Motivational Modulation of the Attentional Blink

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Contents

0. Abstract

The present study aimed to investigate if and to what degree motivationally-behaviourally relevant material modulates the “attentional blink” effect during rapid serial visual presentation (RSVP). Written eating verbs (e.g. “essen”, “speisen”, “kauen”; “to eat”, “to dine”, “to chew”, respectively) and written arts and craft verbs (e.g. “hämmern, sägen, schnitzen”; “to hammer, to saw, to carve”, respectively) were used as a second target (T2) in an 8.7-Hz RSVP paradigm. Participants came to the laboratory twice: once in a satiated state, and once in a hungry state (food-deprived for 24 hours). The crucial experimental question was whether food deprivation modulates the attentional blink effect. In particular, the hypothesis of a facilitated identification of eating verbs compared to arts and craft verbs in a hungry state was tested. Successful manipulation of motivational state was controlled with a blood test and with ratings of hunger and appetite. Subjective ratings of the target verbs using the Self-Assessment-Manikin showed a state-dependent difference in the hungry state specifically for the eating verbs. In the hungry state, participants rated eating verbs as more arousing and as more pleasant compared to the satiated state. As expected, the classic attentional blink effect was replicated in the present study. Interestingly, the results did not show that being in a hungry state leads to a better identification of eating-relevant verbs. Although the successful manipulation of motivational state was demonstrated in this study, food deprivation did not influence the attentional blink pattern. Instead, a very robust attentional blink effect was found for both T2 stimulus classes. The findings of the present study are discussed in relation to recent attentional blink experiments using affectively arousing material and in relation to other paradigms dealing with hunger-related attention biases towards food-relevant stimuli.

1. Introduction

Research on attention is concerned with selective processing of incoming sensory information. Core phenomena according to attention research are selectivity of perception, voluntary control over this selectivity, and capacity limits in mental functioning that cannot be attributed to mere limitations in our sensory or motor systems (Pashler, 1998). One of the biggest changes in the field of attention research has been the realization that the concept of "attention" is best thought of as a general broad topic, encompassing a range of selective issues, rather than as a single explanatory process (Driver, 2001).

In the present study, attentional limitations for processing a temporal sequence of visual stimuli are examined. The rapid serial visual presentation (RSVP) paradigm provides a useful tool for researchers exploring the temporal characteristics of information processing because it provides the experimenter with precise control not only over the time a given item is in view, but also over the preceding and subsequent processing demands on the participants (Chun and Potter, 1995).

1.1 The Rapid Serial Visual Presentation Paradigm (RSVP)

The limits governing the brain's ability to process a stream of visual information can be studied in the laboratory with rapid serial visual presentation (RSVP). In this paradigm, stimuli such as letters, digits, words or pictures are presented briefly in the same location and in rapid succession (from 6 to about 20 items per second). In the case of words, the presentation rate ranges only between 7 to 12 Hz given it is a more demanding task (Raymond, Shapiro, & Arnell, 1992). Typically one or two items in the stimulus stream, the target(s), is / are differentiated in some way (e.g., presented in a different colour), and the subject's task is to identify the target(s).

1.2 The Attentional Blink

When a human observer has to identify two objects presented in succession, the processing of the first object interferes with the processing of the second object. This phenomenon, which lasts for several hundred milliseconds, was termed the attentional blink

(AB) or dwell time, and is a measure of the observer's ability to shift attention over time (Raymond, Shapiro, and Arnell, 1992).

The standard procedure for studying AB is based on the rapid serial visual presentation (RSVP) of stimuli. In 1992, Raymond, Shapiro, and Arnell were the first ones to introduce the term "attentional blink". In their study (Raymond, Shapiro, and Arnell, 1992) participants were presented with an RSVP stream of letters. One of the letters was white, whereas the other letters were black on a grey background. The single white letter was the target, and one of the black letters (an X) was the probe. On experimental trials, the task was to identify the white letter and to indicate whether the probe had appeared following the target. On control trials, the task was to indicate only whether the probe had appeared, without identifying the target. The RSVP streams contained between 7 and 15 pre-target items and 8 post-target items. Results showed that, on experimental trials, the participant's ability to detect the probe varied according to its temporal position in the RSVP stream: If the probe occurred within about 400 ms of the target, detection was impaired.

Since then, the AB effect has been replicated in various studies. For example, a RSVP-study by Chun and Potter (1995) examined categorically defined targets (letters among nonletters) in seven experiments. In this study, for Experiment 1 they obtained the attentional blink when they presented letter targets among digit distractors (Chun and Potter, 1995). Moreover, Jolicoeur (1998) found the attentional blink effect when he embedded two critical target stimuli (T1 and T2) in a stream of white letters shown on a black background, using a RSVP-paradigm. T1 was a red H or S, T2 was an X or a Y. Performance in a two-alternative discrimination on T2 was impaired when processing of T1 was required.

The AB is a very robust phenomenon which can be found in most of the participants in RSVP-studies. At a typical presentation rate of about 10 items per second, there is a maximum deficit in identification accuracy of the second target (T2) of up to only 20 percent accuracy when one or two distractors are presented between the first (T1) and second (T2) target (stimulus onset asynchrony (SOA) between 200 and 300 ms). The identification accuracy improves slowly as the SOAs become longer. From five distractors between T1 and T2 onwards (that is a SOA of around 600 ms) the report accuracy usually comes back to about 80 to 90 percent which corresponds to the level of accuracy at the beginning. There is no or just a small deficit in accuracy when T2 immediately follows the T1-stimulus (SOA of about 100 ms). The typical pattern of the attentional blink effect is pictured in Figure 1.

