movements has been pursued for over a century, accurate, non-invasive methods have been developed only in the last thirty years (Duchowski, 2003). Today the most popular methods involve directing a video camera and infrared light source at the participant's eye(s). This way the pupil can be detected by its lack of reflectance (dark pupil tracking; Richardson & Spivey, 2004); alternative with a bright light aimed at the eye, the pupil can be identified by the light reflecting through the pupil, off the retina (light pupil tracking; Richardson & Spivey, 2004). Two different kinds of reflections concerning the measurement of eye movements are located, once the pupilary reflection which provides the primary indicator of eye movements, and additionally, the corneal reflection which is often used to indicate participants' frequently head movements and this way enables the possibility for compensatory adjustments like re-calibration and re-validation (Duchowski, 2003). An alternative method of eye tracking includes the use of electrodes near the eye (electro-oculography) to record changes in electrical potentials produced by eye movements (e.g., Rohner, 2002).

Eye tracking devices allow researchers to dissect the orientation and engagement of attention as the locations of initial fixations indicate orientation (where one looks first), while the durations of these fixations indicate the engagement of attention (how long one looks). Eye tracking also provides richer data for the analysis of later attentional processes. Extended dot probe tasks reveal the probability of attending to one location at a single point in time. Instead, eye tracking allows the comparison of fixation durations at multiple locations across the time course of the trial. Whereas the dot probe requires additional conditions, e.g., varying the presentation time of the stimulus in order to register different components of attentional processes (earlier and later stages of the process), eye tracking can asses a multitude of attentional processes within the same trial (Armstrong & Olatunji, 2009).

2.3.3 Eye tracking applications

Nowadays, a wide variety of eye-tracking applications exists that can be distinguished by an analysis point of view into two categories: diagnostic or interactive. The difference between those two categories is that in its diagnostic role, the stimulus does not usually need to change or react to the viewer's gaze, whereas an interactive system responds to or interacts with the user on the basis of the observed eye movements. The eye tracker serves as a powerful input device, an interface modality, based on its richness of graphical designs and robustness of interactive styles. Several key problems and solutions have been identified in interactive eye-tracking systems. For example, for disabled users, an eye-tracking interface may be an indispensable form of communication (e.g., eye typing). With the beginning of the fourth era, eye-tracking may coincide with an increased number of interactive applications. Gaze-contingent applications are simply extensions of gaze-contingent paradigms of the third era. Duchowski (2002) takes the richness and flexibility of graphical environments into account and announced novel interactive uses of eye trackers within complex contextual situations which would lead to investigations with a broader class of applications than has been seen in the past. Eye Tracking is a promising methodology for future research. It provides crucial improvements over manual reaction time measures of attention. However, eye tracking measures need not replace reaction time measures. Indeed, research thus far suggests that eye tracking can actually improve the utility of a dot probe by clarifying the determinants of reaction time (Mogg et al., 2000). Future research should continue to combine eye tracking with previously used reaction time measures in order to enhance the interpretation of reaction time data.

2.3.4 Monitoring eye movements in case of a visual probe task

Gerdes, Pauli, and Alpers (2009) conduct a study monitoring eye movements with arachnophobic (spider-fearful) participants. They examined the case that highly fearful participants showed an attentional bias towards threat, but it is still unclear whether initial engagement of attention towards threat or difficulties to disengange from threat is the underlying mechanism. It is difficult to differentiate between these processes by measuring only reaction times. *"Recently, the use of eye-movement registration allows a deeper inspection of the time course and to continuously measure the deployment of attention"* (Gerdes et al., 2009, p. 726). Thus, eye tracking is used to clarify the question about disengagement and initial engagement involving threat-related stimuli. They found that fearful participants enhanced their attentional allocation not specifically towards threat, but they had difficulties to disengage their attention from fear-relevant information. This disengagement deficit could either be a cause, a correlate, or the results of phobic fear. Field et al. (2004b) investigated a study that examined the effect of nicotine deprivation on different aspects of attentional biases for smoking-related cues. They found a selective effect of deprivation on the maintenance of attention on smoking-relaed cues. Besides biases in orienting, that effect was suggested in recent theories of addiction. The authors also warned that an over-simplified view of selective attention is one limitation of much recent research into attentional biases in drug dependence. Research in cognitive science suggested that the attentional system is not unitary (e.g., Allport, 1989; LaBerge, 1995). They also claimed that the extent to which the probe reaction time measures (which reflects the spatial location to which individuals are attending when the stimuli disappear and the probe appears) reflect initial orienting versus maintenance of attention is uncertain, because the stimuli pairs that are presented in a long duration (2000 ms) which allows multiple shifts of attention and so may reflect a combination of attentional shifting and maintenance processes. That would indicate a relatively impure index of specific attentional component processes measured by the reaction times in the dot probe paradigm.

3. Empirical Section

3.1 Objectives of the present study

A rather important current debate concerns what exactly is measured by the dot probe? The dot probe is a measure of attential bias, widely used in alcohol abuse and other types of substance abuse, and advocated as a better alternative to the stroop task. The question, whether participants are faster to identify the dot when it replaces the food-related stimulus relative to the neutral stimulus, is most important when dealing with food-related stimuli. If participants are faster, then this is taken as evidence that there is an attentional bias for food-related information. The point where this conclusion is not well-defined anymore is that the time delay between the onset of the stimuli presentation and their disappearance/appearance of the dot (SOA) can vary. In this study the SOAs are 100 ms, 500 ms and 2000 ms long. Effects of attentional biases during 100 ms or even still at 500 ms probably reflect initial orientation. On the contrary, during a SOA of 2000 ms, people have advocated this as sustained attention.

The time course of users' attention from the initial orienting to the later stages of attentional processing (i.e. maintenance of attention [also called sustained attention]) remains to be investigated. The main weakness of most recent research on attention bias in dependence is the lack of a theoretical distinction between the above mentioned mechanisms. Furthermore, the “traditional” methodology of the dot probe task is not well-suited to reveal these different components of selective attention, because the measured reaction time (response latencies) only provides information about the allocation of the attention at the time of stimulus offset.

Additionally, Schmukle (2005) found a very poor reliability in his study, which might explain the inconsistent findings as reported in the literature and suggests that the dot probe task is not adequate for research of individual differences in non-clinical samples (e.g., unreliability of the dot probe task in non-anxious samples; Staugaard 2009) and results of studies with these samples should be interpreted with caution. Boon et al. (2000) suggested that dot probe paradigm might not be sensitive enough for non-clinical samples and that it might be a rewarding enterprise to replicate their study with a clinical sample.

Although Posner (1980) developed the cueing paradigm, an improved reaction time measure to better differentiate components of attention, many researchers have turned to eye tracking technology to overcome the limitations inherent in manual reaction time measures.

Eye Tracking (ET) might shed further light on the attention process by providing crucial improvements over manual reaction time measures of attention, although it need not replace reaction time measures. Indeed, research thus far suggest that monitoring of eye movements can actually improve the utility of a dot probe (Mogg et al., 2000) by clarifying the determinants of reaction time. The present research measured eye movements during the visual probe task, because this offers an unambiguous measure of attention compared to the measurement of response latencies (dot probe task), which is only an indirect measure of attention. In contrast, eye movements are direct manifestations of attention and the monitoring of eye movements offers the possibility of assessing attention during the entire length of stimulus presentation. Boon et al. (2000) retained from their study that only the examination of the eye movements during the presentation of target and neutral stimuli could reveal the exact attention curve. The initial fixations (direction bias) and the dwell time of the fixations (duration bias) are calculated from the data of the neutral and the food-related stimuli and therefore differentiate between initial orienting and sustained attention. This way it should be possible to find out if the dot probe indicates an attentional bias for food or not. Future research should continue to combine eye tracking with previously used reaction time measures, in order to enhance the interpretation of reaction time data.

Furthermore, the influence of different amounts of hunger on attentional biases as well as a distinction between certain ways of measuring the reaction times with the dot probe task were utilised in this research. The common method by pressing a button at the end of each trial when the dot appears (gamepad version) as well as the basic investigation of a new version of the dot probe task, where reaction times are measured by fixating the dot (eye version) were both carried out in the present research. Eye movements are simultaneously recorded during both versions of the dot probe task.

3.2 Methods

3.2.1 Apparatus

3.2.1.1 Dot probe task

The dot probe task is a measure of attentional bias, originally developed by MacLeod et al. (1986), widely used in evaluations of alcohol abuse and other types of substance abuse, like smoking or drugs. Further usage of this methodology takes place in studies investigating anxiety or certain eating behaviours. The dot probe task is advocated as a better alternative to the stroop task by now. Its basic procedure requires participants to identify the location of a dot across a series of trials (Pothos et al., 2008). The decision to use this paradigm in the present study was not only based on empirical evidence, but also on theoretical considerations. What allocates the dot probe task, compared to many other paradigms – for example the emotional stroop task – is that its measurement intentions are relatively indisputeable (Schmukle, 2003).

3.2.1.2 Eye tracking

The present research focused on measuring fixations with the eye tracker (Eye Link 1000, SR Research: Complete Eye Tracking Solutions) sampling at 1000 Hz at different time blocks. Participants were seated in front of a display screen at a distance of approximately 57 cm, while an infrared ray of light was directed upon their eyes. After an initial calibration, participants were instructed to keep their head in a persisting position and just look attentively at the screen. The video camera was recording an image from the designated eye which recorded both pupil and corneal reflex. All Eye trackers from Eye Link were fully supported by Experiment builder, a highly flexible graphically based experiment delivery software package, and the Eye data viewer for extracting hundreds of dependent measures (SR research Ltd., 2010c).

Experiment builder and the Eye data viewer are described in detail in the Appendix.

3.2.1.3 Questionnaires

3.2.1.3.1 The Grand hunger scale

The Grand hunger scale (GHS; Grand, 1968) is used to assess participants' hunger during the experimental session by evaluating their given answers to four questions. The questions contain informations about how hungry they were at the time of testing and how much of their favourite food they could eat at the moment. After that participants have to estimate when they ate their last meal and the amount of time until they are going to eat the next meal. Responses of the two hunger questions are indicated using two visual analogue scales (coded from 0-100) anchored by 'not at all hungry'/'extremely hungry' and 'none at all'/'as much as I could get', respectively. The values are combined into a single hunger index which is calculated by adding together the two analogue scales *hunger* and *favourite food* (0 -100 in millimeters, 200 in total), and *the time since the last meal* (hours) minus the *expected time until the next meal*. Higher scores indicate a greater amount of hunger (Pothos et al., 2008).

3.2.1.3.2 The BAS-Drive scale

Reward drive is assessed using the Behavioural Activation Scale (BAS) drive subscale (BAS-D; Carver & White, 1994). The BAS-D consists of four statements ("I go out of my way to get things I want", "when I want something I usually go all-out to get it", "if I see a chance to get something I want I move on it right away", "when I go after something I use a "no holds barred" approach") that participants rate on a 4-point scale as true or false (1 = very true for me, 2 = somewhat true for me, 3 = somewhat false for me , 4 = very false for me). Relative to the other BAS subscales, BAS-D is a clearer measure of generalized reward expectancies (Caseras, Avila, & Torrubia, 2003), and uniquely predicts neural activity to appetizing food images (Beaver et al., 2006).

3.2.1.3.3 The personal evaluation of the food stimuli

Finally, a personal evaluation, comprising four questions about every single food item (20 items) that had been shown before, was assessed on a 4- point rating scale. (1 = very, 2 = rather, 3 = rather not, 4 = not at all). Phrasing of the questions:
"How big is your appetite on the following aliments at the moment?"
"How much affection do you bear for the following aliments in general?"
"How healthy are the following aliments in your opinion?"
"How filling are the following aliments in your opinion?"

3.2.2 Stimuli

The stimuli material consisted of 14 neutral pairs of stimuli which were used for practice (10 pairs) and buffer (4 pairs) trials and were presented at the beginning of each session.

The relevant stimuli material consisted of 20 colour photographs of food, 10 of which were palatable foods (e.g., foods containing large amounts of fat, sugar and/or salt such as chips, kebab, cake) and 10 of which were bland foods (e.g., lettuce, asparagus and cauliflower) and 20 neutral stimuli (e.g., household items). Respectively one neutral and one food stimuli were matched to each other (concerning size and shape) and therefore 20 stimuli pairs were built (see Appendix). 80 possibilities of food-neutral stimuli pairs were created by presenting the food stimuli once on the right side and in another trial on the left side (same with the dot – one trial on the left and another trial on the right side).

Between the actual stimuli pairs, 10 neutral stimuli pairs (five neutral-neutral (matched in size and shape to a bland food) and five neutral-neutral (matched in size and shape to a palatable food) were presented. By changing the order of the stimuli on the screen as mentioned above (once stimuli on the right and once the same stimuli on the left side), and the same procedure with the dot, 40 possibilities of neutral-neutral pairs were created. By adding them to the 80 pairs of food-neutral stimuli, the whole set contained 120 trials.

The stimuli have been selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). The presentation area included 1024 x 768 pixels. Each stimulus was 50 x 50mm and was placed parallel to the other with a distance of 6cm from the centre of the presentation area. The dot was approximately 2 x 2mm. The visual angle corresponded to the viewing distance (57 cm) and the stimulus size (5 cm) and amounted to 5.02.

3.2.3 Participants

Participants were 48 female undergraduate students attending the University of Vienna, 31 of them received course credit (VPMS) for participating. The age varied from 19 and 32 years (*M* = 23.04, *SD* = 3.2). The sample contained 45 psychology students (93.75%) and respectively one student (6.25%) of journalism, pharmacy and political science.

The length of their studies varied between the first and the twentieth semester (*M* = 6.21, *SD* = 5.34). The sample comprised 29 (60.42%) people from Austria, 15 (31.3%) from Germany and respectively one person (2.1%) from Italy, Norway and Bosnia-Herzegovina. The participants consisted of 39 omnivores (81.3%), nine vegetarians (18.8%) and no vegans. The BMI ranged from 17.8 to 27.7 (*M* = 21.7, *SD* = 2.3). The selected participants were told not to wear glasses or other visual aids whereas at least soft contacts were usually no handicap for recording with the eye tracker. When the participants wore hard contacts a problem in regard to mirror effects turned up, because the contacts exhibited too strong reflective infrared radiations and this disturbed the calibration of the apparatus as well as the measure itself. The study contained 35 participants (72.92%) with no visual aids, another six had glasses (12.5%) and further seven (14.58%) wore soft or hard contacts. Two people who usually wore glasses were tested without them due to their high acuity. One session with hard contacts had to be cancelled during the practice trials and successfully retried a few days later with glasses.

3.2.4 Design and procedure

The investigation took place in the Lab of the Psychological Institute of Vienna. The first testruns with the experiment revealed that in many trials just one or two eye movements (one or two fixations) were measured. On that account, the traditional method (button press) of the dot probe task had been extended and another slightly different version of the dot probe task was created. The main difference between the versions was the way reaction times were measured, namely in the “gamepad version” (common method) by pressing the associated button on the gamepad (left dot - left button, right dot - right button) and the “eye version” (new method) measured the reaction times by fixating the distinct area where the dot appeared. The trial was finished when participants had a 50 ms fixation on the area of the dot. In the gamepad version, participants could have already detected the dot in the peripheral view. Instead, this new implementation in the eye version confirmed that participants looked directly on the dot. The Eye tracker recorded the eye movements in both versions simultaneously.

In each stimuli pair, neutral stimuli (e.g., furniture) were matched with food-related bland or palatable stimuli (salad, rice; kebab, cake). In each experimental block, the location of the dot probe relative to the food-related stimuli was fully counter-balanced. Also, all of the food-related and neutral stimuli appeared in equally both the left half and the right half of the screen.

The order and match in which the stimuli occured was randomized across participants. If the dot appeared on the side of the food stimulus, the trial was called “congruent”; if the dot appeared on the side of the neutral stimulus, the trial was called “incongruent”. In case of neutral-neutral stimuli pairs (no food item), where the dot always appeared on the side of a neutral stimuli the trial was called “neutral”.

Three blocks of dot probe trials were created (each with 120 trials) for the SOA of 100 ms (initial orientation), 500 ms (initial orientation or sustained attention) and 2000 ms (sustained attention). The trials within a set were presented in a new random order for each subject. This way it was possible to examine attentional responses to food stimuli in each part of the task separately as there was evidence that cognitive biases might vary over the course of a test session (e.g., Broadbent & Broadbent, 1988; Green, McKenna, & de Silva, 1994).

Finally, four distinct regions (areas of interest, AOI) were created for analysing the eye movements around the centre of the stimuli. The two main areas of interest were created around the two stimuli (left and right) and matched exactly their size (50 x 50 mm), and the third area was created between the stimuli. The fourth area included anything else around the three areas, in case any eye movements happened to be measured outside the areas.