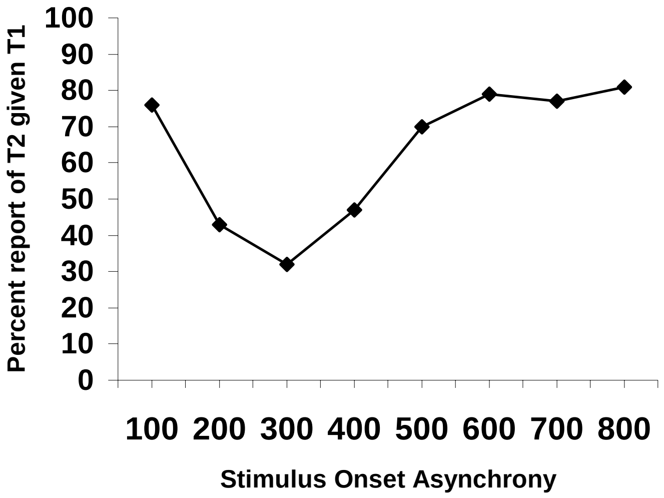

Figure 1: Typical pattern of the attentional blink effect: Percentage report of the second target (T2; given report of the first target; T1) as a function of stimulus onset asynchrony (see Chun & Potter, 1995).

The term "attentional blink" introduced by Raymond, Shapiro, and Arnell (1992) was used to indicate that participants experience an attentional impairment after engaging the target. The exact mechanism of this loss of attention is still a matter of debate (see Milliken & Tipper, 1998). Raymond and colleagues (1992) originally proposed an explicit inhibitory process. Later Shapiro and Raymond (1994) suggested a competitive retrieval process. A third account is based on the notion of a bottleneck created by a capacity-limited stage of processing (Chun & Potter, 1995). Finally, as a fourth possible mechanism of the attentional blink, Jolicoeur (1998) introduced a central interference model.

1.3 Models of the Attentional Blink

1.3.1 Attentional Gate Model

On the basis of their data, Raymond, Shapiro, & Arnell (1992) postulated the following sequence of events which may lead to the attentional blink. During the presentation of the RSVP stream of stimuli, the target-defining feature of the first target T1 (e.g. colour) is detected preattentively in the sensory store. This information is then used to initiate an attentional response to facilitate target identification: attention is allocated to the target in the the sensory store. If attention is allocated episodically, then target identification may involve the opening and closing of an "attentional gate" (Raymond et al., 1992) to regulate the flow of postperceptual visual information to recognition centres of the brain.

If a new stimulus (the post-target item) is presented immediately after the target but before the termination of the attentional episode, this will result in features of the post-target item being processed along with features of the target item in the sensory store. The availability of features from both the target and the post-target item in the sensory store, however, will provide the identification mechanism with confusing information: for instance, two letter colours and two letter names.

This potential confusion is noted by the system and then used to initiate a suppressive (inhibitory) mechanism to eliminate further confusion: the attentional gate is shut and locked, making it impossible for new items to enter the sensory store; as a consequence, new items are not processed. The shut-and-lock procedure lasts for about 450 ms. During this period of a closed attentional gate, the system is attempting to conjoin the correct colour with the correct identity (that is, letter name). Consequently, the initiation of the next attentional episode is delayed. In the attentional blink analogy, the locking of the attentional gate is like the closing of an eyelid.

When confusion is not present (i.e. target identification can reach completion without interference from new stimuli; that is, a blank screen instead of a post-target item follows the target), the attentional gate is merely closed and the next attentional episode can be initiated rapidly.

1.3.2 Similarity Theory

Raymond, Shapiro, and Arnell (1992) suggested that the AB results from confusion manifest by a limited capacity attentional mechanism attempting to identify a target while being confronted with additional competing stimuli before identification has been completed. Competing stimuli lead to confusion and a potential conjunction error: visual short-term memory (VSTM) might contain two letters and two colours for instance.

The set of experiments reported by Shapiro, Raymond, and Arnell (1994) suggested that the attentional system's attempt to avoid a conjunction problem during the process of target identification need not be the root cause of the AB. On the one hand, Shapiro and colleagues (1994) demonstrated that a mere T1-detection task instead of a more difficult T1-identification task leads to an AB. That means target identification is not a necessary precondition to produce the AB. On the other hand, they showed that a simple dot pattern shown as a first post-target item (T1+1 stimulus) impairs (even though in an alleviated way) the processing of the subsequent items. In both cases, a suppressive (inhibitory) attentional mechanism to avoid conjunction errors (between features of T1 and the T1+1 stimulus) seems inappropriate as an explanation. Moreover, Shapiro and colleagues (1994) revised their position on the basis of results from "temporal gap experiments" in which T1 was a period of time during the RSVP stream in which there was no patterned stimulus (achieved by replacing a letter in the stream by a blank field). They found a very much reduced AB effect, despite the fact that this T1-task was quite difficult to perform (as indexed by error rates in this task) relative to other experiments producing a substantial AB effect. Shapiro and colleagues (1994) interpreted the small AB effect in the temporal gap experiments as an indication that visual patterned stimulation in the T1 stimulus is a necessary condition for the manifestation of an AB. This led them to propose an alternative theory: similarity theory.

In their similarity theory, Shapiro and colleagues (1994) postulate the following scenario: First, in an early and parallel state of visual information processing, representations of all items in the visual field are generated. Second, these representations are compared with internal selection templates of the T1 and the T2 stimulus. Third, those items that match the templates for T1 and T2 approximately are selected for entry into visual short-term memory (VSTM), which has limited capacity.