Each participant was tested and instructed individually via e-mail to either abstain eating before 10 o'clock in the morning (when tested between 10 to 14 o'clock) or to fast after 14 o'clock (when tested between 14 and 18 o'clock). Before the experiment, participants got an information sheet that outlined the study procedure and afterwards they had to sign a written consent to take part. Then two visual tests were carried out to eventually exclude participants with any kind of impairment in eyesight or colour vision (an acuity test for hyperopia and myopia and the Ishihara vision test for colour blindness). Additionally the participants completed a handedness test. Finally, a short test was conducted that identified the dominant eye which was the one that had been tracked afterwards. After the initial tests, participants were instructed to sit in front of the display and to place their head on a chin rest. Then the eye tracking began with the calibration and validation of the recorded eye. The experiment started with displaying the instructions of the dot probe task (see Appendix), which participants had to read for themselves. Afterwards, participants completed 10 practice trials and 4 buffer trials (between practice and critical trials). These trials were not analysed. Following, particpants got the chance to ask questions concerning the trials.

Finally, participants completed the total of 360 food-neutral and neutral–neutral stimuli pairs individually.

They saw a blank screen after each of the 360 trials with an advice that they could blink occasionally and then continue by pressing a button. So they were able to pause as long as they want and relax their eyes. In case they wanted to move their head out of the chin rest, a re-calibration and re-validation had to be done afterwards. After finishing the trials of the dot probe task, participants filled out the Grand hunger scale (GHS), the BAS-D scale and the personal evaluation of the stimuli. The testing session ended afterwards.

The design of the present study was a 2 x 3 x 3 x 2 mixed design with three within-subject factors and one between-subject factor. The within-subject factors were the food type (bland and palatable), the SOA (100 ms vs. 500 ms vs. 2000 ms) and the congruency levels (incongruent vs. congruent vs. neutral). The between-subject factor was the experiment version (gamepad version vs. eye version). The dependent variable was the reaction time, which was measured by pressing a button when the dot appeared in the “gamepad version” and by a 50 ms fixation on the dot in the “eye version”.

Each trial began with the presentation of a fixation cross in the centre of the screen. To continue, participants had to look for at least 50 ms directly on the fixation cross, otherwise a “fixation fail” message was displayed and the trial started again. Successful fixations were followed by the presentation of two critical stimuli centred on the left half and right half of the screen, a neutral stimulus and a food-related stimulus or two neutral stimuli. The intentions of the dot probe task induce that participants move their eyes to the stimuli. After certain SOAs the stimuli were replaced by a small dot on either the left or the right side of the screen. The participants were instructed to respond to the side where the dot appeared by (1) pressing the corresponding response key on the gamepad as quickly and accurately as possible or (2) looking as quickly and accurately as possible on the dot for at least 50 ms. Once the dot had appeared it remained on the screen until the participants responded. Pressing the button/looking on the dot started an intertrial interval (during which a short text was displayed that participants could blink occasionally and then click on the designated button to continue with the trials). After the intertrial interval, the next fixation cross was presented (see Figure 3).

27 participants finished the gamepad version and 21 finished the eye version, the data collection was completed in 4 weeks.

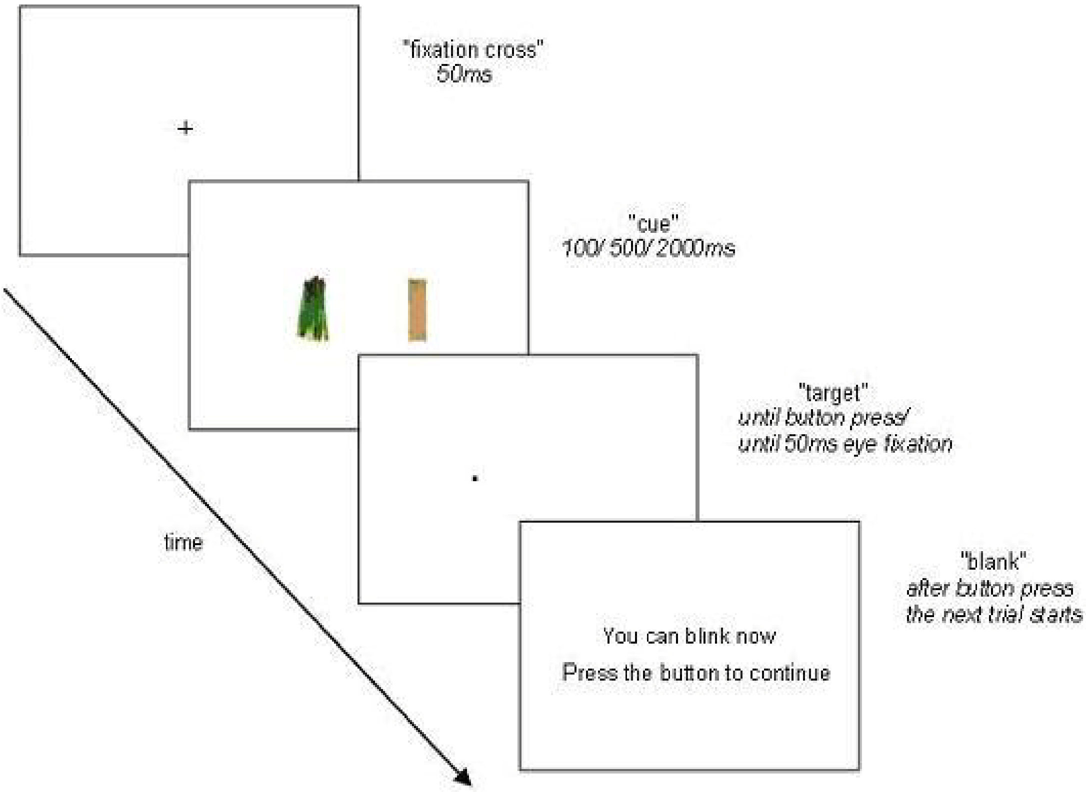


Figure 3. Procedure of the dot probe task.

3.2.5 Hypotheses

The present study investigates the influence of hunger on the bias indices and reaction times for bland and palatable food stimuli during different SOAs. Furthermore, the effect of the new experiment version (“eye version”) of the dot probe task’s score remains to be examined. In order to provide a structure for further analyses, the following Hypotheses are proposed.

The new version has been created to assure that participants fixate the dot and not just detect the dot left or right in their peripheral view (preliminary data showed that participants made only very few eye movements during the gamepad version). Thus, it is expected that the eye version is a more precise and pure measure of attentional bias.

Tapper et al. (2010) described different underlying mechanisms for the different SOAs (delayed disengagement rather than enhanced orienting for 100 ms and 500 ms, and delayed disengagement and enhanced orienting for 2000 ms). Thus, differences between certain SOAs in raw reaction times and reaction time bias as well as possible interactions with other study variables are expected. However, it is not clear in which direction the differences might arise. Therefore, *Hypothesis 1* is formulated in an undirected and exploratory way.

Hypothesis 1: There is a significant difference between the different SOAs (main effect of SOA) and significant interaction effects of SOAs with other study variables (e.g., experiment version and food type).

It has been repeatedly shown that humans generally have a pronounced preference for sweet, salty and energy-dense foods because of their innate high incentive values (Birch, Fisher, & Grimm-Thomas, 1996; Cowart & Beauchamp, 1986); a possible explanation could be provided by an adaptive/evolutionary approach to human food preference). Furthermore, palatability results showed that participants had a greater attentional bias for foods that were rated as being more palatable (Hepworth et al., 2010). Thus, *Hypothesis 2* proposed that food-related attentional bias should be higher towards palatable foods (i.e., high in sugar, salt and/or fat) than towards bland foods (i.e., less inherently palatable foods). Thus, a main effect of food type is expected.

Hypothesis 2: Bias indices for palatable food stimuli are significantly higher than bias indices for bland food stimuli.

An attentional bias for food-related items is likely to be measured when participants are hungry (e.g., Mogg et al., 1998). Since attentional bias is said to reflect the biological value of the stimuli (Tapper et al., 2010), and palatability results showed generally that participants had a greater attentional bias for foods that were rated as being more palatable (see *Hypothesis 2*), *Hypothesis 3* is formulated that there should be no difference between the bias indices for bland and palatable food stimuli in participants with low hunger, but attentional biases for palatable stimuli should be higher when individuals are experiencing higher levels of hunger. This mechanism would manifest itself in an interaction of food type and hunger level.

Hypothesis 3: High levels of hunger lead to significantly higher bias scores for palatable food stimuli than for bland food stimuli.

The measured reaction times, of which bias indices are calculated from, are distinguished in “congruent”, “incongruent” and “neutral” conditions. Participants are expected to prefer the food stimuli over the neutral stimuli, further, they should respond faster during the “congruent” trial than during the “incongruent” or “neutral” trials. In the current study this suggestion is leading to the formation of *Hypothesis 4*, main effect of “congruence”.

Hypothesis 4: Response times are significantly shorter during congruent than during incongruent or neutral trials.

Since eye movements have been recorded during the dot probe task simultaneously, an investigation of the different biases (direction bias, duration bias, biasindex) and possible correlations between them is carried out in this research. *Hypothesis 5* and *6* are proposed as the following prediction.

Hypothesis 5: There is a significant difference for direction biases between the two experiment versions.
Hypothesis 6: There is a significant difference for duration biases between the two experiment versions.

To follow up to *Hypothesis 3,* which predicts that food-related attentional biases should be higher during higher levels of hunger, and investigate this prediction combined with EM data for “initial orientation” (direction bias), “dwell time” (duration bias) and reaction time (RT) data for bias indices on food-related stimuli lead to the formation of *Hypothesis 7*.

Hypothesis 7: There is a significant positive correlation between hunger and direction biases, duration biases and bias indices towards food-related items in both the gamepad and the eye version.

Finally, the last *Hypothesis 8* is logically derived out of one of the basic assumptions of the dot probe task. The dot probe task should be able to predict an attentional bias for food-related stimuli. To prove this assumption not only with the measured reaction times from the dot probe task, eye movements were recorded simultaneously. Therefore a positive correlation between these two measures of attention is assumed, and *Hypothesis 8* is formulated the following way:

Hypothesis 8: There is a significant correlation between the measured bias indices within the dot probe task and the measured mean gaze “dwell time” within the recorded eye movements in both the gamepad and the eye version.

3.3 Results

3.3.1 Analyses of the questionnaires

Data of 48 participants had been collected (27 completed the gamepad version, 21 took part in the eye version). One participant was excluded from the whole analyses due to a large number of fixation failures and outliers, most probably caused by observed calibration problems during the test situation. The total number of participants was therefore 47. The questionnaires were analysed with data from 47 participants.

3.3.1.1 Results of the Grand Hunger Scale

The average score of the Grand hunger scale (GHS) was calculated by adding together the two analogue scales *hunger* and *favourite food* (0 -100 in millimeters, 200 in total), and *the time since the last meal* (hours) minus the *expected time until the next meal*. Higher scores indicate a greater amount of hunger. Results ranged from 18.0 to 193.5 (see Table 1, *M* = 113.71, *SD* = 46.93).

Table 1. Means and standard deviations of the scores in the GHS

	Experiment version	*M*	*SD*	*N*
Grand hunger scale	Gamepad	101.33	51.23	26
	Eye	129.04	36.59	21

Independent t-tests were carried out to analyse the effects of experiment version. The Levene test was marginally significant, (*F* = 4.109, *p* = .049), so equality of variances was not assumed. There was a significant difference between the scores of the two experiment versions, *t*(44.409) = -2.159, *p* = .036, Cohen's *d* = 0.63. Participants from the eye version showed a significantly greater score on the GHS than participants from the gamepad version.

Follow-up t-tests comparing the four constituent parts of the GHS (see Table 2) were conducted in order to investigate which of the items had the biggest contribution to the significant effect. The Levene tests were non-significant, so equality of variances was assumed. Participants from the eye version had significantly higher scores on the analogue scale: *how hungry are you at the moment? t*(45) = -2.246, *p* = .030, Cohen's *d* = -0.66 which implied that participants from the eye version were hungrier than participants from the gamepad version.

There were no significant differences between the participant groups on the other components of the GHS: *how much of your favourite food could you eat at the moment?*, $t(45) = -1.177$, $p = .245$, Cohen's $d = -0.35$, *when do you presumably expect your next meal?*, $t(45) = 0.687$, $p = .469$, Cohen's $d = 0.02$, *when was your last meal?*, $t(45) = -0.755$, $p = .454$, Cohen's $d = -0.22$.

Table 2. Means and standard deviations of the four subscales of the GHS

	Experiment version	*M*	*SD*	*N*
hungry	Gamepad	42.50	28.67	26
	Eye	61.38	28.65	21
favourite food	Gamepad	57.77	25.14	26
	Eye	65.29	16.58	21
next meal	Gamepad	2.73	1.46	26
	Eye	2.45	1.28	21
last meal	Gamepad	3.79	4.24	26
	Eye	4.82	5.14	21

Note. hungry = How hungry are you at the moment?; favourite food = How much of your favourite food could you eat at the moment?; next meal = When do you presumably expect your next meal?; last meal = When was your last meal?

3.3.1.2 Results of the BAS-D Scale

The BAS-D Scale consists of four statements that participants rated on a 4 - point scale as true or false. The ratings were recoded (*1 = 4, 2 = 3, 3 = 2, 4 = 1*) and summarized to give total scores on the scale (see Table 3) and its subscales, with higher scores indicating higher levels of behavioural activation. Results ranged from 9 to 16 ($M = 12.57$, $SD = 1.89$) which indicated a generally higher level of behavioural activation among the participants.

Table 3. Means and standard deviations of the BAS-D Scale

	Experiment version	*M*	*SD*	*N*
BAS-D Scale	Gamepad	12.73	2.03	26
	Eye	12.38	1.72	21

Independent t-tests have been chosen to analyse the effects of experiment version. The Levene test for equality of variances was not significant, so equality of variances was assumed. The analysis of the scores showed no significant differences between the experiment versions, $t(45) = 0.628$, $p = .533$, Cohen's $d = 0.18$.

3.3.1.3 Results of the personal evaluation of the food stimuli

The last part of the questionnaires comprised four questions regarding appetite, preference, healthiness and saturation about every food item that was presented during the dot probe task which should be assessed on a 4 - point rating scale (1 = very, 2 = rather, 3 = rather not, 4 = not at all). For better comparison, the scores of the food stimuli were divided into the categories “bland” and “palatable” within every of the four scales: *appetite*, *preference, healthiness* and *saturation* (Means and standard deviations for the total scores of each category are shown in Table 4).

Mean scores of bland and palatable per scale as the dependent variable were entered into a 2 x 2 mixed analysis of variance (Mixed ANOVA) with *food type* (bland vs. palatable) as a within-subject and *experiment version* (gamepad vs. eye) as a between-subject independent variable.

Multivariate tests of within subject effects revealed no significant main effect of experiment version, $F(4,42) = 1.008$, $p = .414$, $\eta_p^2 = 0.088$, and no interaction between experiment version x food type, $F(4,42) = 0.385$, $p = .818$, $\eta_p^2 = 0.035$, confirming that the mean scores were in general the same for bland and palatable food stimuli in the gamepad and eye version.

However, a significant main effect of food type was found, $F(4,42) = 418.784$, $p < .001$, $\eta_p^2 = 0.976$ which implied that there was a significant difference between the mean scores for the two food types in both experiment versions. Univariate tests discovered that the mean scores of the ratings from the item “healthiness” were significantly different for bland and palatable food-related stimuli. The main effect of “healthiness”, $F(1,45) = 1682.350$, $p < .001$, $\eta_p^2 = 0.974$, showed that bland produced significantly higher scores ($M = 3.56$) than palatable ($M = 1.36$) on the “healthiness” scale.

Table 4. Means and standard deviations of the evaluation of the stimuli

	Experiment version	*M*	*SD*	*N*
BLAND				
appetite	Gamepad	2.13	0.64	26
	Eye	2.03	0.41	21
preference	Gamepad	2.62	0.56	26
	Eye	2.56	0.29	21
healthiness	Gamepad	3.60	0.27	26
	Eye	3.51	0.23	21
saturation	Gamepad	2.71	0.38	26
	Eye	2.63	0.37	21
PALATABLE				
appetite	Gamepad	1.99	0.60	26
	Eye	1.91	0.56	21
preference	Gamepad	2.49	0.46	26
	Eye	2.62	0.49	21
healthiness	Gamepad	1.42	0.29	26
	Eye	1.31	0.24	21
saturation	Gamepad	2.65	0.68	26
	Eye	2.62	0.52	21

Note. appetite = How big is your appetite on the following aliments at the moment?; preference = How much affection do you bear for the following aliments in general?; healthiness = How healthy are the following aliments in your opinion?; saturation = How filling are the following aliments in your opinion?

3.3.1.4 Correlations between the GHS & the personal evaluation scale

Finally, Pearson correlations were used to examine the relationship between the GHS and the “evaluation of the food stimuli”, investigating whether the amount of hunger could have an influence on the ratings of the food stimuli (correlations see Table 5). Significant effects were only found in the gamepad version. The first significant correlation was found between the GHS and “palatable appetite” (r = .811, p < .001). A second significant correlation (r = .505, p = .009) was detected between the GHS and “palatable preference”.

Table 5. Correlations between the GHS and the “evaluation of the food stimuli” separated for the gamepad and the eye version

	bland				palatable			
Item	appetite	preference	healthiness	saturation	appetite	preference	healthiness	saturation
Gamepad	.184	-.214	.025	-.132	.811***	.505**	.007	.347
Eye	.247	.174	.096	.255	.335	.046	.151	.151

Note. appetite = How big is your appetite on the following aliments at the moment?; preference = How much affection do you bear for the following aliments in general?; healthiness = “How healthy are the following aliments in your opinion?; saturation = “How filling are the following aliments in your opinion?
***p < .001, two-tailed; **p < .01, two-tailed; N = 26 (Gamepad); N = 21 (Eye).

3.3.2 Analysis of the dot probe task

3.3.2.1 Preparation of the reaction time data

Reaction time data from practice (10) and buffer trials (4) were removed from the whole analyses.

Removing errors, “fixation fails” and “target fails”

Error trials were defined as trials in which negative reaction times were measured, this happened only in the “eye version”. Reaction times from these error trials (0.9%) were discarded. At the beginning of each trial the participants had to fixate the cross in the centre of the screen for 50 ms. In case of a “fixation fail” the trial starts again. The number of “fixation fails” accounted for 1.3% of the trials, and ranged from 0 to 49 trials (*M* = 4.79, *SD* = 5.2). These trials were excluded. “Target fails” were only possible in the gamepad version. An incorrect response was made by pressing the wrong button (e.g., target left, but right button pressed). The amount of “target fails” per participant ranged from 0 to 9 (*M* = 2.15, *SD* = 1.82) and these trials (0.3%) were also excluded from further analyses.

Treatment of outliers within reaction time measurement

The treatment of outliers within reaction time measurement in this study followed the proposition of Schmukle (2002) and was explained in his dissertation as follows:

> During the measurement of reaction times, extraordinary short or long times (outliers) have been recorded partly. The problem with these outliers is that they

carry strong weight by calculating the mean and distort the results. Additionally, under certain circumstances, these extreme reactions are the implication of processes that were not intended during the measurement. Extremely long reaction times could be a consequence of participants' lack of attention, not being concentrated or temporary distraction. The reactions would be independent from the actual interest in attention direction und would only increase the measurement error. Certainly, it is also possible that extreme reactions capture valid information which means, participants actually are very fast or very slow, without interfering uninteresting processes. (p. 61)

In previous studies with the dot probe task, different strategies for dealing with reaction time outliers have been applied. The first outlier criterion sets a lower cut-off score of e.g., 100 ms (for a justification of this procedure, (see Ratcliff, 1993) and an upper cut-off score of e.g., 2000 ms. The use of the first method leads to the problem that a lot of comparatively long reaction times of participants and probably a lot of valid reaction times had to be cut out. Ratcliff (1993) suggested for cases in which the mean reaction times of the participants strongly vary a second method which used an upper and a lower cut-off score of two standard deviations above and below the mean of each participants' reaction times (see e.g., Mansell, Clark, Ehlers, & Chen, 1999; Mogg, Bradley, & Williams, 1995). In case of differences in the mean reaction times between the slowest and the fastest participant by 300ms, this procedure performed better as the one with the fixed cut off score.

The mean reaction times per participant in this study vary with a range of 398 milliseconds between 356 and 745 (*M* = 467.71, *SD* = 62.30), so only the second outlier criterion is used here. Reaction times more than two standard deviations above each participant’s mean were excluded as outliers. The mean reaction times for the different SOAs were: 100 ms condition: *M* = 432.04, *SD* = 249.40, 500 ms condition: *M* = 470.58, *SD* = 272.11, 2000 ms condition *M* = 500.75, *SD* = 259.82. The number of outliers (*M* +/- 2 *SD*) per participant ranged from 6 to 62 (*M* = 22, *SD* = 7.82) and were removed (6% of trials).

Descriptive statistics for bias indices

Whether the two experiment versions differed in their attentional allocation during different levels of hunger was measured with a four factor design with the two between factors “experiment version” (gamepad version vs. eye version) and “hunger levels” (low levels vs. high levels) and the two within factors “food type” (bland vs. palatable) and “SOA” (100 ms vs. 500 ms vs. 2000 ms).

To simplify the four-way interaction, bias scores were calculated, modifying the procedure of Macleod and Mathews (1988). A bias index for attentional allocation for food type and stimulus duration (SOA) for each participant is defined which is calculated by subtracting the mean reaction time for dots replacing food stimuli from the mean reaction time for dots replacing neutral stimuli. Listing the food-related position with L for Left and R for Right and the dot position analogically l and r, the bias index results from [(Lr+Rl)-(Ll+Rr)]/2. That index provides data considering attention reaction to food-related stimuli for each person. Thus, positive values of the bias index reflect a bias favouring food stimuli relative to neutral stimuli (increased contribution), negative values result from increased avoidance of food-related stimuli (Schmukle, 2002).

Two groups with an equal amount of participants were allocated on the basis of their subjective hunger ratings. The final individual scores of the GHS range from 0 to 200. A median-split design divided the participants in two groups. The '"low hunger" group with hunger ratings below the score of 122.75, and the "high hunger" group with hunger ratings of 123 and more.

3.3.2.2 ***Results of the mixed ANOVA for bias indices***

Two participants were excluded just from the analysis of bias indices as they had outlying bias scores (bias scores were >2 *SD* above sample mean). The bias indices were analysed with data from 45 participants.

Attentional bias scores were entered into a 2 x 3 x 2 x 2 mixed analysis of variance (Mixed ANOVA) with bias indices as the dependent variable (see Table 6), "food type" (bland vs. palatable) and "SOA" (100 vs. 500 vs. 2000 ms) as within-subjects independent variables, and "experiment version" (gamepad version vs. eye version) and "hunger levels" (low levels vs. high levels) as a between-subject.

Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of SOA (χ^2 = 6.594, p = .037) and the interaction food type x SOA (χ^2 = 11.816, p = .003). Therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (ε = 0.969 for SOA, and ε = 0.884 for food type x SOA).

There were no significant main effects of food type, $F(1,41)$ = 0.258, p = .614, η_p^2 = 0.006, or experiment version, $F(1,41)$ = 0.114, p = .737, η_p^2 = 0.003, or hunger, $F(1,41)$ = 0.061, p = .807, η_p^2 = 0.001, confirming that the bias indices from the two experiment versions were in general the same for bland and palatable food stimuli during the two levels of hunger.

Table 6. Means and standard deviations of bias indices with food types and SOA

	Experiment version	*Hunger levels*	*M*	*SD*	*N*
biasindex_b_100	Gamepad	Low	-1.33	21.22	15
		High	-7.48	16.85	10
	Eye	Low	-12.21	49.49	9
		High	5.13	71.14	11
biasindex_p_100	Gamepad	Low	-13.45	18.98	15
		High	-12.95	18.92	10
	Eye	Low	-29.48	35.35	9
		High	-37.00	56.53	11
biasindex_b_500	Gamepad	Low	5.08	17.47	15
		High	-6.34	20.16	10
	Eye	Low	17.56	58.57	9
		High	24.31	47.58	11
biasindex_p_500	Gamepad	Low	7.32	16.64	15
		High	6.40	23.25	10
	Eye	Low	-7.04	33.71	9
		High	8.61	80.07	11
biasindex_b_2000	Gamepad	Low	4.93	18.21	15
		High	7.91	28.08	10
	Eye	Low	-0.45	64.98	9
		High	-14.38	81.51	11
biasindex_p_2000	Gamepad	Low	6.71	29.44	15
		High	-4.05	22.06	10
		Total	2.41	26.78	25
	Eye	Low	29.99	85.23	9
		High	24.91	89.65	11

Note. b = bland, p = palatable, SOA = 100, 500, 2000.

However, there was a significant main effect of SOA, $F(1.939,79.492) = 5.283$, $p = .008$, $\eta_p^2 = 0.114$ which implied that there was a difference between the bias indices, when measured during different presentation durations in both experiment versions.

Contrasts (repeated) revealed that a SOA of 100 ms was significantly more likely to orient attention away from food-related stimuli than a SOA of 500 ms, $F(1,41) = 8.998$, $p = .005$, $\eta_p^2 = 0.180$, whereas participants directed their attention towards food-related stimuli. Furthermore, during a SOA of 500 ms participants' were more likely to direct attention towards food-related stimuli than during a SOA of 2000 ms, $F(1,41) < 0.001$, $p = .996$, $\eta_p^2 < 0.001$.

There were no significant interactions between experiment version x food type, $F(1,41) = 0.042$, $p = .839$, $\eta_p^2 = 0.001$, and experiment version x SOA, $F(1.939,79.492) = 0.860$, $p = .424$, $\eta_p^2 = 0.021$, experiment version x hunger, $F(1,41) = 0.585$, $p = .449$, $\eta_p^2 = 0.014$, SOA x hunger, $F(1.939,79.492) = 0.230$, $p = .788$, $\eta_p^2 = 0.006$, food type x hunger $F(1,41) = 0.002$, $p = .65$, $\eta_p^2 < 0.001$. Whereas a significant interaction between food type x SOA was found, $F(1.768,72.485) = 3.167$, $p = .054$, $\eta_p^2 = 0.072$. This significance meant that there was a difference between the bias indices for bland and palatable items when measured during different presentation durations in both experiment versions (see Figure 4).

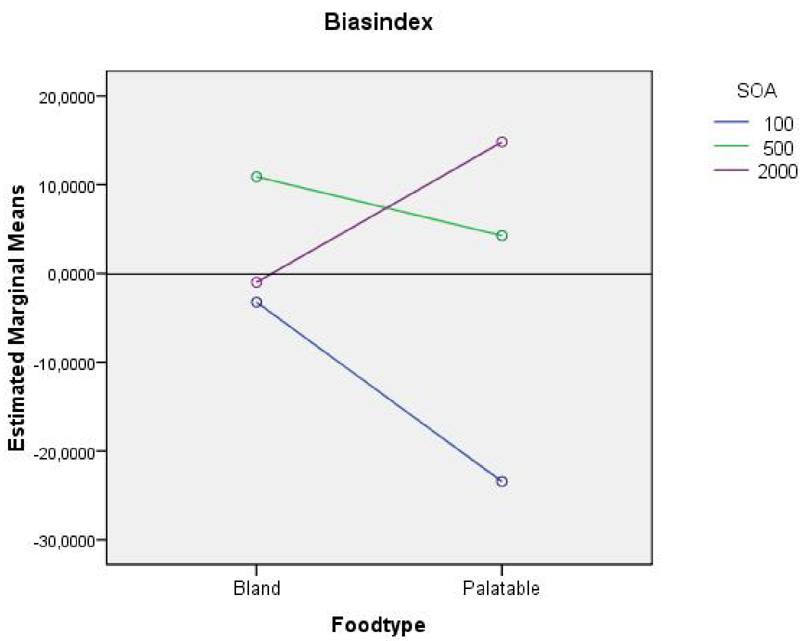


Figure 4. Mean bias indices for the significant food type x SOA interaction.

To break down this significant food type x SOA interaction, contrasts (repeated) were performed comparing each level of food type across each level of SOA with the middle category of "500 ms". The first contrast compared the bias indices of bland to palatable stimuli during the SOA of 100 ms compared to 500 ms.

This contrast was not significant, $F(1,41) = 1.291$, $p = .262$, $\eta_p^2 = 0.031$, and the means indicated that the bias indices for 100 ms showed a bias avoiding both food types, whereas the bias indices for 500 ms showed a bias towards both food types. The second contrast also revealed no significant effects when comparing the bias indices of bland to palatable stimuli during the SOA of 500 ms compared to 2000 ms, $F(1,41) = 2.963$, $p = .093$, $\eta_p^2 = 0.067$, and indicated that the bias indices for 500 ms showed an equal bias for both food types, and the bias indices for 2000 ms showed a positive bias score towards palatable food stimuli, and a negative bias score to bland food stimuli (which meant avoiding the bland food stimuli).

There were no significant interactions between experiment version x food type x hunger, $F(1,41) = 0.016$, $p = .901$, $\eta_p^2 < 0.001$, and experiment version x SOA x hunger, $F(1.939,79.492) = 0.312$, $p = .726$, $\eta_p^2 = 0.008$, food type x SOA x hunger, $F(1.768,72.485) = 0.242$, $p = .758$, $\eta_p^2 = 0.006$. Finally, the experiment version x food type x SOA interaction was significant, $F(1.768,72.485) = 3.695$, $p = .035$, $\eta_p^2 = 0.083$ which indicated that the food type x SOA interaction described previously was different for participants in both experiment versions (see Figure 5 and 6).

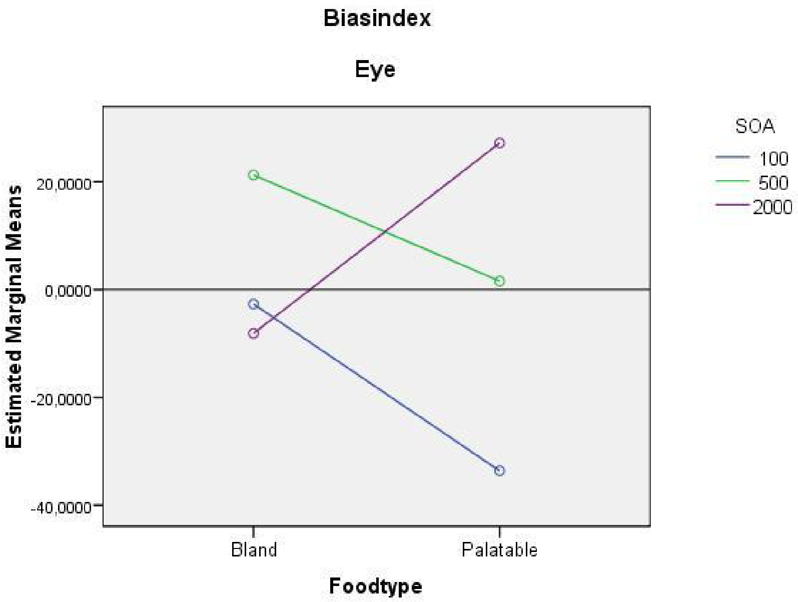


Figure 5. Mean bias indices for the significant experiment version x food type x SOA interaction (Eye).

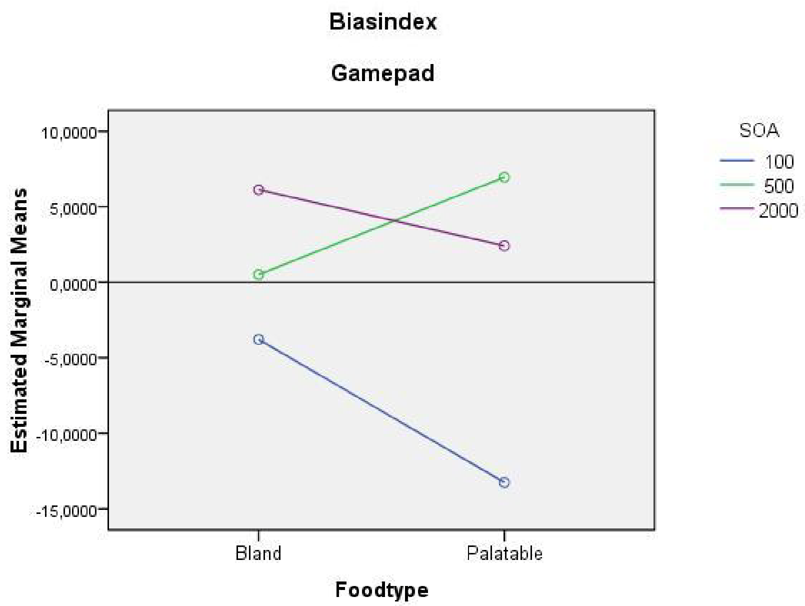


Figure 6. Mean bias indices for the significant experiment version x food type x SOA interaction (Gamepad).

Again, contrasts were used to break down this interaction, contrasts (repeated) for the significant experiment version x food type x SOA were performed to compare the bias indices of the experiment versions across each level of food type and each level of SOA to the middle category of “500 ms”.The first contrast revealed a non-significant difference between the experiment versions when comparing bland to palatable stimuli and when the SOA of 100 ms was compared to 500 ms, $F(1,41) = 0.088$, $p = .769$, $\eta_p^2 = 0.002$. This indicated that in the gamepad version as well as in the eye version the bias indices for 100 ms indicated a bias avoiding the food stimuli, and the bias indices for 500 ms indicated a bias towards food stimuli for both food types. The second contrast investigated differences between gamepad and eye version when comparing bland to palatable food-related stimuli and when the SOA of 500 ms was compared to 2000 ms. This was significant, $F(1,41) = 7.520$, $p = .009$, $\eta_p^2 = 0.155$, and indicated that in the gamepad version the bias indices for 500 ms and 2000 ms showed a bias towards bland and palatable food stimuli in the gamepad version, and towards palatable food stimuli in the eye version. In the eye version, a bias towards bland food stimuli was revealed during 500 ms, but an avoidance of bland food stimuli was found during 2000 ms.