The crucial factor for entry of distractor items in VSTM is their similarity to the target templates. Furthermore, the temporal contiguity to the target stimulus defines the entry in VSTM. According to Shapiro and colleagues (1994), four items receive entry in the VSTM: the first target T1, the item which immediately follows on T1 (T1+1), the second target T2 and the following stimulus T2+1. Items which gain entry into VSTM, are assigned weights that determine the probability of report from VSTM. The similarity between distractor items (most importantly the item following T1) and the selection template for T1 (and between the item following T2 and the template for T2) is an important determinant of entry into VSTM. When similarity is low, distractors are less likely to gain access to VSTM. Shapiro and colleagues (1994) argued that, as a result of temporal limitations in the speed of selection, the item immediately following T1 and the item immediately following T2 both have a high likelihood of gaining entry into VSTM. The weights assigned to items in VSTM also depend on a pool of limited resources. Items that enter VSTM earlier are assigned larger weights, all else being equal, because there are more available resources. Later items receive smaller weights, because resources have been depleted by the entry of earlier items in VSTM.

Hence, the probability of report from VSTM at the end of a trial is determined by weights that are assigned to each item in VSTM. A higher weight results in a higher probability of output from VSTM. The weights are a function of the goodness of match to the selection templates. Although distractors, in general, will have lower weights than T1 and T2, distractors that match the selection templates partially may nonetheless have a weight that is sufficiently high to result in performance decrements when items are selected for report from VSTM.

Therefore, according to Shapiro and colleagues (1994), both the number of items in the VSTM and their weights are postulated to influence performance. The AB effect according to their theory occurs at the time of output from VSTM, as a function of the weights associated with the items in VSTM. In order to account for the recovery of performance in the task associated with T2, as the delay between T1 and T2 is increased, Shapiro and colleagues (1994) propose that T1 either decays or is flushed from VSTM in the 450 ms following its presentation so that T1 no longer interferes with T2. Presumably, T1 has had time to be transferred from VSTM to another system (such as the short-term memory (STM) system), but this is not stated explicitly by Shapiro and colleagues (1994).

1.3.3 Two-Stage Model

The experiments undertaken by Chun and Potter (1995) extended previous findings of the AB effect. Their results indicated that target search performance in RSVP is a function of both global and local target-distractor discriminability and that the degree of post-target interference on T2 / T1 is modulated by the difficulty of T1 processing. The discriminabilty of the distractors compared to the letter-targets was varied in two ways: either the distractors were composed of easily discriminabel items (symbols) or they were composed of difficultly discriminable items (numbers). Results showed that even these categorically defined targets (letters in-between symbols or numbers) caused an AB effect. Chun and Potter (1995) also indicated that the AB effect was significantly reduced by the increase of the local discriminablity (by manipulating those items that are immediately following on the targets). The AB effect was also reduced by the increase of the global discriminability (by manipulating all distractors).

Chun and Potter (1995) proposed a two-stage model of the AB phenomenon in order to explain their experimental results. This two-stage model claims the AB deficit arises from a limited-capacity stage of processing and consolidation of the target after it has been initially detected.

In the first stage, called “rapid detection”, virtually every item presented in RSVP streams at a rate of about 10 items per second will be processed. Feature cues relevant for target detection (such as colour, letter case, or targethood on the basis of categorical identity) are analyzed and can be selected for further processing and consolidation in subsequent stages of processing. These initial, and only briefly available, stage 1 representations are subject to rapid forgetting when there is interference from subsequent items in the RSVP stream, unless they are selected for further processing.

In the bottle-neck like second stage, called "capacity-limited processing", items selected for further processing are transferred into a more durable representation (such as verbal short-term memory, VSTM). Stage 1 representations cannot serve as the basis for a later verbal report or for a manual response. The information must first be transferred to short-term memory, which results in full identification and consolidation for subsequent report. Stage 2 processing is capacity limited and is initiated by a transient attentional response that occurs on Stage 1 detection of a probable target. This attentional response actively selects and enhances processing of the target. Until this second processing stage is completed, no subsequent items are processed beyond Stage 1. When T2 appears before the second stage is free, it will be detected by Stage 1 processing, but Stage 2 processing will be delayed. The longer the delay, the greater the probability that T2 will have been lost, according to the previous assumption that Stage 1 representations are short-lived.

In other words, according to the model of Chun and Potter (1995), the AB phenomenon is caused by the capacity limit in Stage 2 processing. If T2 is presented while T1 is being processed in Stage 2, Stage 2 processing of T2 must wait, and T2 may be lost.

1.3.4 Central Interference Model

In a series of experiment, Jolicoeur (1998) showed that manipulations affecting a relatively late stage of processing – response selection – affect the magnitude and duration of the AB phenomenon. Jolicoeur (1998) compared the performances on two different tasks: either the participants had to respond to T1 immediately while the RSVP stimulation was running ("speeded task"), or the participants had to respond the traditional way, namely at the end of a trial with a delay ("unspeeded task"). In both tasks, the response to T2 occurred at the end of each trial. Jolicoeur (1998) found a larger AB effect when a speeded response was required. Furthermore, in the speeded conditions, faster responses in the T1-task (=Task1) were associated with a smaller and shorter AB effect than were slower responses.

Jolicoeur (1998) proposed a central interference theory to account for his results. The central interference theory extends postponement models of the PRP (psychological refractory period) effect to account for the AB phenomenon. According to the central interference theory, the AB is similar to the PRP effect and is caused by central postponement of short-term consolidation of T2.

The theory supposes that the critical stage of processing required to perform Task2 that is affected by concurrent processing in Task1 is short-term consolidation (STC). STC is the process of encoding information into short-term memory (STM). The key concept in the theory is that certain cognitive processes require central mechanisms that are capacity limited. This capacity limitation imposes a seriality in the sequence of operations for certain combinations of operations but not for others. (The model assumes that the earliest stages of encoding, called sensory encoding (SE) and perceptual encoding (PE), can take place without central involvement and essentially without mutual interference across tasks.) It is assumed that STC requires central capacity-limited processing. STC for Task2 can be delayed by a number of different operations that could be required for Task1. Jolicoeur's term "central interference" stands for this conflict between several operations which all require central involvement. That is, the STC encoding process for T2 cannot occur when central mechanisms are occupied with the processing required for another concurrent task – Task1.

1.3.5 Similarities and differences of the AB models

While the attentional gate model (Raymond et al., 1992) states a complete shut-down of the processing system (that is a locking of VSTM), the similarity model (Shapiro et al., 1994) describes the AB phenomenon as a competition of items which all compete for retrieval from VSTM. It is not explicitly stated for the attentional gate model, but the crucial factor for the development of the AB is also the similarity of items. While according to the attentional gate model the similarity between T1 and T1+1 is decisive, in the similarity model the similarity between T2 and all other items, which gained access to VSTM (namely T1, T1+1, and T2+1), is the crucial point. In the attentional gate model, the T2-Stimulus only plays a passive part, whilst its features are crucial for the development of a processing deficit in the similarity model.

For the two-stage model, consolidation of T2 is impaired by the ongoing consolidation of T1. The central interference model extends this assumption by proposing that short-term consolidation of T1 requires central capacity-limited processing and that T2-consolidation might also be disturbed by other processes which need these central mechanisms. Examples for these cognitive processes are retrieval from long-term memory, mental rotation, or task-switching which all delay T2-consolidation.

If one assumes that the VSTM according to the similarity model corresponds to stage two of the two-stage mode, then there is a crucial difference between the similarity model and the two-stage model. In the similarity model both T1 and T2 arrive at VSTM, in the two-stage model the T2-stimulus does not even reach VSTM.

All four introduced models of the AB effect have in common that they propose a transformation from initial representations of items to more stable representations of these items. They all claim that for an item being selected for further processing, attention has to be allocated to this item. Furthermore, all of the described models propose that visual short-term memory (VSTM) is capacity-limited. The transformation from an early representation to a more stable representation (that is a representation in VSTM) is called consolidation, at least in the two-stage model and in the central interference model.

As mentioned earlier, the exact mechanism of the AB effect is still a matter of debate. Presumably, the authors of the introduced models use different names for identical processes because there are some substantial similarities in the models, for instance the transformation from initial representations to more durable ones or the involvement of short-term memory in the AB effect. That means there are aspects of the AB effect which can be predicted from all models. Besides these introduced traditional AB models, several hybrid models have been proposed to combine different assumptions from these models (Shapiro et al., 1997; Vogel et al., 1998). A recent paper by Nieuwenstein and colleagues (2005) discusses some interesting alternatives of the traditional AB models. Still, future experiments will determine which of the models provides the best solutions to account for the AB.

Despite the ongoing debate about which AB model accounts best for the attentional blink phenomenon, the pattern of the AB effect is examined thoroughly and there is great agreement about the course of the effect (see also Figure 1). In the following section, it is illustrated how the robust attentional blink pattern can be modulated.

1.4 Motivational Significance changes the AB effect: Modulations of the AB

1.4.1 Salience modulation with one's own name

In 1997, Shapiro, Caldwell and Sorensen published a series of experiments demonstrating a modulation of the AB effect if a highly salient stimulus such as the participant's own name is used as a T2-stimulus (Shapiro, Caldwell, & Sorensen, 1997). Participants had to identify two target words in a stream of black distractor words by identifying a white T1-stimulus and by detecting the presence of a defined T2-word. They used the participant's own name, another personal name, or a normal noun as second targets (T2s). The results showed that participants experienced the usual AB effect for normal nouns and personal names. However, when the participant's own name functioned as the T2-stimulus, participants did not show an AB effect.

In order to explain their findings, Shapiro, Caldwell and Sorensen (1997) used an analogy to an auditory phenomenon, the "cocktail party effect" which was first described by Moray (1959). Using the dichotic listening paradigm, Cherry (1953) reported that individuals shadowing a message presented to one ear were completely unaware of the semantic information presented to the unattended ear. However Moray (1959) was successful in replicating Cherry's findings with numbers and words but showed that if a participant's own name was presented to the unattended ear, the participant was able to successfully report its occurrence in a significant number of trials. This outcome has become known as the "cocktail party effect" to suggest that certain items of semantic information are not filtered out, instead, salient information stands out like mentioning of one's own name in one of the numerous conversations on a cocktail party.

To explain their "visual cocktail party effect", Shapiro, Caldwell and Sorensen (1997) refer to Treisman's theoretical explanations. In an attempt to preserve Broadbent's (1958) filter theory, Treisman (1960, 1980) proposed that the filter is not an "all or nothing" mechanism but instead serves to attenuate rather than block information from the unattended channel. According to her views, a node for a particular word in a mental "dictionary" possesses a threshold that must be exceeded for that word to reach "awareness". Information from the unattended is transformed in such a way as to make it less likely that the information will activate a particular node. Thus, only words with very low thresholds can be activated by the unattended channel. For example, words with high salience, such as an individual's name, have thresholds for activation that are permanently lower than those for other words and can reach awareness even when presented to the unattended channel.