There was no significant interaction between experiment version x food type x SOA x hunger, $F(1.768,72.485) = 0.490$, $p = .592$, $\eta_p^2 = 0.012$.

3.3.2.3 Results of the mixed ANOVA for reaction times

The reaction times were analysed with data from 47 participants.

Descriptive statistics for the reaction times

The data analysis of the dot probe task was based on reaction times (RT) for correct responses. Whether the two experiment versions distinguish in their attentional allocation was measured with a four factor design with the between factor “experiment version” (gamepad version vs. eye version) and the three within factors “food type” (bland vs. palatable), “SOA” (100 ms vs. 500 ms vs. 2000 ms) and “congruence” (incongruent vs. congruent vs. neutral). “congruent” meant that the dot appeared on the side of the screen, where the food-related stimuli was shown before (food-neutral stimuli pairs), “incongruent” meant that the dot appeared on the side of the neutral stimuli (food-neutral stimuli pairs) and “neutral” meant that the trials did not have a food-related stimuli (neutral-neutral stimuli pairs). The mean reaction times of each person were the dependent variable. In the gamepad version, probe detection latencies were considerably shorter when the congruent trials occurred in the left area than in the right area of the display (M = 433.48 ms vs. M = 470.51 ms). In the eye version, probe detection latencies were shorter, when the congruent trials occurred in the right area than in the left area of the display (M = 480.56 ms vs. M = 483.10 ms).

Mean reaction times of the stimuli pairs as the dependent variable (see Table 7) were entered into a 2 x 3 x 3 x 2 multivariate analysis of variance with “food type” (bland vs. palatable), “SOA” (100 ms vs. 500 ms vs. 2000 ms) and “congruence” (incongruent vs. congruent vs. neutral) as within-subjects factors, and experiment” version” (gamepad version vs. eye version) as a between-subjects factor.

Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of SOA (χ^2 = 6.972, p = .031), the interaction SOA x congruence (χ^2 = 21.752, p = .010) and the interaction food type x SOA x congruence (χ^2 = 29.863, p < .001). Therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity for the main effect of SOA (ε = 0.925), SOA x congruence (ε = 0.905) and food type x SOA x congruence (ε = 0.861).

Table 7. Means and standard deviations of stimuli pairs with congruence, food type and SOA

	Experiment version	*M*	*SD*	*N*
I_bland_100	Gamepad	395.79	39.22	26
	Eye	420.00	113.46	21
C_bland_100	Gamepad	398.83	43.05	26
	Eye	421.82	123.99	21
N_bland_100	Gamepad	400.18	44.01	26
	Eye	429.93	128.54	21
I_palatable_100	Gamepad	393.63	41.03	26
	Eye	400.23	98.93	21
C_palatable_100	Gamepad	405.31	40.76	26
	Eye	431.76	98.73	21
N_palatable_100	Gamepad	402.76	40.77	26
	Eye	421.19	115.90	21
I_bland_500	Gamepad	442.00	57.18	26
	Eye	442.19	97.72	21
C_bland_500	Gamepad	437.85	46.12	26
	Eye	418.93	118.15	21
N_bland_500	Gamepad	432.49	48.55	26
	Eye	441.75	94.55	21
I_palatable_500	Gamepad	448.01	54.57	26
	Eye	448.02	94.80	21
C_palatable_500	Gamepad	439.67	52.42	26
	Eye	440.37	103.06	21
N_palatable_500	Gamepad	439.91	54.68	26
	Eye	425.96	96.06	21
I_bland_2000	Gamepad	473.50	70.36	26
	Eye	458.45	95.81	21
C_bland_2000	Gamepad	464.53	60.03	26
	Eye	460.95	103.98	21
N_bland_2000	Gamepad	470.34	62.73	26
	Eye	439.26	89.57	21
I_palatable_2000	Gamepad	474.95	70.98	26
	Eye	479.81	124.62	21
C_palatable_2000	Gamepad	471.27	66.31	26
	Eye	453.53	114.73	21
N_palatable_2000	Gamepad	471.48	65.79	26
	Eye	467.72	112.82	21

Note. I = incongruent, C = congruent, N = neutral, SOA = 100, 500, 2000.

Multivariate tests of within subject effects revealed no significant main effects of congruence, $F(2,90) = 0.790$, $p = .457$, $\eta_p^2 = 0.017$, or experiment version, $F(1,45) = 0.012$, $p = .912$, $\eta_p^2 < 0.001$. The main effect of food type was marginally significant, $F(1,45) = 3.732$, $p = .060$, $\eta_p^2 = 0.077$, which implied that there was a marginally significant difference between the two food types bland and palatable.

However, there was a significant main effect of SOA, $F(1.849,83.212) = 18.986$, $p < .001$, $\eta_p^2 = 0.297$, which implied that there was a difference between the three stimuli durations. Contrasts were performed comparing each level of SOA to the middle category of “500 ms”.

Contrasts (repeated) revealed that participants reacted significantly faster during the SOA of 100 ms than during the SOA of 500 ms, $F(1,45) = 8.179$, $p = .006$, $\eta_p^2 = 0.154$. Further, participants reacted significantly faster during the SOA of 500 ms than during the SOA of 2000 ms, $F(1,45) = 15.053$, $p < .001$, $\eta_p^2 = 0.251$.

Multivariate tests of within subject effects exhibited no significant interaction between experiment version x SOA, $F(2,90) = 1.798$, $p = .172$, $\eta_p^2 = 0.038$, between experiment version x food type, $F(1,45) = 0.012$, $p = .912$, $\eta_p^2 < 0.001$, between experiment version x congruence, $F(2,90) = 0.099$, $p = .905$, $\eta_p^2 = 0.002$, between food type x SOA, $F(2,90) = 1.118$, $p = .331$, $\eta_p^2 = 0.024$, and no significant interaction between food type x congruence, $F(2,90) = 0.281$, $p = .756$, $\eta_p^2 = 0.006$.

There was a significant interaction between SOA x congruence, $F(3.618,162.812) = 4.529$, $p = .002$, $\eta_p^2 = 0.091$, which indicated that there was a difference between the mean reaction times for congruent vs. incongruent vs. neutral stimuli during the different stimuli durations (see Figure 7).

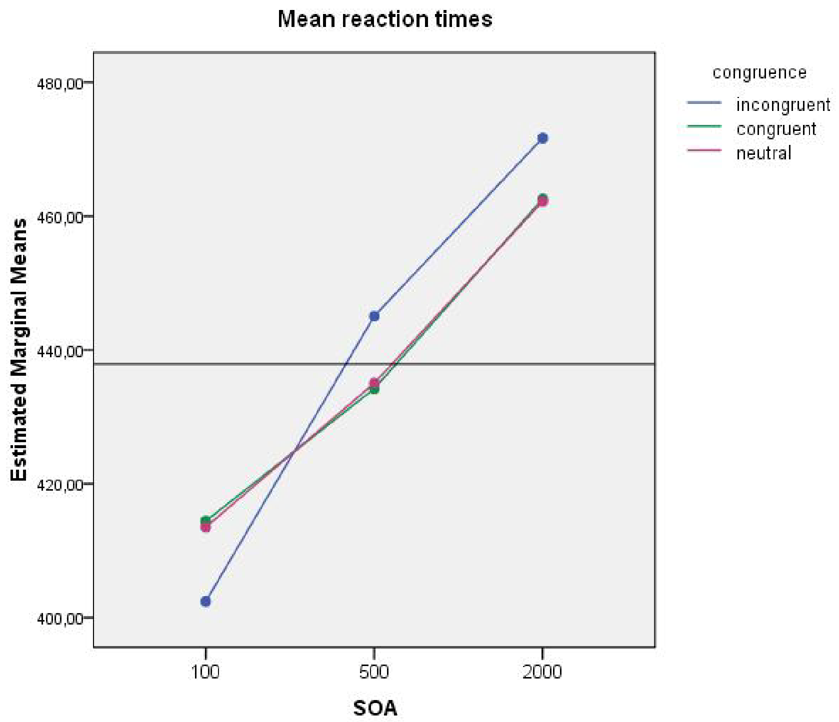


Figure 7. Mean reaction times for the significant SOA x congruence interaction.

To break down this interaction, contrasts for the significant SOA x congruence interaction were performed comparing each level of congruence (incongruent vs. congruent vs. neutral) to the middle category “congruent” across each level of SOA (100 ms vs. 500 ms vs. 2000 ms) which was compared to the middle category of “500 ms”. The first contrast revealed a significant effect when comparing congruent to incongruent trials during a SOA of 100 ms compared to 500 ms, $F(1,45) = 12.428$, $p = .001$, $\eta_p^2 = 0.216$, and showed longer reaction times for congruent than for incongruent trials during a SOA of 100 ms, and shorter reaction times for congruent than for incongruent trials during a SOA of 500 ms. The second contrast compared congruent to neutral trials during the SOA of 100 ms compared to 500 ms, this was not significant, $F(1,45) = 0.058$, $p = .811$, $\eta_p^2 = 0.001$. The third contrast compared congruent to incongruent trials during a SOA of 500 ms compared to 2000 ms, there were no significant differences, $F(1,45) = 0.047$, $p = .829$, $\eta_p^2 = 0.001$. The fourth contrast compared congruent to neutral trials during a SOA of 500 ms compared to 2000 ms, this was not significant, $F(1,45) = 0.029$, $p = .865$, $\eta_p^2 = 0.001$.

Multivariate tests of within subject effects exhibited no significant interaction between experiment version x food type x SOA, $F(2,90) = 0.960$, $p = .387$, $\eta_p^2 = 0.021$, between experiment version x SOA x congruence, $F(4,180) = 0.929$, $p = .449$, $\eta_p^2 = 0.020$, between experiment version x food type x congruence, $F(2,90) = 0.087$,

p = .917, η_p^2 = 0.002, and also no significant interaction between food type x SOA x congruence, $F(3.446,155.061)$ = 1.805, p = .140, η_p^2 = 0.039.

Finally, the interaction between experiment version x food type x SOA x congruence was marginally significant, $F(4,180)$ = 2.327, p = .058, η_p^2 = 0.049, which implied that there was a marginally difference between the two experiment versions for the congruence levels of the two food types during the different stimuli durations.

3.3.3 Analysis of the eye movement data

3.3.3.1 Preparation of the eye movement data

For each trial, the total number of fixations in which gaze was directed at one of the four distinct regions (areas of interest; AOI) of the computer screen was collected, which made it able to calculate the initial fixation on food-related and neutral stimuli: those regions were occupied by (1) food-related stimuli (2) neutral stimuli (3) the central region in the middle and (4) anywhere else (none of the three defined regions). Equally, the total amount of time (in ms) in which gaze was directed at one of the four distinct regions of the computer screen was collected which made it possible to calculate gaze "dwell time" on food-related and neutral stimuli.

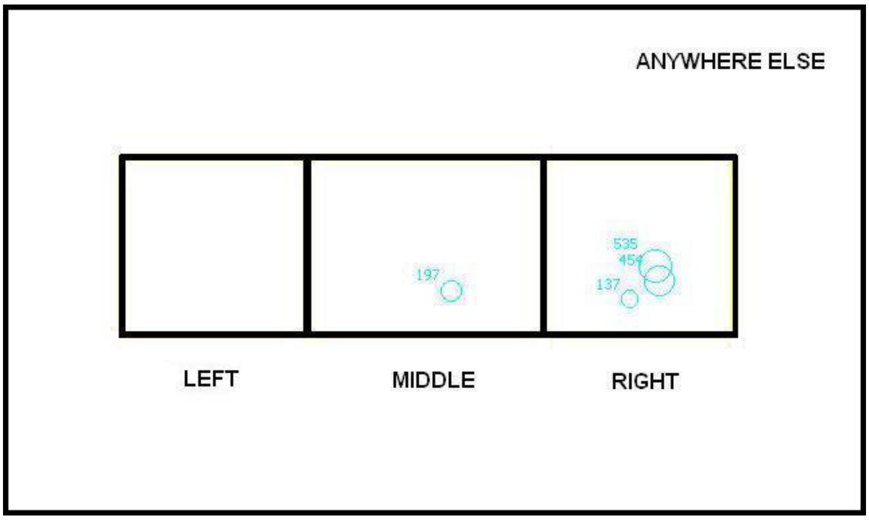


Figure 8. Four distinct areas of interest (AOI).

Fixations were classified as being directed at the left or right stimuli within the predestinated four areas of interest (AOIs) containing the left side, the middle, the right side and anywhere else (see Figure 8).

Eye movement (EM) data was only analysed from critical trials in which food-related and neutral stimuli were presented. Trials in which two neutral stimuli were presented were excluded from the analysis. Our dependent measures were the direction of the initial fixation during critical trials in which food-related and neutral stimuli were presented which might reflect initial orientation and the total amount of time fixating on food-related and neutral stimuli during critical trials (“dwell time”) which might reflect sustained attention.

The variables of interest for this measure were a direction bias score (>.50), indexing an initial attentional orientation to food stimuli, and a duration bias score (>.50), indexing sustained attention to food stimuli (see also Castellanos et al., 2009). Additionally, mean gaze “dwell time” biases were calculated by subtracting the mean dwell time on neutral stimuli from food stimuli for each session.

Exclusion of outliers

Two participants were excluded from the whole analyses of eye movements, the first participant had technical problems, and the data output was not interpretable, and the second participant had only 40% detectable initial fixations, of which 97.9% were directed to the central region. The eye movements were analysed with data from 45 participants.

Data from two participants were excluded from the analysis of direction bias scores and duration bias scores, because they had detectable fixations on only 20% and 8.1% of critical trials which was largely due to calibration or technical difficulties. Based on a total sample of 43 participants, further five participants were excluded from the analysis due to outlying direction bias scores (*M* +/- 2 *SD*), respectively including two that had no bias (0.5), so the direction bias scores were analysed with data from 38 participants.

Based on a total sample of 43 participants, data from two participants were excluded from the analysis of duration bias scores, because most of their detectable fixations were directed to the central region (93.66% and 96.13%). There were no participants with outlying duration bias scores. The duration bias scores were analysed with data from 41 participants.

Two additional participants were excluded from the analysis of mean gaze “dwell time” due to outlying bias scores (*M +/- 2 SD*). Mean gaze “dwell time” were analysed with data from 39 participants.

3.3.3.2 Results of the direction biases

The direction bias score was calculated for each participant by expressing the number of trials in which the first fixation was directed initially at the food-related stimulus as a percentage of the total number of trials in which eye fixations on either the food-related or neutral stimulus were observed.

To analyse initial eye movements during stimulus presentation, it was important to distinguish between fixations on either one of the stimuli rather than on the central position or anywhere else on the display. The first analysis of the areas of interest (AOI) revealed that 99.3% of the first recorded fixations were made to the central region. On this account the second fixation was analysed as the “initial fixation”. One possible explanation might be that the 50 ms verification period (during the sequence with the fixation cross), that has been established to make sure that participants were invariably looking at the centre region at the beginning of each trial, had an impact on the gaze until the stimuli were already shown.

After outlying data had been excluded, an initial fixation on either stimulus was made during 65.4% of the trials in the gamepad version and during 84.5% of the trials in the eye version, the remaining 34.6% (gamepad version) and 15.5% (eye version) to the central position. Participants fixated the food stimulus, instead of the neutral stimulus, in 54.8% of all trials in the gamepad version, and in 50.6% of all trials in the eye version, averaged 52.7% across the participants groups.

To examine whether participants preferentially direct their gaze at food-related, rather than neutral stimuli, their bias scores were compared with 50%. A proportion score >.50, = .50, and <.50 is assumed to reflect respectively an orientation bias towards food-related stimuli, no bias, and an orientation bias towards neutral stimuli.

85% of the participants in the gamepad version, and 56% in the eye version revealed a direction bias towards food-related stimuli (see Table 8). Two participants (one per experiment version) had an exact bias score of .5 which meant that there was no bias.

Table 8. Means and standard deviations of the percentages of direction bias scores to food.

	Experiment version	*M*	*SD*	*N*
Direction Bias Food	Gamepad	.85	0.37	20
	Eye	.56	0.51	18

Independent t-tests were carried out to analyse the effects of experiment versions. The Levene test was significant, (F = 14.914, p < .001), so equality of variances was not assumed. There was a significant difference between the two experiment version concerning the frequency of direction bias scores for food-related or neutral stimuli: t(30.510) = 2.021, p = .052, Cohen's d = 0.66. Participants in the gamepad version showed significantly more often a direction bias towards food-related stimuli than participants in the eye version.

The mean score of all direction biases (to food or neutral) amounted to .56 in the gamepad version, and .51 in the eye version (see Table 9)

Table 9. Means and standard deviations of direction bias scores (food, neutral).