By referring to the observations described above, Shapiro and colleagues (1997) argue that a person's own name as a T2-stimulus is less susceptible to interference from other items because of its lower threshold (higher salience).

1.4.2. Affective modulation with negative words

In a study with healthy subjects and patients with amygdala damage Anderson and Phelps (2001) showed that the affective content of a T2-stimulus modulates the AB effect. Subjects had to identify two targets, T1 and T2, which appeared in bright green, whereas the distractor words appeared in black. The first target stimuli (T1) were composed of neutral words only (e.g. “broom”, “distance”). On the contrary, the second target stimuli (T2) consisted of negative (for example, “rape”, “bastard”) and neutral words. The negative word list comprised aversive words intended to be more negative and physiologically arousing in nature than their neutral counterparts. The negative and neutral lists were matched for average word length, written word frequency and interletter frequency.

The results demonstrated robust benefits for the perception of T2 verbal stimuli of aversive content compared with T2-stimuli of neutral content for healthy subjects (Anderson and Phelps, 2001). These healthy observers identified negative words with greater accuracy than neutral words across all seven temporal lags: mean identification accuracy across all lags was 79.8% for negative T2 words versus 61.5% for neutral T2 words. (Lags ranged from lag 1 (that is no intervening items between T1 and T2, SOA = 130 ms) to lag 7 (six intervening items, SOA = 910 ms).) The affective modulation of the AB effect was strongest for the short T1-T2 intervals (SOAs from 130 to 390 ms).

In contrast, the tested patients with either left or bilateral amygdala damage had no enhanced perception for such aversive T2 stimulus events. However, patients with right amygdala lesions showed an increase in identification accuracy for negative T2s.

A rating study after the RSVP-task was conducted asking the subjects to evaluate each stimulus on the dimensions valence and arousal. This rating study showed that all amygdala patients were able to comprehend normally the affective meaning of the stimulus events. Thus, Anderson and Phelps (2001) concluded that comprehension of words was unimpaired in patients and that lesions of the amygdala disrupt the ability to modulate the efficiency of perceptual encoding of emotionally significant linguistic events.

1.4.3 Affective modulation with emotional verbs

In his diploma thesis, Ihssen (2003) used neutral verbs as first targets (T1s) and neutral as well as affectively arousing (pleasant and unpleasant) verbs as second targets (T2s). Distractors consisted of neutral verbs and were shown in white colour, whereas target stimuli were shown in green colour on a black screen. The study showed an identification facilitation for both affectively arousing T2 stimulus classes compared to the neutral T2s for the shortest SOA of 230 ms (= lag 2, that is one intervening distractor between T1 and T2). Mean identification accuracy for pleasant verbs was 45.4 %; mean identification accuracy for unpleasant verbs was 48.2 % compared to neutral verbs for which mean accuracy was only 33.0 %. This arousal effect was not present in later lags as there was no difference in mean report accuracy between the three T2 stimulus classes. (Later lags were lag 4 = three intervening distractors and lag 6 = five intervening items.) A rating study conducted after the RSVP experiment revealed that the target verbs were perceived according to their categories. That is, neutral verbs were rated neutrally and low arousing, whereas pleasant verbs were rated as pleasant and high arousing as well as unpleasant verbs which were rated as being unpleasant and high arousing.

This diploma study by Ihssen (2003) also indicated that salience of target stimuli in an RSVP task modulate the attentional blink effect. In this case, the salience of the target stimuli was mediated via affectively arousing verbs. Salient or motivationally significant stimuli seem to capture attention, leading to better performance and more accurate reports.

Moreover, in an attentional blink study comprising three experiments by Keil and Ihssen (2004), the authors also found enhanced identification accuracy for emotionally arousing (pleasant and unpleasant) second targets (T2s) compared with neutral T2s specifically during short (232 ms) SOAs. In their Experiment 1, identification accuracy for affectively arousing T2s in the 232-ms SOA condition was enhanced by 15 % on average (Keil and Ihssen, 2004). When T2s were matched for self-rated emotional arousal in Experiment 2, these early differences were weak and did not reach statistical significance. Using low-arousing verbs throughout categories in Experiment 2, pleasant stimuli were rated as slightly more arousing than the other categories (neutral and unpleasant) and were associated with better performance during early AB. Experiment 3 was designed to clarify issues related to differences of semantic coherence in the categories used. In this experiment, all semantic categories differed regarding both valence and emotional arousal. Again, T2 findings pointed to a role of emotional intensity for early AB modulation, as they reflect the pattern of self-rated emotional arousal. As a consequence, identification performance in the short-SOA condition varied as a function of self-rated arousal across experiments.

The findings by Ihssen (2003) and Keil and Ihssen (2004) replicate and extend the findings by Anderson and Phelps (2001) by demonstrating that motivationally-affectively relevant material was selected preferentially from a temporal stream of verbal information.

1.5 Motivation shapes attention

From the already conducted studies of attentional blink effect modulations, one may conclude that certain motivationally-behaviourally relevant stimuli are selected preferentially from a temporal stream of information, facilitating processes such as working-memory consolidation and action. Indeed, according to the theories of Öhman (1986) and Lang and colleagues (1997), motivationally-behaviourally relevant stimuli shape attention and are viewed as action dispositions and ensure efficient and adaptive reactions.