	Experiment version	*M*	*SD*	*N*
Direction Bias	Gamepad	0.56	0.05	20
	Eye	0.51	0.03	18

Independent t-tests were carried out to analyse the effects of experiment version. The Levene test was significant, (F = 5.978, p = .020), so equality of variances was not assumed. There was a significant difference between the two experiment versions concerning the mean of the direction bias scores, t(30.611) = 4.140, p < .001, Cohen's d = 1.35. Participants in the gamepad version showed a significantly greater direction bias than participants in the eye version.

Additional one-sample t-tests demonstrated that the direction bias scores differed significantly from the value of 0.5, p < .001.

3.3.3.3 Results of the duration biases ("dwell time")

Two types of duration bias scores have been calculated.

1) Mean gaze "dwell time" bias was calculated by subtracting the mean dwell time looking at the neutral stimuli from the mean dwell time looking at the food stimuli for each participant.

2) The duration bias is regarded as an index of sustained attention and was computed as the average gaze duration to the food stimulus per trial (gaze duration was the sum of eye fixation durations within one trial).

The average gaze duration to the food stimulus (duration bias) was calculated in relation of the average gaze duration to both the food and the neutral stimuli overall trials.

Again, a duration bias >.50, = .50, and <.50 is assumed to reflect respectively a bias for sustained attention to food stimuli, no bias, and a bias for sustained attention to neutral stimuli.

After removing the outlying data dwell time was calculated for each of the four distinct areas of interest. "Dwell time" on each AOI was calculated by summing the duration of fixations made to each region on each trial. This was calculated regardless of the latency to the first fixation.

For the analysis of fixation durations ("dwell time") had to be distinguished between fixations on either one of the stimuli, rather than the central position or anywhere else during stimuli presentation. Results showed a distribution of the total amount of dwell time (given in percent) overall trial to each region as following (see Table 10).

Table 10. Percentages of the total amount of "dwell time" overall trial to each region

	Experiment version	*M*	*N*
either stimulus (left or right)	Gamepad	39.81	21
	Eye	62.54	20
	Total	52.69	41
left	Gamepad	19.83	21
	Eye	31.2	20
	Total	26.26	41
right	Gamepad	19.98	21
	Eye	31.34	20
	Total	26.43	41
central position	Gamepad	59.71	21
	Eye	37.37	20
	Total	47.03	41
anywhere else	Gamepad	0.49	21
	Eye	0.14	20
	Total	0.29	41

Further analysis showed a distribution of the total amount of fixations (given in percent) overall trial to each region as following (see Table 11).

Table 11. Percentages of the total amount of fixations overall trial to each region

	Experiment version	*M*	*N*
either stimulus (left or right)	Gamepad	53.5	21
	Eye	67.4	20
	Total	61.16	41
left	Gamepad	26.9	21
	Eye	34.4	20
	Total	31.03	41
right	Gamepad	26.6	21
	Eye	33	20
	Total	30.13	41
central position	Gamepad	46	21
	Eye	32.4	20
	Total	38.4	41
anywhere else	Gamepad	0.6	21
	Eye	0.2	20
	Total	0.4	41

Participants had a total amount of 50.75% fixations on the food-related stimulus, instead of the neutral stimulus, averaged across gamepad and eye version. 52.03% of the total amount of dwell time was directed to the food-related stimulus.

Again, to examine whether participants spent more dwell time at food-related, rather than neutral stimuli, their bias scores were compared with 50%. A proportion score >.50, = .50, and <.50 is assumed to reflect respectively a duration bias towards food-related stimuli, no bias, and a duration bias towards neutral stimuli.

46% of the participants in the gamepad version and 42% of the participants in the eye version revealed a bias index (RT) towards food-related stimuli. 67% of the participants in the gamepad version and 85% in the eye version revealed mean gaze “dwell time” as well as a duration bias towards food-related stimuli (see Table 12). A bias of .5 (no bias) was not detected.

Table 12. Means and standard deviations of the percentages of duration bias scores to food

	Experiment version	*M*	*SD*	*N*
Duration Bias Food	Gamepad	.67	0.48	21
	Eye	.85	0.37	20

Independent t-tests were carried out to analyse the effects of experiment versions. The Levene test was significant, (F = 8.110, p = .007), so equality of variances was not assumed. There was no significant difference between the two experiment versions concerning the frequency of duration bias scores for food-related stimuli: t(37.178) = -1.373, p = .178, Cohen's d = -0.30. Participants in the eye version were not revealing significantly more duration bias scores to food-related stimuli bias than participants in the gamepad version.

The mean score of all duration biases (to food or neutral) amounted to .52 in the gamepad version and .52 in the eye version (see Table 13).

Table 13. Means and standard deviations of duration bias scores (food, neutral)

	Experiment version	*M*	*SD*	*N*
Duration Bias	Gamepad	0.52	0.05	21
	Eye	0.52	0.02	20

Independent t-tests were carried out to analyse the effects of experiment versions. The Levene test was significant, (F = 10.660, p = .002), so equality of variances was not assumed. There was no significant difference between the two experiment versions on the duration bias scores, t(26.167) = 0.515, p = .611, Cohen's d = 0.11. Participants in the gamepad version showed no significantly greater duration bias scores than participants in the eye version.

The mean score of mean gaze “dwell time” bias scores (food and neutral) amounted to 68.18 in the gamepad versionand 96.97 in the eye version (see Table 14).

Table 14. Means and standard deviations of mean gaze “dwell time” (food, neutral)

	Experiment version	*M*	*SD*	*N*
Mean gaze "dwell time"	Gamepad	68.18	148.40	19
	Eye	96.97	98.68	20

Independent t-tests were carried out to analyse the effects of experiment versions. There was no significant difference between the two experiment versions in the mean gaze bias scores, $t(37) = -0.717$, $p = .478$, Cohen's $d = -0.23$. Participants in the gamepad version showed no significantly greater mean gaze bias score than participants in the eye version.

42% (32% to food) of the participants in the gamepad and 37% (32% to food) of the participants in the eye version had a bias index as well as mean gaze “dwell time”. 70% (65% to food) of the participants in the gamepad version and 58% (47% to food) of the participants in the eye version had a direction bias as well as a duration bias to food-related stimuli.

Additional one-sample t-tests demonstrated that the mean gaze “dwell time” scores differed significantly from the value of zero, $p < .001$. The duration bias scores also differed significantly from the value of 0.5, $p = .001$. There were no significant differences in the magnitude of bias scores between the experiment versions.

3.3.3.4 Correlations between the EM biases & RT biases

Finally, Correlations between direction bias, duration bias, mean gaze “dwell time”, which were bias indices from the eye movements (EM) and bias indices from the reaction times (RT) were calculated for both experiment versions (correlations see Table 15). There was just one significant correlation between duration bias and mean gaze “dwell time” in the gamepad version (r = .874, p < .001) and in the eye version (r = .973, p < .001).

Table 15. Correlations between biases from the EM and RT

Gamepad	Direction Bias	Bias index (RT)	Mean gaze "dwell time"	Duration Bias
1. Direction Bias				
2. Bias index (RT)	.233			
3. Mean gaze “dwell time”	-.131	-.006		
4. Duration Bias	.153	.351	.874**	
Eye	**Direction Bias**	**Bias index (RT)**	**Mean gaze "dwell time"**	**Duration Bias**
1. Direction Bias				
2. Bias index (RT)	.113			
3. Mean gaze “dwell time”	.058	-.401		
4. Duration Bias	.096	-.347	.973**	

Note. ***p < .001, two-tailed, N = 38 (Direction Bias); N = 39 (Mean Gaze “dwell time”); N = 41 (Duration bias); N = 45 (Biasindex RT).

3.3.3.5 Correlations between the GHS, EM biases & RT biases

Pearson correlations were used to examine the relationship between the GHS and the biases of the eye movements (EM) and reaction times (RT), investigating whether the amount of hunger could have an influence on the biases (correlations see Table 16). Significant effects were found in both experiment versions. The first significant correlation was found between the GHS and direction biases (r = -.653, p < .001), but only in the gamepad version. The second significant correlation was detected between the GHS and Biasindex RT (r = .445, p = .043), but only in the eye version.

Table 16: Correlations between the GHS and biases from the EM and RT

Gamepad	GHS	Direction Bias	Bias index (RT)	Mean gaze "dwell time"	Duration Bias
1. GHS					
2. Direction Bias	-.653**				
3. Bias index (RT)	.086	.122			
4. Mean gaze “dwell time”	-.219	-.131	-.006		
5. Duration Bias	-.213	.153	.351	.874**	
Eye	**GHS**	**Direction Bias**	**Bias index (RT)**	**Mean gaze "dwell time"**	**Duration Bias**
1. GHS					
2. Direction Bias	.038				
3. Bias index (RT)	.445*	.113			
4. Mean gaze “dwell time”	.259	.058	-.401		
5. Duration Bias	.300	.096	-.347	.973**	

Note. **p < .001, two-tailed; *p < .05, two tailed; N = 38 (Direction Bias); N = 39 (Mean Gaze “dwell time”); N = 41 (Duration bias); N = 45 (Biasindex RT).

3.4 Discussion

3.4.1 Summary and Interpretation

In the present study, participants completed a dot probe task (with different experimental maniupulations) while their eye movements were tracked. Afterwards, they had to fill out a set of questionnaires (see below).

The main aim of the present study was to examine whether a difference in reaction times (RT) bias indices and eye movement (EM) bias indices existed between users with different hunger levels, and also between users completing the gamepad version (participants had to press a button after the dot appeared) versus users taking part in the eye version (participants had to fixate the dot with their eyes).

Moreover, differences between two food types (bland vs. palatable), during three stimuli durations (stimulus onset asynchrony (SOA), 100 ms vs. 500 ms vs. 2000 ms), and three congruence levels (incongruent vs. congruent vs. neutral) were examined.

3.4.1.1 Questionnaires

The questionnaire consisted of three parts: the Grand Hunger Scale (GHS) for measuring the intensity of hunger, the BAS-Drive (BAS-D) scale to estimate behavioural activation, and a personal evaluation of the food-related stimuli that were presented during the dot probe task. In the following section, differences between the two experiment versions were examined. Since participants were randomly assigned to both groups, no differences were expected.

Differences between experiment versions in the GHS

Results of the GHS showed that participants from the eye version showed a significantly greater score on the scale (particularly on the item “How hungry are you at the moment?”) than participants from the gamepad version which led to the conclusion that participants from the eye version were hungrier than participants from the gamepad version. However, there were no differences in the instructions when to stop eating before the experiment between the two experiment versions.

A possible explanation could be that completing the eye version was more exhausting (i.e., participants moved their eyes and fixated stimuli a lot more than those in the gamepad version) and, thus, participants might have had a subjective greater hunger feeling afterwards when they filled out the questionnaires. Interestingly, the item “How big is your appetite on the following aliments at the moment?” of the personal evaluation of stimuli did not back up this finding, and showed nearly the same scores for the two groups.

Differences between experiment versions in the BAS-D scale

As expected, there were no significant differences between both experiment version concerning scores of the BAS-D scale. However, scores indicated that participants of both groups had rather high levels of behavioural activation.

Differences between experiment versions in the personal evaluation of stimuli

There were no differences concerning the personal evaluation of the stimuli between both experiment versions. This was expected, because participants were randomly assigned to both groups. It was interesting, however, that participants of both groups indicated the same levels of appetite and preference towards all stimuli whereas they also indicated that they had different levels of hunger at the same time (participants of the eye version were hungrier).

Since stimuli could be categorized into the categories “bland” and “palatable”, further analyses were carried out in order to investigate differences between those categories. Results revealed a significant difference between the mean scores of the two food types, bland and palatable, on the item “How healthy are the following aliments in your opinion?” in both experiment versions. The scores showed that participants rated the bland food stimuli (e.g., lettuce, asparagus,) significantly healthier than the palatable food stimuli (e.g., hamburger, kebab) which was expected and speaks to the validity of the data.

Relationship between the GHS and the personal evaluation of the stimuli

Pearson correlations were used to examine the relationship between the GHS and the “personal evaluation of the food stimuli” scale. Significant medium to high positive correlations were found only for the gamepad version and therein only for palatable food items. The first significant correlation was found between the GHS and the item “palatable_appetite” (in detail: “How big is your appetite on the following aliments at the moment?”).

The second correlation was found between the GHS and the variable "palatable_preference" (in detail: "How much affection do you bear for the following aliments in general?"). These findings led to the conclusion that there was a relationship between hunger levels and the ratings concerning preference and appetite on certain palatable food-related stimuli afterwards in the gamepad version. A higher preference for palatable food in hungry individuals is in line with previous literature (e.g., Birch et al., 1996; Cowart & Beauchamp, 1986) and thus speaks to the validity of the data. It is unknown however, why this result was not found in the eye version.

3.4.1.2 Dot probe task

The present research also included the measurement of reaction times within a dot probe task. For the sake of the readers' convenience and readability, the results of the mixed ANOVAs with reaction times (RT) bias indices and results of the mixed ANOVAs with raw RT were structured according to the hypotheses of the present study. For the same reason, each hypothesis was stated again before it is discussed.

The main finding of the present study was a significant three-way interaction (experiment version x food type x SOA), which revealed that during rather short SOAs no difference between the measured bias indices for the food types in the experiment versions was found, but during the longest SOA, participants were more attracted to palatable food stimuli and avoided bland food stimuli in the eye version (in the gamepad version they showed the same attraction to both food types). The eye version was created to reveal bias indices more precisely, thus, this finding was in line with the expectations to this study.

Hypothesis 1: There is a significant difference between the different SOAs (main effect of SOA) and significant interaction effects of SOAs with other study variables (e.g., experiment version and food type).

The mixed ANOVA for bias indices showed a significant main effect of SOA (which had to be interpreted with caution, because it was qualified by the two-way and three-way interactions), a significant interaction of food type x SOA (which was not interpreted), and a significant interaction of experiment version x food type x SOA (see above). The main effect of SOA (bias indices) indicated an avoidance of food-related stimuli during a SOA of 100 ms and a bias towards food-related stimuli during the SOA of 500 ms and 2000 ms. These findings were backed up by the results of the raw reaction time data (the bias indices were calculated from these data).

There was also a main effect of SOA for the raw reaction time data, participants reacted significantly faster during the SOA of 100 ms than during the SOA of 500 ms, and they reacted significantly faster than during the SOA of 500ms than during the SOA of 2000 ms. These results of the SOAs might be explained by the sequence of the stimuli presentation duration, meaning short stimuli presentations provided a more stressful testing situation and therefore signalized participants to react faster in general, long stimuli presentations brought up a more relaxed testing situation and favoured longer reaction times. The SOA of 2000 ms also signalized the last part of the experiment where participants were already exhausted and tired and therefore not so fast anymore. Further, the significant SOA x congruence effect revealed that during a SOA of 100 ms, longer reaction times for congruent than for incongruent trials were measured. During the SOA of 500 ms and 2000 ms shorter reaction times for congruent than for incongruent trials were measured. An explanation for the avoidance (longer RT to food) of the food stimuli during the short SOAs, and the bias towards food stimuli (shorter RT to food) during the longer SOAs might be that it was not possible to distinguish between food and neutral stimuli during the short SOA, because they passed by too fast. During the longer SOAs, participants had more possibilities to look at the stimuli and to recognize and distinguish them better and faster. The findings for the SOAs of 500 ms and 2000ms were in line with previous literature, which indicated that participants were more attracted to the food stimuli instead of neutral stimuli.

Hypothesis 2: Bias indices for palatable food stimuli are significantly higher than bias indices for bland food stimuli.

There was no significant main effect of food type for the bias indices, indicating that the findings were not in line with, for example, the study of Hepworth et al. (2010). The bias indices showed no significant differences between bland and palatable food stimuli that is why *Hypothesis 2* could not be confirmed. Although, results for the raw reaction times showed a maginally significant main effect for food type, but they revealed shorter reaction times to bland food stimuli than to palatable food stimuli, which was a quite unexpected result. An explanation for this might be that palatable food stimuli capture participants' attention longer than bland food stimuli which favoured slower target detections.

Hypothesis 3: High levels of hunger lead to significantly higher bias scores for palatable food stimuli than for bland food stimuli.

The interaction food type x hunger for the bias scores was not significant. There were no differences between the bias indices for the food types bland and palatable during low or high levels of hunger, so *Hypothesis 3* could not be confirmed.

Hypothesis 4: Response times are significantly shorter during congruent than during incongruent or neutral trials.

There was no main effect of the factor congruence level. However, a significant SOA x congruence interaction showed that the raw reaction times were significantly longer for congruent and neutral trials than for incongruent trials during the SOA of 100 ms. Therefore, *Hypothesis 4* could not be confirmed during SOAs of 100. On the other hand, reaction times were shorter for congruent and neutral trials than for incongruent trials during the SOA of 500 ms and the SOA of 2000 ms. These findings supported *Hypothesis 4* during SOAs of 500 ms and 2000 ms. Thus *Hypothesis 4* could be only partly supported.

3.4.1.3 Eye Movements

The present research also included the measurement of eye movements within a dot probe task. For the sake of the readers' convenience and readability, the results of the t-tests with eye movements (EM) bias indices and results of the correlations between EM bias indices (and hunger) were structured according to the hypotheses of the present study. For the same reason, each hypothesis was stated again before it is discussed.

Hypothesis 5: There is a significant difference for direction biases between the two experiment versions.

There was a significant difference between the direction biases in the experiment versions in that participants showed significantly more often a direction bias towards food-related stimuli in the gamepad version than in the eye version, so *Hypothesis 5* could be accepted. An explanation for the increased direction biases in the gamepad version might be that participants had more desire to look around, because they did not necessarily need to fixate the dot like participants in the eye version. This "challenge" every time might have influenced their concentration and could have made their eyes tired after a while. Participants from the gamepad version just needed to detect the dot to press the button and could concentrate on the stimuli more than participants of the eye version.

Hypothesis 6: There is a significant difference for duration biases between the two experiment versions.

The frequency and the magnitude of the duration bias scores and dwell time to food-related stimuli did not differ significantly between participants in the gamepad and the eye version. On this account, *Hypothesis 6* could be confirmed.

Hypothesis 7: There is a significant positive correlation between hunger and direction biases, duration biases and bias indices towards food-related items in both the gamepad and the eye version.

Correlations between the GHS and the different bias indices showed a significant negative correlation between hunger and direction biases in the gamepad version, suggesting that lower levels of hunger more likely led to an initial fixation towards food-related stimuli and higher levels of hunger more likely led to an initial fixation towards neutral food stimuli. Participants from the gamepad version seemed to avoid the first gaze to food-related stimuli, when they were hungry. On the other hand, a significant positive correlation between hunger and reaction time (RT) bias indices was found for the eye version, which revealed that during lower levels of hunger, participants showed longer reaction times to the food stimuli and during higher levels of hunger participants showed rather short reaction times to food-related stimuli. Thus, *Hypothesis 7* could only be accepted for the eye version, but not for the gamepad version.

Hypothesis 8: There is a significant correlation between the measured bias indices within the dot probe task and the measured mean gaze “dwell time” within the recorded eye movements in both the gamepad and the eye version.

There was no correlation between reaction time (RT) bias indices within the dot probe task and the measured mean gaze “dwell time” within the recorded eye movements, so *Hypothesis 8* could not be confirmed. This is in line with the study of Isaacowitz, Wadlinger, Goren, and Wilson (2006), which also found no significant correlations between eye tracking and dot-probe reaction time measures.

The findings of this study were still basically consistent with other work suggesting that different measures of attentional preference may not correlate (e.g., Pothos et al., 2008). Other studies of attention (e.g., Mogg, Bradley, Field, & de Houwer, 2003) found a closer correspondence between eye tracking and the dot probe task as has been found in this study. The authors found several ways of interpreting this apparent discrepancy. The argument that eye tracking is a better method for measuring attentional biases is supported by the declaration that eye tracking provides a relatively pure measure of visual attention, minimizing the influence of response biases that contaminates the interpretation of dot-probe results as indicators of attentional preference (Mogg et al., 2000). This raises the possibility that the two methodologies assess different temporal aspects of visual attention.

3.4.1.4 Overall Discussion

In conclusion, results for the gamepad version showed a correlation between hunger levels and the ratings concerning preference and appetite on certain palatable food-related stimuli afterwards, but these findings were not backed up by the other results of the gamepad version, for example, no bias indices to palatable food stimuli were found in the gamepad version. Bias indices to palatable food stimuli were only found in the eye version (therein only for the SOA of 2000 ms). Even though direction biases to food were more often observed in the gamepad version, the correlation between hunger and direction biases was negative, which was not an expected finding. In general, the common method of the dot probe task showed inconsistent results, especially in non-clinical samples (Mogg et al., 2000). This sample was a non-clinical sample, which could also be a reason for the ambigous significant results. Another reason for the indefinite results could be that the conventional method of the dot probe paradigm might not be sensitive enough for non-clinical eaters (Boon et al., 2000).

On the other hand, participants from the new version (the “eye version”) of the dot probe task were significantly more hungry (results from the GHS), significantly more attracted to palatable food stimuli (results from the bias indices), and correlations showed a significant positive correlation between hunger and bias indices. Results from the eye movement data showed more fixations and more “dwell time” on both stimuli instead of the central position from participants in the eye version. Since they had to fixate the dot at the end of each trial anyway, participants from the eye version seemed to attend the stimuli quite more often and longer. The results from the eye version were able to confirm the expectations of this study better than results from the gamepad version.

3.4.2 Review and Criticism

After the interpretation of the data, a closer look on the experimental situation revealed some limitations of our study. Some participants did not have many measured eye movements. An explanation for this could be that the instructions of the dot probe task are not well-defined. The instructions did not actually give advices to look at the two stimuli after participants had to fixate a cross in the middle. Nevertheless, the task should be intentional, but this non-distinctive instruction could be modified in the future, because many participants reported afterwards that they believe they should fixate the cross the whole time. The instructions just mentioned that two stimuli would be shown and how to react to the dot, but not to look at the stimuli. This is especially interesting during the SOA of 2000 ms where more shifts in attention are possible. Participants might also have wrong expectations about the intentions of this task, for example, because they took a quite similar test before in which they had to fixate only the centre of the screen and participants generalized it and came to the conclusion eye tracking is all about that. Someone actually apologized that her gaze accidentally shifted to one of the stimuli, because she was exhausted.

Some of the participants mentioned that the experiment was a bit long. The recording time took 45 minutes at least, if everything worked out as planned. Problems with calibration and validation forced participants to concentrate over an hour which was quite long. Participants mentioned afterwards that their eyes were quite exhausted at the end of the session which increased blinking. These observations also comprised participants whose testing sessions were finished in regular time. However, only a few students concluded that the session was too exhausting for them. This might depend on how long the set up of the camera and the recording session lasted which varied quite a bit between the participants. To conclude, the number of trials should be reduced in general to avoid an overload of the eyes.

The feedback about the different stimuli durations indicated that participants preferred the short SOAs. The reason for this might be that during this part of the experiment, time seemed to pass faster. 100 ms were a lot shorter than 2000 ms and there were still quite many trials in each session block. Another critical issue of the design of the study was that the different SOAs always occurred in ascending order. Obviously participants were already quite exhausted when they got to the last session block. Participants' ambitions to look at the stimuli carefully during the last block of SOAs might not be the same as at the beginning of the testing session.

Another reason for ignoring the stimuli could be that they already looked a bit familiar, because the same stimuli were used during every session block. The stimuli pairs could be slightly different during the different SOAs, for instance, a few new stimuli pictures between the original pictures to keep participants' minds focussed.

3.4.3 Conclusion and Outlook

Some interesting questions arose during the analyses of the data. For example, were the food-related stimuli already too familiar and participants too tired after the SOA with 500 ms? Maybe they had no pretensions to look around, although they had more time and possibilities for that during a SOA of 2000 ms? The experimental conditions were the same for everyone which provided a better comparison among the participants. To beware of this side effect and avoid tiredness during the SOA of 2000 ms, the number of stimuli could be reduced, and the order in which the SOAs are presented should be randomized.

Another important issue examined the fact that participants from the gamepad version could have already detected the dot in the peripheral view, so there was no actual reason to shift the eye gaze exactly to the position of the dot. Therefore, the durations of the reaction times to the dot could not always been based on their current position (food or neutral stimuli). This problem has been met by creating the eye version where participants had to fixate the dot at the end of the trial. This way, a more precise reaction time measurement to the food-related and the neutral stimuli was possible. This extension of the conventional dot probe task seems to be quite promising for future research in combination with eye tracking. This new version still has scope for improvement, for example, if participants were not looking on the side where the dot appeared in an appropriate amount of time. In the gamepad version, a “target fail” was marked in the output file when they pressed the wrong button. In the eye version, these reaction times were unusually longer and therefore mostly excluded as outliers. This should be revised and these trials (target fails) should be excluded from the analyses, like pressing the wrong button in the gamepad version. To sum up, future research with the eye version should include a “target fail”.

The last interesting observation happened after the experiment situation. Some participants have not realized that they were observing food stimuli until they had to evaluate the food stimuli in the questionnaire or were asked about their impressions during the testing situation. Most of the participants noticed that they have seen food stimuli during the experiment, but they did not realize that the experiment was concerned with their reactions to food stimuli. After the dot probe task participants reported increased levels of hunger caused by the food-related stimuli. The exposure to a certain amount of food stimuli seems to influence participants personal levels of hunger (see “external eating”).

In this study, quite a few differences existed between the experiment versions. Future research should concentrate on investigating the new “eye” version. Is it distinctively better than the usual one? And how could it be improved even more? The ambiguity of our data might make consider running a similar study with a greater number of participants in every experiment version. Time limits just allowed a rather small analysis with the eye movements. Subsequent hypotheses for further calculations with the recorded eye movements included for example, distinguishing the data into bland and palatable and the three SOAs and calculate a direction and duration bias for every of these groups. Afterwards the eye movement data could be set in relation to the reaction time data. Finally, future research could also differentiate between biases resulting from delayed disengagement versus biases resulting from enhanced orienting by comparing the food-related with the neutral-neutral stimuli pairs (Koster et al., 2004).

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5. List of tables

6. List of figures

7. Appendix

FRAGEBOGEN

SEHR GEEHRTER TEILNEHMER, SEHR GEEHRTE TEILNEHMERIN,

Zunächst einmal herzlichen Dank, dass Sie sich bereit erklärt haben im Rahmen meiner Diplomarbeit an meiner wissenschaftlichen Studie teilzunehmen. Die Teilnahme an dieser Studie und ihre Antworten sind **vertraulich** und werden für keine anderen Zwecke als diese Studie verwendet. Wichtig ist vor allem die **Vollständigkeit der Fragebögen** – werden einzelne Fragen ausgelassen, so kann dies dazu führen, dass Ihr Fragebogen nicht ausgewertet werden kann. Bitte antworten Sie aufrichtig und ohne lange zu überlegen. Es gibt keine richtigen oder falschen Antworten.

BEVÖLKERUNGSSTATISTISCHE INFORMATION

Bitte geben Sie die folgenden Informationen wahrheitsgemäß an. Sie dienen NICHT zur Identifikation sondern zur allgemeinen Beschreibung der TeilnehmerInnen an dieser Studie.

1. **Geschlecht:** ❑ männlich ❑ weiblich
2. **Alter:** _______ Jahre
3. **Staatsbürgerschaft:** _______________
4. **Studienrichtung:** _______________
5. **bisherige Studiendauer:** ________________ Semester
6. **Ich ernähre mich...** ❑ vegetarisch ❑ vegan ❑ keines von beiden
7. **Gewicht:** _______________
8. **Größe:** _______________
9. **Familienstand:**

   ❑ **Single** ❑ **verheiratet** ❑ **Partnerschaft** ❑ **verwitwet** ❑ **geschieden**

Der nächste Teil des Fragebogens enthält Aussagen, denen man entweder zustimmen oder widersprechen kann. Geben Sie bitte für jede Aussage an, wie sehr Sie zustimmen oder nicht zustimmen.
Wählen Sie pro Aussage bitte nur eine Antwort aus. Seien Sie bitte so genau und ehrlich wie möglich. Antworten Sie auf jede Aussage so, als wäre sie die einzige Aussage im Fragebogen. Das heißt, machen Sie sich keine Gedanken darüber, dass ihre Antworten "konsistent" (zusammenpassend) sind.

Diese Aussage **trifft auf mich...**	**sehr** zu	**eher** zu	**eher nicht** zu	**gar nicht** zu
1. Ich strenge mich besonders an, um Dinge zu bekommen, die ich mir wünsche.	1	2	3	4
2. Wenn ich etwas möchte, versuche ich normalerweise mit ganzer Kraft es zu bekommen.	1	2	3	4
3. Wenn ich eine Möglichkeit sehe, etwas zu bekommen, das ich haben will, nehme ich sie sofort wahr.	1	2	3	4
4. Wenn ich etwas erreichen will, setze ich dafür alle denkbaren Mittel ein.	1	2	3	4

Bitte versuchen Sie die Fragen so ehrlich und genau wie möglich zu beantworten. Wenn Sie unsicher sind, wie die Fragen zu beantworten sind, fragen Sie bitte nach.

1. Wann haben Sie ihre letzte Mahlzeit eingenommen? _________ (Uhrzeit)

2. Wie hungrig sind sie im Moment?
(Bitte setzen Sie ein X an einen Punkt auf der Linie, der am besten beschreibt, wie hungrig Sie im Moment sind. Zum Beispiel, wenn Sie nicht hungrig sind, platzieren Sie das X näher zum linken Ende, wenn Sie sehr hungrig sind, platzieren Sie das X näher zum rechten Ende)

Überhaupt nicht hungrig |____| **Extrem hungrig**

3. Wie viel von Ihrem Lieblingsessens könnten Sie im Augenblick essen? *(bitte platzieren Sie ein X an der Stelle der Linie, die am besten beschreibt, wie viel ihres Lieblingsessens Sie im Moment imstande wären zu essen)*

Überhaupt nichts |____| **Soviel wie ich davon bekommen könnte**

4. Wann werden Sie voraussichtlich Ihre nächste Mahlzeit einnehmen? _________ (Uhrzeit)

5. Sind Sie mit Ihrem momentanen Körpergewicht zufrieden?
❑ Ja
❑ Nein

6. Versuchen Sie gerade abzunehmen?
❑ Ja
❑ Nein

Wie groß ist **momentan** Ihr **Appetit** auf die folgenden Nahrungsmittel?

	sehr groß	**eher** groß	**eher nicht** groß	**gar nicht** groß
Blumenkohl / Karfiol	1	2	3	4
Donut	1	2	3	4
Fisolen / Grüne Bohnen	1	2	3	4
grüner Spargel	1	2	3	4
Hamburger	1	2	3	4
Hot Dog	1	2	3	4
Kartoffelchips	1	2	3	4
Kebab / Döner	1	2	3	4
Kekse	1	2	3	4
Kohlrabi	1	2	3	4
Rosenkohl / Kohlsprossen	1	2	3	4
Kuchen / Torte	1	2	3	4
Linsen	1	2	3	4
Pommes Frites	1	2	3	4
Reis	1	2	3	4
Reiswaffel	1	2	3	4
Salat	1	2	3	4
Schokolade	1	2	3	4
Speck	1	2	3	4
Weizenflocken (Toppas)	1	2	3	4

Wie **groß** ist Ihre Vorliebe für die folgenden Nahrungsmittel **generell?**

	sehr groß	**eher** groß	**eher nicht** groß	**gar nicht** groß
Blumenkohl / Karfiol	1	2	3	4
Donut	1	2	3	4
Fisolen/ Grüne Bohnen	1	2	3	4
grüner Spargel	1	2	3	4
Hamburger	1	2	3	4
Hot Dog	1	2	3	4
Kartoffelchips	1	2	3	4
Kebab / Döner	1	2	3	4
Kekse	1	2	3	4
Kohlrabi	1	2	3	4
Rosenkohl / Kohlsprossen	1	2	3	4
Kuchen / Torte	1	2	3	4
Linsen	1	2	3	4
Pommes Frites	1	2	3	4
Reis	1	2	3	4
Reiswaffel	1	2	3	4
Salat	1	2	3	4
Schokolade	1	2	3	4
Speck	1	2	3	4
Weizenflocken (Toppas)	1	2	3	4

Für **wie gesund** halten Sie die folgenden Nahrungsmittel?

	sehr gesund	**eher** gesund	**eher nicht** gesund	**gar nicht** gesund
Blumenkohl / Karfiol	1	2	3	4
Donut	1	2	3	4
Fisolen/ Grüne Bohnen	1	2	3	4
grüner Spargel	1	2	3	4
Hamburger	1	2	3	4
Hot Dog	1	2	3	4
Kartoffelchips	1	2	3	4
Kebab / Döner	1	2	3	4
Kekse	1	2	3	4
Kohlrabi	1	2	3	4
Rosenkohl / Kohlsprossen	1	2	3	4
Kuchen / Torte	1	2	3	4
Linsen	1	2	3	4
Pommes Frites	1	2	3	4
Reis	1	2	3	4
Reiswaffel	1	2	3	4
Salat	1	2	3	4
Schokolade	1	2	3	4
Speck	1	2	3	4
Weizenflocken (Toppas)	1	2	3	4

Für **wie sättigend** halten Sie die folgenden Nahrungsmittel?

	sehr sättigend	**eher** sättigend	**eher nicht** sättigend	**gar nicht** sättigend
Blumenkohl / Karfiol	1	2	3	4
Donut	1	2	3	4
Fisolen/ Grüne Bohnen	1	2	3	4
grüner Spargel	1	2	3	4
Hamburger	1	2	3	4
Hot Dog	1	2	3	4
Kartoffelchips	1	2	3	4
Kebab / Döner	1	2	3	4
Kekse	1	2	3	4
Kohlrabi	1	2	3	4
Rosenkohl / Kohlsprossen	1	2	3	4
Kuchen / Torte	1	2	3	4
Linsen	1	2	3	4
Pommes Frites	1	2	3	4
Reis	1	2	3	4
Reiswaffel	1	2	3	4
Salat	1	2	3	4
Schokolade	1	2	3	4
Speck	1	2	3	4
Weizenflocken (Toppas)	1	2	3	4

Participant number………… **Male / Female** **Age …………** _Grand HS 1_
Time completed ……………… am / pm

Thank you for taking the time to complete these questionnaires.