In 1986, Arne Öhman suggested a model for the processing of emotional stimuli. In his model, an affective reaction (or automatic attention response) is elicited after a fast, involuntary, holistic and automatic analysis of an emotionally relevant stimulus. This automatic processing mechanisms matches stimulus input with memory elements which are primed to be significant. These memory elements are so-called “tagged memory elements” which have a “tag” put on them indicating particular important environmental events. The initial affective reaction may include, for instance, orienting and defence responses and it also primes response mobilisation systems and initiation of controlled processing of the stimulus in a central capacity-limited channel. Controlled processing includes primary and secondary appraisal of the situation which leads to further mobilisation and eventually to the selection of an overt response. Various aspects of information processing sequence are reflected in verbal reports, physiological measures, and overt behaviour (Öhman, 1986). In his paper, Öhman (1986) stresses that psychological phenomena should be analysed in terms of causal factors operating at three different levels, perception and action, learning, and evolutionarily determined effects. This functional-evolutionary perspective of emotions shows that motivationally-affectively relevant stimuli make fast and adaptive reactions possible.

In line with Öhman (1986), Lang, Bradley, and Cuthbert (1997) view human attention as information processing that involves procedures of selection and evaluation of motivationally relevant input, similar to that occurring in an animal as it forages in a field, encounters others, pursues prey or sexual partners, and tries to avoid predators and comparable dangers. Similar to Öhman, Lang and colleagues (1997) support a functional-evolutionary theoretical conception of emotions. According to Lang and colleagues (1997), emotions are viewed as action dispositions; they prepare the organism for an action (for instance, fight or escape) before it is too late. Furthermore, their theoretical approach to motivation postulates two drive systems, an approach / appetitive system and an avoidance / defense system, which modulate attention and perception (Lang et al., 1997). The avoidance / defense system is activated by unpleasant, arousing stimuli, whereas the approach / appetitive system is activated by pleasant, arousing stimuli. Hence, Lang and colleagues (1997) suggest a dimensional perspective on emotions; it is proposed that the two motive systems exist in the brain – appetitive and aversive – accounting for the primacy of the valence dimension in affective expression. These two systems are associated with widespread cortical, autonomic, and behavioural activity. Arousal is not viewed as having a separate substrate, but rather, as representing activation (metabolic and neural) of either the appetitive or aversive system, or the coactivation of both systems (Lang et al., 1997).

The attentional blink (AB) experiments with emotionally arousing (pleasant and unpleasant) second targets (T2s) can be interpreted with the theoretical framework of Öhman (1986) and Lang and colleagues (1997). Lang and colleagues (1997) state that attention is automatically directed to cues that have motivational significance, and many of the same (i.e. central nervous system, somatic, and autonomic) covariates of attention appear across species. As high arousing emotional stimuli are important for the organism's survival, they should capture attention automatically (or in Öhman's words (1986) emotional stimuli should "elicit a fast, involuntary, holistic and automatic analysis of an emotionally relevant stimulus") resulting in activation of the appetitive or aversive system, preparing the organism to react efficiently. Thus, the identification facilitation of affectively arousing verbs in an AB paradigm might be a result of attention automatically directed to this motivationally-affectively relevant verbal material.

Not only motivationally-behaviourally relevant stimuli in form of affectively arousing stimuli might be selected preferentially from a temporal stream of information but also food stimuli which might be especially motivationally-behaviourally relevant when the organism is food-deprived. When a deprived organism is exposed to food cues, the appetitive system should be activated and attention should be directed to these pleasant arousing stimuli. Actually, paradigms dealing with affectively-related attention biases in the visual modality have been used to examine hunger-related attention biases. For instance, in the "emotional Stroop" task – a variation of the well-known colour naming task (Stroop, 1935) – participants name the colour in which emotionally salient and emotionally neutral words are displayed, typically needing more time for the emotional words. This same approach has been used in "food Stroop" tasks exploring biases towards food-related words in participants who were food-deprived (e.g. Channon and Hayward, 1990; Lavy and van der Hout, 1993). Besides, experiments using the "dot probe" task have examined hunger-related biases for food words (e.g. Mogg et al., 1998; Placanica et al., 2002). In dot probe tasks, word pairs are presented on a computer screen, one word above the other. Immediately after the display of each word pair, a small dot probe appears in one of two locations on the screen which had just been occupied by one of the words. Participants indicate the position of the probe (i.e. upper or lower) by pressing one of two response keys as quickly as possible. Mogg and colleagues (1998) as well as Placanica and colleagues (2002) used food-related words as experimental probes in order to find out whether participants with high levels of hunger were more likely to shift their attention towards food-related words than towards control words.

So far, attentional blink research has investigated the processing of salient stimuli by using a participant's own name (Shapiro, Caldwell, and Sorensen, 1997), or by using affective stimulus material (see above, Anderson and Phelps, 2001; Ihssen, 2003; Keil and Ihssen, 2004). Thus, a particular interesting research question is whether not only affectively significant stimuli influence the attentional blink pattern, but also food-related stimuli in food-deprived participants. Therefore, in the present study, an attentional blink experiment was designed to investigate a possible motivational modulation of the attentional blink effect by conducting an experiment with eating-relevant stimuli under food-deprived and non-food-deprived conditions.

1.6 Hypotheses

The present study's aim was to extend the findings of attentional blink experiments dealing with motivationally-behaviourally relevant stimulus material. So far, stimuli in attentional blink paradigms have been made especially salient by using mainly affective stimulus material. In the present study, however, motivation is manipulated via food deprivation. Studies by Schaer (2004) and Schmälzle (2005) showed that manipulating motivational state with food deprivation can be realised well in an experimental setting. Hence, the present study investigated whether food deprivation influences the attentional blink pattern in a similar way that motivationally-affective stimuli do.