- The questions should be answered by placing a tick in the appropriate box, writing in the space provided, or placing a mark along the length of a line.

- Please try to answer the questions as honestly and as accurately as possible. If you are unsure about how to answer any of the questions, please ask.

All information collected will be strictly confidential.

---

1. What time did you last eat something? …….. am / pm *(delete am or pm as appropriate)*

2. How hungry are you at the moment? *(Please place an X at a point on the line that best indicates how hungry you are at the moment. For example, if you are not hungry, place the X nearer to the left, if you are very hungry, place the X nearer to the right.)*

Not hungry at all |______________________________| **Extremely hungry**

3. How much of your favourite food would you be able to eat at the moment? *(Please place an X at a point on the line that best indicates how much of your favourite food you would be able to eat at the moment.)*

None at all |______________________________| **As much as I could get**

4. When do you next expect to eat? ……….. am / pm *(delete am or pm as appropriate)*

BIS/BAS Scale

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

1 = very true for me
2 = somewhat true for me
3 = somewhat false for me
4 = very false for me

1 . A person's family is the most important thing in life.
2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.
3. I go out of my way to get things I want.
4. When I'm doing well at something I love to keep at it.
5. I'm always willing to try something new if I think it will be fun.
6. How I dress is important to me.
7. When I get something I want, I feel excited and energized.
8. Criticism or scolding hurts me quite a bit.
9. When I want something I usually go all-out to get it.
10. I will often do things for no other reason than that they might be ftm.
11 . It's hard for me to find the time to do things such as get a haircut.
12. If I see a chance to get something I want I move on it right away.
13. I feel pretty worried or upset when I think or know somebody is angry at me.
14. When I see an opportunity for something I like I get excited right away.
15. I often act on the spur of the moment.
16. If I think something unpleasant is going to happen I usually get pretty "worked up."
17. I often wonder why people act the way they do.
18. When good things happen to me, it affects me strongly.
19. I feel worried when I think I have done poorly at something important.
20. I crave excitement and new sensations.
21 . When I go after something I use a "no holds barred" approach.
22. I have very few fears compared to my friends.
23. It would excite me to win a contest.
24. I worry about making mistakes.

Items other than 2 and 22 are reverse-scored.

BAS Drive: 3, 9, 12, 21
BAS Fun Seeking: 5, 10, 15, 20
BAS Reward Responsiveness: 4, 7, 14, 18, 23
BIS: 2, 8, 13, 16, 19, 22, 24
Items 1, 6, 11, 17, are fillers.

The fact that there are three BAS-related scales and only one BIS-related scales was not planned or theoretically motivated. The factors emerged empirically, from an item set that was intended to capture diverse manifestations of the BAS, according to various theoretical statements. It is likely that a broader sampling of items on the BIS side would also have resulted in more than one scale. I do not encourage combining the BAS scales, however, because they do turn out to focus on different aspects of incentive sensitivity. In particular, Fun Seeking is known to have elements of impulsiveness that are not contained in the other scales.

Classification of stimuli

20 Stimuli: Practice trials (10 pairs)

PR1_dustpan
PR1_iron
PR2_towels
PR2_coasters
PR3_curtains
PR3_vacuum
PR4_ironboard
PR4_bath
PR5_sponge
PR5_string
PR6_recliningchair
PR6_diningset
PR7_blinds
PR7_drawers
PR8_aeriel
PR8_dishtowel
PR9_chandler
PR9_lampshade
PR10_coffeetable
PR10_pillow

8 stimuli: Buffer trials (4 pairs)

BU1_footstall
BU1_laundry
BU2_mirror
BU2_pegs
BU3_potpouri
BU3_showerpouf
BU4_stairs
BU4_toothbrush

10 stimuli: bland food

asparagus
brussels
cauliflower
greenbeans
lentils
lettuce
rice
ricecakes
swheat
turnip

10 neutral stimuli matched with bland food (results in 10 pairs of bland-neutral stimuli)

wardrobe
cottenwool
featherduster
fireplace
clock
cushion
soap
beanbag
sideboard
radiator

Matched pairs (both ways, e.g., asparagus-wardrobe, wardrobe-asparagus)

asparagus-wardrobe
brussels-cottenwool
cauliflower -featherduster
greenbeans-fireplace
lentils-clock
lettuce-cushion
rice-soap
ricecakes-beanbag
swheat-sideboard
turnip-radiator

10 stimuli: palatable food

bacon
cake
chips
chocolates
cookies
crisps
doughnut
hamburger
hotdog
kebab

10 neutral stimuli matched with palatable food (results in 10 pairs of palatable-neutral stimuli)

carrierbag
plasmaTV
matches
stereo
teddybear
remote
computer
cdplayer
football
bed

Matched pairs (both ways, e.g., bacon-carrierbag, carrierbag-bacon)

bacon-carrierbag
cake-plasmaTV
chips-matches
chocolates-stereo
cookies-teddybear
crips-remote
dougnut-computer
hamburger-cdplayer
hotdog-football
kebab-bed

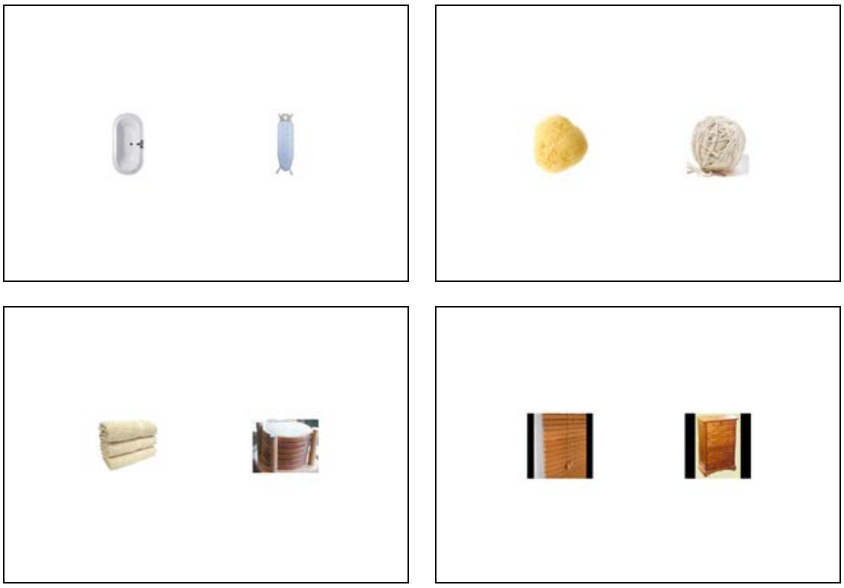
10 stimuli matched in size and shape to bland stimuli (5 pairs of neutral-neutral stimuli)

NB_broom
NB_dressingtable
NB_flowerpot
NB_doorhandle
NB_lightbulb
NB_paintbrush
NB_rake
NB_showerhead
NB_sofa
NB_spade

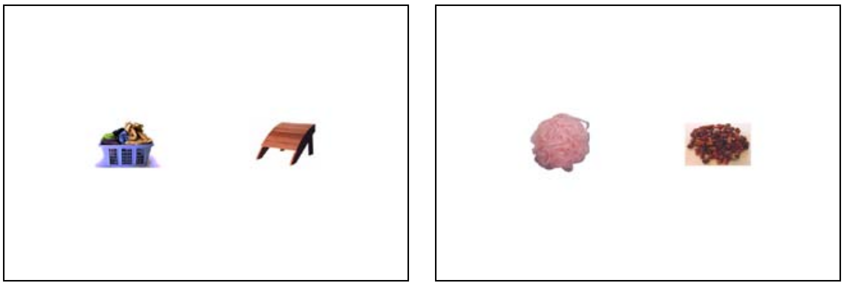
10 stimuli matched in size and shape to palatable stimuli (5 pairs of neutral-neutral stimuli)

NP_ballCandles
NP_CD
NP_windchimes
NP_gnome
NP_lavalamp
NP_mouse
NP_paperweight
NP_phone
NP_scissors
NP_vase

Examples for stimuli pairs

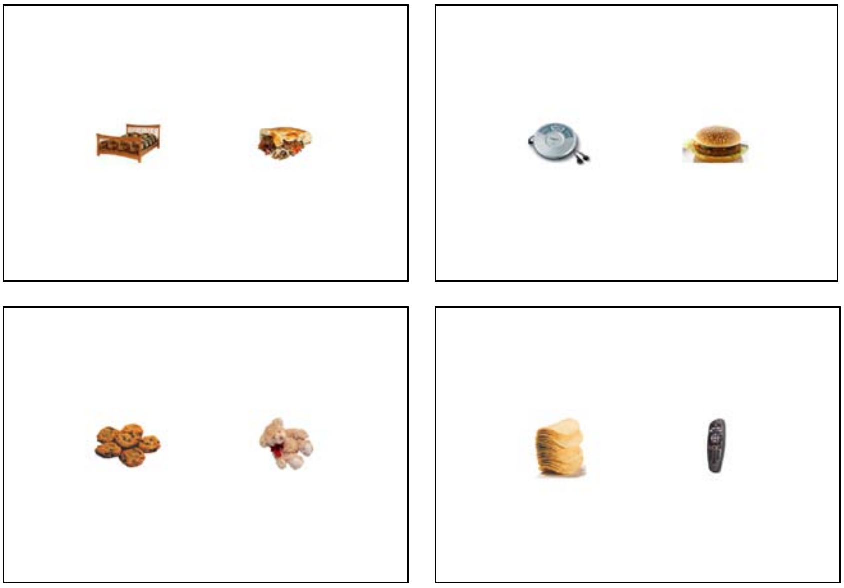


Examples for practice trials

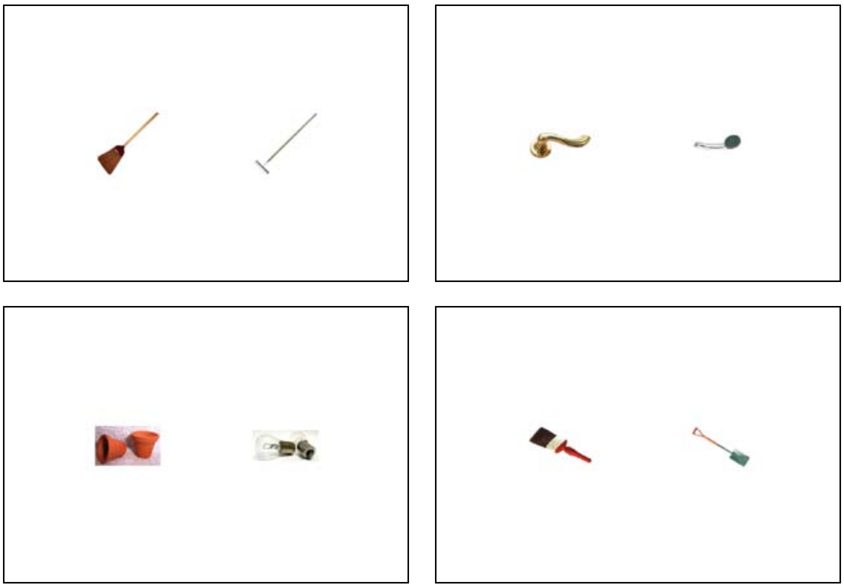


Examples for buffer trials

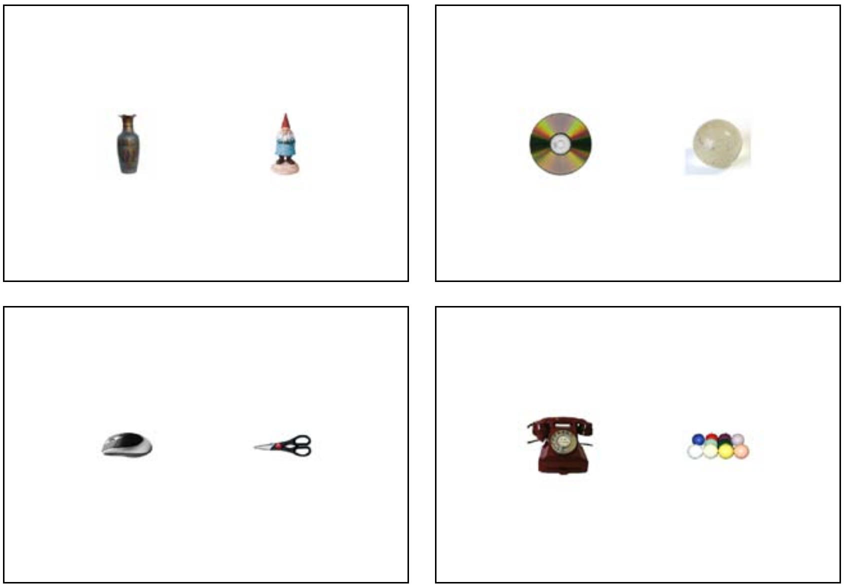
Examples for bland food – neutral stimuli



Examples for palatable food – neutral stimuli



Examples for NNB stimuli: 2 neutral stimuli matched in size and shape to bland stimuli



Examples for NNP stimuli: 2 neutral stimuli matched in size and shape to palatable stimuli

Instructions for the dot probe task

WELCOME

Press SPACE to continue…

DOT PROBE TASK

INSTRUCTIONS

On each trial a cross (+) will appear in the centre of the screen.

You should look at the cross at the beginning of each trial. The cross will be replaced by two pictures. The stimuli will appear for only a short time. The length of time the pictures remain on screen will vary across trials.

One picture will be positioned to the left of the screen centre and the other to the right of the screen centre.

The pictures will be replaced by a dot (.) The dot will appear in the location of one of the pictures.

Your task is to indicate if the dot is in the place of the picture that was on the left of the screen or the right of the screen.

Using the END BUTTONS on the response box…

Press the LEFT button if the dot is in the LEFT part of the screen.

Press the RIGHT button if the dot is in the RIGHT part of the screen.

Respond as QUICKLY and ACCURATELY as you can.

Lets first begin with some practice trials.

Press the MIDDLE button to continue.

That concludes the practice trials. What follows is the experiment proper.

Remember…

Press the LEFT button if the dot is in the LEFT part of the screen.

Press the RIGHT button if the dot is in the RIGHT part of the screen.

Respond as QUICKLY and ACCURATELY as you can.

OK, let's begin.

Press the MIDDLE button to continue

That concludes this part of the study.

Please leave the computer as it is and see the Experimenter for further instructions.

Thank you again.

WILLKOMMEN ZUM EXPERIMENT

Bitte drücken Sie den mittleren Druckknopf auf der Antwortbox um fortzufahren…

WICHTIGE INFORMATIONEN

Bei jedem der 4 Durchgänge wird ein Kreuz (**+**) in der Mitte des Bildschirms erscheinen.

Es ist wichtig, dass Sie zu Beginn eines jeden Durchgangs auf das Kreuz schauen. Als nächster Schritt wird das Kreuz wird durch 2 Bilder ersetzt werden. Ein Bild wird links von der Bildschirmmitte positioniert sein und das andere rechts von der Bildschirmmitte.

Diese Bilder werden nur für kurze Zeit zu sehen sein. Die Zeitspanne, in der die Bilder am Bildschirm zu sehen sind, wird über die Durchgänge hinweg variieren.

Wenn die Bilder verschwinden, wird eines davon durch einen Punkt ersetzt (•) . Der Punkt wird also anstelle eines der Bilder erscheinen.

Ihre Aufgabe ist es, anzugeben, ob der Punkt das Bild auf der rechten Seite des Bildschirms oder das Bild auf der linken Seite des Bildschirms ersetzt hat.

Verwenden Sie dazu bitte die Druckknöpfe auf der Antwortbox.

Drücken Sie den LINKEN Knopf, wenn der Punkt auf der LINKEN Hälfte des Bildschirms ist.

Drücken sie den RECHTEN Knopf, wenn der Punkt auf der RECHTEN Seite des Bildschirms ist.

Dies erfolgt dadurch, dass Sie den erscheinenden Punkt auf der jeweiligen Seite des Bildschirms mit den Augen fixieren. Wenn die Fixation erfolgreich war, erscheint ein Blank Screen und sie können selbständig mit dem nächsten Trial fortfahren. (eye version)

Antworten Sie so SCHNELL und GENAU wie Sie können.
Reagieren Sie so SCHNELL und GENAU wie Sie können.
(eye version)

Beginnen wir zuerst mit einigen Übungsdurchgängen.

Bitte drücken Sie den mittleren Knopf um fortzufahren…

Die Übungsdurchgänge sind nun beendet. Was nun folgt, ist das eigentliche Experiment.

Erinnern Sie sich...

Drücken Sie den LINKEN Knopf, wenn der Punkt auf der LINKEN Hälfte des Bildschirms ist.

Drücken sie den RECHTEN Knopf, wenn der Punkt auf der RECHTEN Seite des Bildschirms ist.

Fixieren sie den erscheinenden Punkt auf der jeweiligen Seite des Bild-schirms mit ihrem Augen solange, bis ein Blank Screen erscheint. (eye version)

Antworten sie so SCHNELL und GENAU wie Sie können.
Reagieren sie so SCHNELL und GENAU wie Sie können. (eye version)

Gut, beginnen wir.

Bitte drücken Sie den mittleren Knopf um fortzufahren…

Dieser Teil des Experiments ist hiermit beendet.

Bitte lassen Sie den Computer wie er ist und wenden Sie sich an den Versuchsleiter für weitere Anweisungen.

Vielen Dank, dass Sie an dieser Studie teilgenommen haben.

Experiment Builder

The study was programmed with Experiment Builder. SR Research Ltd's Experiment Builder is a visual experiment creation tool designed to be easy to use while maintaining a high degree of flexibility, without comprimising accuracy. The key features of Experiment Builder are, for example, its seamless integration with the EyeLink Hardware and Software, visual drag and drop interface and intuitive hierarchical experiment building block interface. It also provides support for simple to complex experimental paradigms and precise and accurate sub-millisecond timing. Last, but not least, the built-in 2D visual stimulus creation tool supports shape primitives, images and video clips. You can also extend experiments when required by adding custom Python code (SR research Ltd., 2010b).

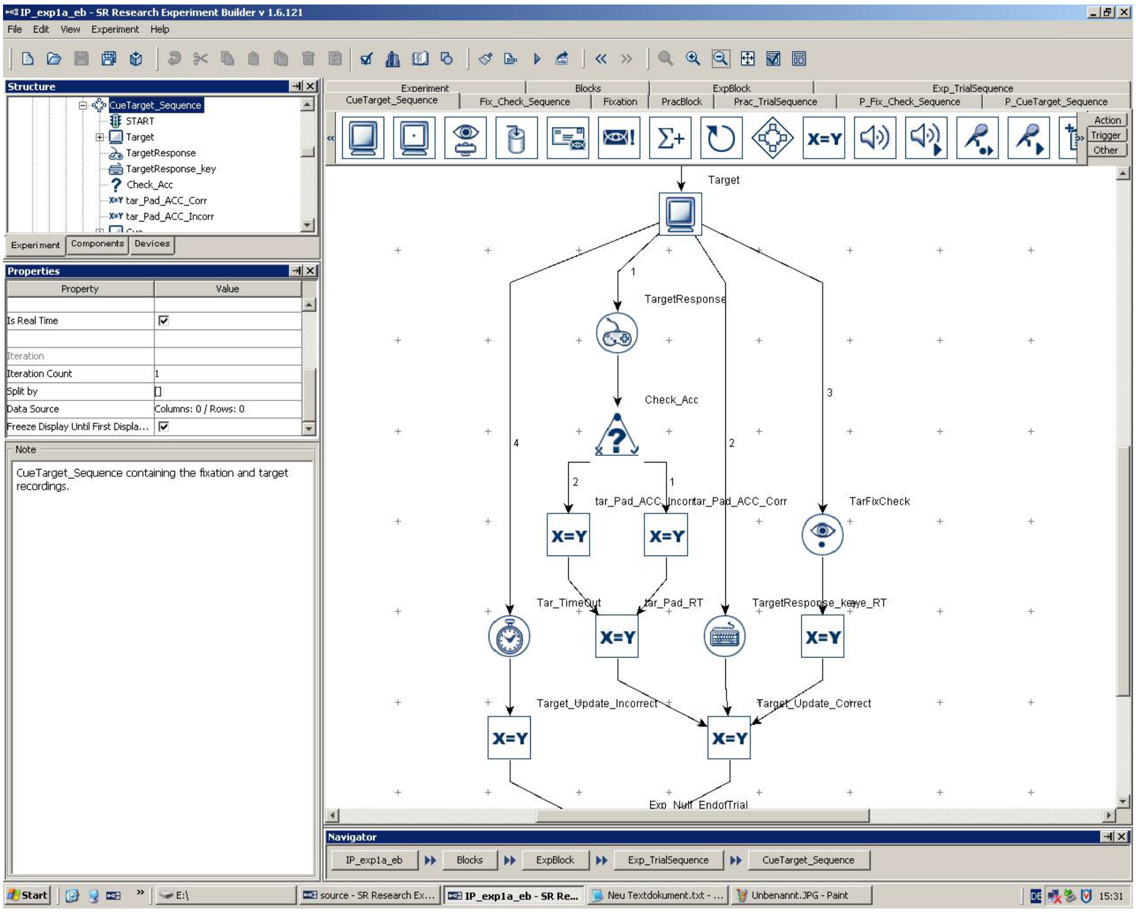


Figure 9. Experiment Builder Interface of the present analysis.

Eye Data Viewer

Resulting eye data was analysed with Eye Data Viewer which is an intuitive tool that is used for viewing, filtering, and processing EyeLink gaze data. The Eye Data Viewer is highly integrated with the SR Research Experiment Builder. Several different data viewing modes are available. Some of its key features are, for example that the User can overlay views which provides eye event position and scan path visualization on top of presented stimulus. It also affords a series of reporting tools that can be used to tab and limit the data files for use in common statistical analysis packages: e.g., outputs of eye sample, fixation, saccade, interest area (dwell time), or trial based reports for statistical analysis. It's possible to generate rectangular, elliptical, or free form interest areas or heat maps, time plot views support eye sample trace visualization. Eye Data viewer offers a temporal playback view and movie export of recording with gaze position overlay. Finally you can create reaction time definitions for automatic trial by trial Reaction time calculation and interest periods for temporal data filtering (SR research Ltd., 2010a).

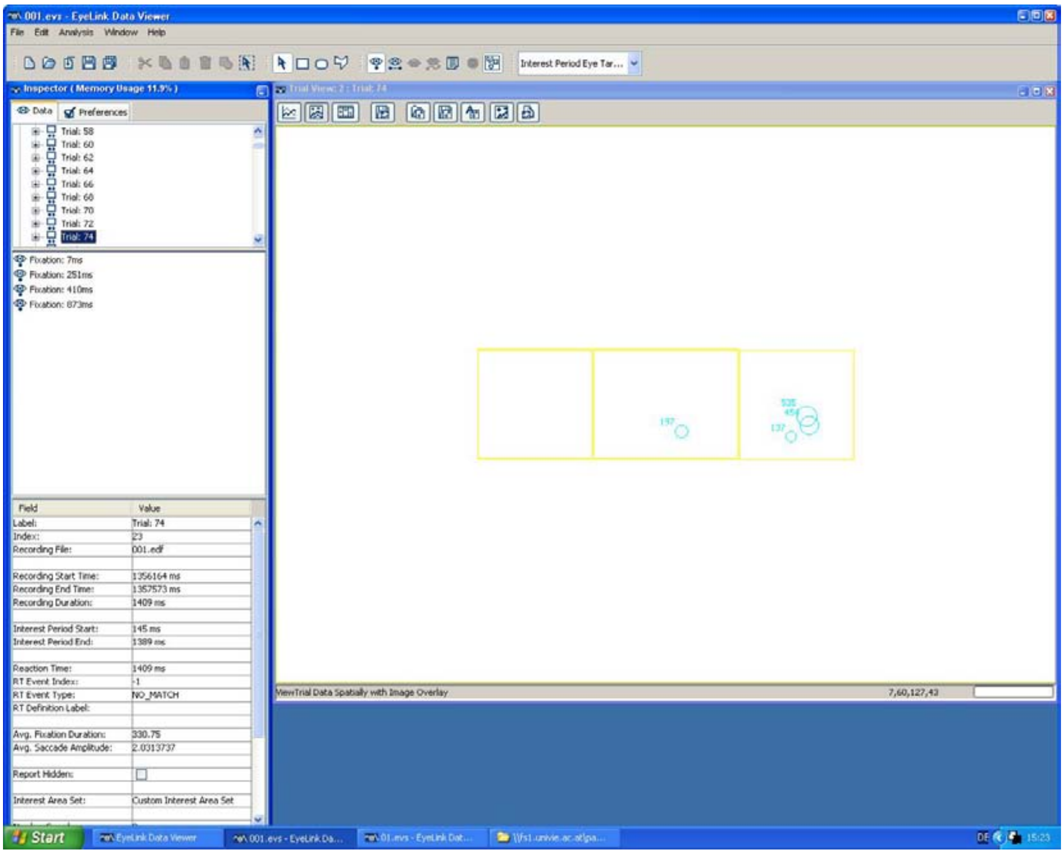


Figure 10. Eye Data Viewer Interface of the present analysis.

Participant's declaration of consent

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Versuchspersonen-Information und Einverständniserklärung

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Handedness test

Händigkeitstest

Initialen: ________ Alter: ________ Geschlecht: ______________

Händigkeit (eigene Einschätzung): L: ___ R: ___

In der unten angeführten Liste sind Aktivitäten aufgelistet. Bitte geben Sie an, mit welcher Hand Sie bevorzugt diese Aktivitäten ausführen, indem Sie ein X in das entsprechende Kästchen einfügen. Wenn Sie bei einer Tätigkeit denken, dass Sie diese immer nur mit einer bestimmten Hand ausführen, dann markieren Sie das dementsprechende Kästchen mit XX. Falls es Fälle geben sollte, in denen Sie sich nicht für eine Hand entscheiden können, notieren Sie in beiden Kästchen ein X. Bei einigen der Tätigkeiten sin in Klammer spezifiziert, was Ihre bevorzugte Hand in diesem Fall tut oder welchen Gegenstand sie hält.

	Linke Hand	**Rechte Hand**
1. SCHREIBEN		
2. ZEICHNEN		
3. WERFEN		
4. Mit einer SCHERE schneiden		
5. Zähne putzen (ZAHNBÜRSTE)		
6. MESSER (ohne Gabel)		
7. LÖFFEL		
8. BESEN (obere Hand)		
9. STEICHHOLZ anzünden (Streichholz)		
10. KISTE ÖFFNEN (Deckel)		

Abstract in English

Consumption and abstinence from substances with a high reward level is often related to a cognitive bias regarding information concerning these substances. The present research focused on measuring the attentional bias to food-related stimuli within a dot probe paradigm combined with eye tracking. The experimental manipulations included differences in food types (bland and palatable), stimuli durations (100 ms vs. 500 ms vs. 2000 ms) and congruence levels (incongruent vs. congruent vs. neutral). Two different versions of the dot probe had been programmed, called “gamepad version” (conventional version) and “eye version” (new version). The main research question contained the actual intentions of the dot probe paradigm and whether it was possible to indicate a bias for food-related information or not. Furthermore, the influence of hunger on the attentional bias was investigated. The substantial finding of this study was a significant three-way interaction for experiment version, food type and stimulus duration (SOA). Bias indices from reaction times indicated an avoidance of food-related stimuli during a SOA of 100 ms. Bias indices also indicated a bias towards food-related stimuli during a SOA of 500 ms and 2000 ms. Besides, the findings from the “eye version” also showed that participants were more attracted to palatable food-related stimuli during the SOA of 2000 ms, whereas no difference between the food types could be found in the “gamepad version”. Initial orientation was measured significantly more often in the “gamepad version”, but the negative correlation between hunger and the direction bias showed that participants from the “gamepad version” seemed to avoid the first gaze to food-related stimuli, when they were hungry. In the “eye version” (in which participants were significantly hungrier), correlations showed a significant positive relation between hunger and bias indices from reaction times. Participants needed longer to react to food stimuli under lower levels of hunger and they showed rather short reaction times to food-related stimuli under higher amounts of hunger. The results from the “eye version” confirmed the expectations of this study more than the results of the “gamepad version”. But the ambiguity of the data might consider running a similar study with a greater number of participants in every experiment version.

Abstract in German

Konsumierung bzw. Abstinenz von Substanzen mit hohem Belohnungswert ist oft mit einem kognitiven Bias hinsichtlich Informationen, die diese Substanz betreffen, verbunden. Die aktuelle Studie widmete sich der Messung des Aufmerksamkeit Bias für essensbezogene Stimuli mithilfe des Dot Probe Tasks in Kombination mit Eye Tracking. Die Experimentalbedingungen inkludierten Unterschiede in den Essenskategorien (gesunde und appetitliche Stimuli), der Stimuli Präsentationsdauer (100 ms vs. 500 ms vs. 2000 ms) und den Kongruenzebenen (inkongruent vs. kongruent vs. neutral). Zwei verschiedene Versionen des Dot Probe Tasks wurden programmiert, die „gamepad version“ (konventionelle Version) und die „eye version“ (neue Version). Die Hauptforschungsfrage befasste sich damit, was das eigentliche Messvorhaben des Dot Probe Tasks ist und ob es damit möglich ist, einen Bias für essensbezogene Information anzuzeigen oder nicht. Weiters wurde der Einfluss von Hunger auf den Aufmerksamkeitsbias untersucht. Das Hauptergebnis dieser Studie war eine signifikante dreifache Interaktion zwischen der Experimentversion, den Essenskategorien und den Darbietungsdauern. Bias Indices der Reaktionszeiten wiesen auf eine Ablehnung der essensbezogenen Stimuli während der Darbietungsdauer von 100 ms hin. Bias Indices zeigten ebenso eine Verzerrung der Aufmerksamkeit in Richtung der essensbezogenen Stimuli während den Darbietungsdauern von 500 ms und 2000 ms an. Zudem zeigten die Ergebnisse der „eye version“, dass die Teilnehmerinnen während der Darbietungsdauer von 2000 ms mehr von den appetitlichen als den gesunden Stimuli angezogen wurden, wohingegen kein Unterschied zwischen den Essenskategorien in der „gamepad version“ gefunden wurde. Anfängliche Orientierung wurde signifikant öfter in der „gamepad version“ gemessen, aber die negative Korrelation zwischen Hunger und dem Richtungsbias zeigte, dass die Teilnehmer der „gamepad version“ die erste Fixation auf die essensbezogenen Bilder zu vermeiden schienen, wenn sie hungrig waren. In der „eye version“ (in der die Teilnehmer deutlich hungriger waren) zeigten die Korrelationen einen signifikant positiven Zusammenhang zwischen Hunger und Bias Indices der Reaktionszeiten. Bei geringem Hungergefühl brauchten die Teilnehmer länger um auf die Essensstimuli zu reagieren und bei größerem Hungergefühl zeigten sie eher kurze Reaktionszeiten auf die essensbezogenen Stimuli. Die Ergebnisse der „eye version“ bestätigten die Erwartungen dieser Studie mehr als die Ergebnisse der „gamepad version“. Aber die Uneindeutigkeiten in den Daten sollte die Durchführung einer gleichartigen Studie mit einer größeren Anzahl an Teilnehmern in jeder Experimentversion in Betracht ziehen.

8. Affirmation

Ich versichere,

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- dass diese Arbeit mit der vom Begutachter beurteilten Arbeit übereinstimmt.

....

Datum **Unterschrift**

9. Curriculum Vitae

Irene Pamlitschka

Persönliche Daten

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Familienstand:	ledig
Staatsbürgerschaft:	Österreich

Schulausbildung und Studium

Seit Oktober 2001	Studium der Psychologie an der Universität Wien Schwerpunktsetzung in den Bereichen Klinische und Sozialpsychologie
1993 – 2001	Realgymnasium, Linz; Abschluss mit Matura
1989 – 1993	Volksschule, Leonding

Berufserfahrung und Praktika

Seit Dezember 2006	PC-Raumbetreuung: EDV Tutor am zentralen Informatikdienst (ZID) der Universität Wien, Verwaltung von Druckern und Scannern, Ansprechperson für Benutzer der PC-Räume bei Fragen bzw. Problemen jeglicher Art
September – Nov. 2011	Praktikum im Kolping Haus „Gemeinsam Leben“ für betreutes Wohnen. Aufgaben: Gespräche, kognitives Training (u.a. mit diagnostischen Testverfahren), Dokumentation und Gutachtenerstellung, Gruppenleitung
Juli – August 2007	Praktikum im Arbeitsbereich Psychologische Diagnostik: Aufgaben: Literaturrecherche, Überarbeitung eines Skriptums für Testleiter
August – Oktober 2006	6 Wochen Praktikum am Institut für Wirtschaftspsychologie, Bildungspsychologie und Evaluation: Aufgaben: Dateneingabe (Word, Excel, Powerpoint, SPSS), Auswertungen, Evaluationen
Feb. 2005 – Nov. 2006	Brandner Bau GmbH, Bürokraft, administrative Tätigkeiten, Computerarbeit, Telefondienst, erste Anlaufstelle für Kundenfragen, Dateneingabe in Projektdatenbank

Besondere Kenntnisse

Fremdsprachen	Englisch: fließend in Wort und Schrift Französisch: Grundkenntnisse
EDV	ECDL Core und Advanced