Similar to the studies by Schaer (2004) and Schmälzle (2005), the motivational state of the participants in the present study was manipulated via 24-hour-food-deprivation: the participants were required to come to the laboratory twice, once in a hungry state and once in a satiated one. In both experimental sessions, the participants completed a RSVP-task in which they had to attend to neutral verbs as first targets (T1s) and eating verbs as well as arts and craft verbs as second targets (T2s).

1.6.1 Motivational state

Firstly, it was important to ensure experimental manipulation of food deprivation was successful in order to draw conclusions about the outcome of the behavioural attentional blink experiment. If the participants report to be very hungry and their report is confirmed by a blood test measuring concentration of the ketone-body ß-Hydroxybutyrat (see Schmälzle, 2005), then one may conclude that experimental manipulation of hunger was successful. Therefore, it is expected that participants report more hunger and appetite on a rating-scale in a hungry state than in a satiated one. Additionally, the blood ketone level is expected to rise in a hungry state as opposed to a satiated one.

1.6.2. Subjective ratings of target stimuli

Regarding subjective ratings of target stimuli, it is expected that the affective ratings depend on motivational state. In a hungry state, the eating verbs should be rated as more pleasant and as more arousing compared to a satiated state. There should not be such a specific hunger-modulated change in subjective ratings for the other stimulus classes (neutral verbs, arts and craft verbs).

1.6.3. Attentional blink pattern

Regarding the attentional blink pattern in this study, it is expected that the first target stimulus (T1) will be identified with high probability. Furthermore, it is postulated that identification of T1 will result in a reduction of identification of the second stimulus (T2). For the T2-stimuli, overall lower rates of identification accuracy are expected. The shorter the temporal distance between T1 and T2, the fewer T2-words should be identified. That means, the typical attentional blink pattern (e.g. see Raymond, Shapiro, & Arnell, 1992) is expected to be replicated in this study.

Concerning motivational state and its consequences on the attentional blink pattern, it is expected that participants show enhanced identification accuracy for T2 eating verbs in a hungry state. Eating words should be more arousing in a hungry state; therefore a similar modulation of the AB effect to that of affectively-arousing T2-stimuli is expected (see Keil and Ihssen, 2004). Especially for short SOAs, identification facilitation for T2 eating verbs in a hungry state should be found. In a satiated state, however, no such higher identification rates for eating verbs should be obtained. Moreover, for the second class of T2-stimuli, namely the arts and crafts verbs, there should not be an effect of motivational state. Identification accuracy for arts and craft verbs is expected to be similar both for a hungry state and for a satiated one.

2. Methods

2.1 Preparatory Rating study

In order to select applicable eating verbs which should function as second target (T2) stimuli in the RSVP task, a preparatory rating study was conducted.

2.1.1 Participants

Participants of the preparatory rating study were 34 students (12 male, 22 female) of the University of Konstanz. At the time of testing the students were between 20 to 33 years old. The mean age was 23.0 years (SD = 3.15). All participants were native speakers of German. The subjects were given a chocolate bar for their participation.

2.1.2 Material

The preparatory rating study was conducted with a paper-and-pencil-version of the Self-Assessment-Manikin (SAM)-rating by Bradley and Lang (1994). The SAM consists of two dimensions: one representing the pleasure (valence) dimension, the other one the arousal dimension. Each dimension is displayed on a continuous 9-point scale as graphic symbols in the form of little manikins (view Figure 2). The subject can place an ‘x’ over any of the five figures in each scale, or between any two figures, which results in the 9-point rating scale for each dimension. The pleasure dimension SAM ranges from a frowning, unhappy figure to a smiling, happy figure. For the arousal dimension, SAM ranges from a relaxed, sleepy figure to an exited, wide-eyed figure. These pictorial scales can be quantified and encoded by allocating 1 and 9 to the extreme values (valence scale: 1 = unpleasant, 9 = pleasant; arousal scale: 1 = calm, 9 = aroused).The SAM instrument largely culture-free, and can be rapidly administered.

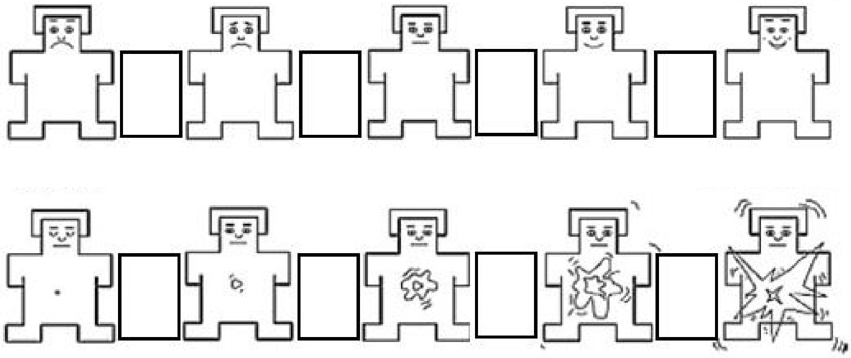

Figure 2: The Self-Assessment-Manikin (SAM) used to rate the affective dimensions of valence (top row) and arousal (bottom row) by Bradley and Lang (1994).

The stimulus material comprised 50 German verbs all describing the activity of consuming food. These eating verbs were chosen from the German dictionary “Duden. Deutsches Universalwörterbuch.” (Mannheim, 2001) and from a linguistic verb book “Deutsche Verben. Eine sprachanalytische Untersuchung des Deutschen Verbwortschatzes” (Ballmer, Brennenstuhl, 1986). A list of the 50 German verbs can be found in Appendix 1.

2.1.3 Procedure

Participants were given a written instruction of the SAM rating and were given the opportunity to ask questions. They completed the SAM ratings for a pool of 50 verbs in a calm room. Testing took 10-15 minutes depending on the individual subject’s speed.

2.1.4 Results of the Preparatory Rating study

The 50 eating verbs showed, similar to affective verbs, a broad range of variation both for the valence dimension and the arousal dimension. The range in valence reached from 2.17 (“reinstopfen“; corresponds approximately to “to stuff oneself”) to 8.35 (“genießen”; “to savour”). Arousal ratings ranged from 2.91 (“ernähren”; “to feed”) to 6.17 (“verschlucken“; „to choke on something“).

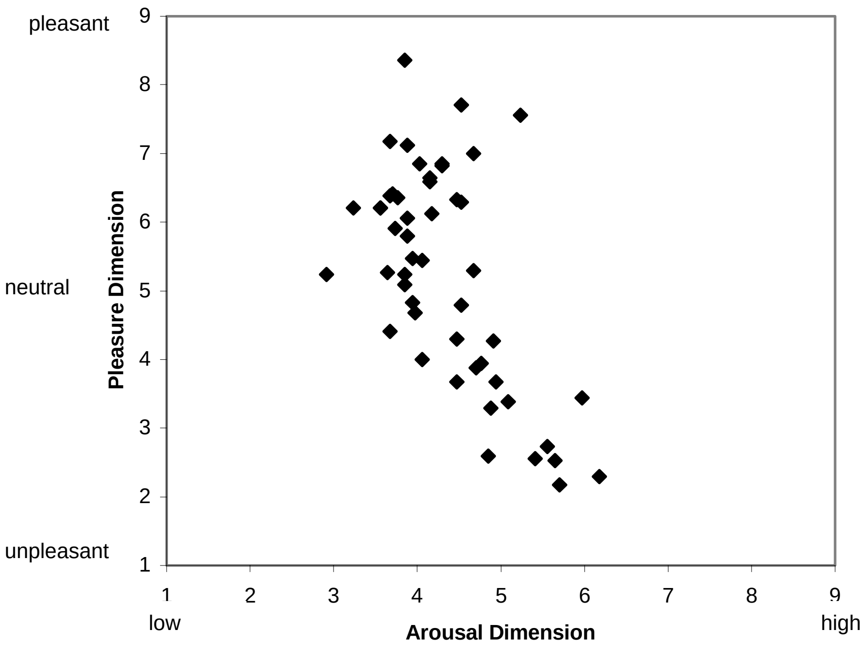

Figure 3: Two-dimensional space for 50 German eating-relevant verbs defined by each word’s arousal and pleasure rating. Means obtained from 34 participants are shown for each verb.

The means obtained from the 34 participants can be plotted in a two-dimensional affective space defined by each word's mean arousal and valence rating (see Figure 3). The verbs showed a distribution that is similar to distributions of affective pictures and affective verbs (Lang, Greenwald, Bradley & Hamm, 1993) (Keil & Ihssen, 2004).

2.2 Behavioural Attentional Blink Study

2.2.1 Participants

Participants of the behavioural attentional blink study were 20 (10 male, 10 female) healthy students of the University of Konstanz. At the time of testing the students were between 18 to 34 years old. The mean age was 23.3 years (SD = 3.73), their mean body mass index (BMI) was 21.84 (SD = 1.49). All participants were native speakers of German. Participants had normal or corrected-to-normal vision and were given either a financial bonus of € 15.00 or class credits. With the aid of placards and flyers at the University of Konstanz students' interest for the study was attracted. Firstly, interested students were contacted via telephone. In a standardised interview it was screened whether the interested person matched the required criteria for the study (view Figure 4). (A copy of the screening interview can be found in Appendix 2). The purpose of these criteria was to exclude factors which are prejudicial to the physical hungry state. Therefore, smokers, extremely under- or overweight persons, persons who regularly diet, persons with current serious health problems such as epilepsy, diabetes mellitus or thyroid diseases, and persons with eating disorders were excluded from the study. Further, it was made sure participants were currently not taking any medication.

Required subject criteria for the behavioural attentional blink study
Body-Mass-Index (BMI) between 19.5 and 25.5
Age between 18 and 35 years
No Metabolic Disorders (e.g. Diabetes mellitus, hypo- or hyperthyroidism)
No Smokers
No severe current diseases
No previous history of eating disorders or excessive dieting
No "Restrained Eaters"
No Psychopathology (especially eating disorders and phobias)

Figure 4: List of the required subject criteria for the behavioural attentional blink study.

2.2.2 Stimulus Material

From the pool of 50 eating verbs examined in the preparatory rating study, 29 neutrally rated eating verbs were selected to function as one class of second target (T2) stimuli in the RSVP task. From the neutrally rated eating verbs only 29 neutrally rated eating verbs were selected, because only these 29 verbs fitted the required linguistic criteria (see below). Examples for these neutrally rated eating verbs are “essen”, “speisen”, “kauen” (“to eat”, “to dine”, “to chew”, respectively). Mean SAM rating scores of the preparatory rating study for eating verbs are shown in Table 1.

Table 1: Means and Standard Deviations of Arousal and Pleasure Ratings Obtained in the Preparatory Rating Study for the pool of 50 eating-relevant verbs.

	Arousal rating		**Pleasure rating**	
Eating verbs	*M*	*SD*	*M*	*SD*
Pleasant (N=6)	4.30	0.60	7.48	0.50
Neutral (N=31)	3.98	0.42	5.68	0.84
Unpleasant (N=13)	5.24	0.53	3.09	0.62

The second class of T2 stimuli contained neutral arts and crafts verbs (e.g. “hämmern, sägen, schnitzen”; “to hammer, to saw, to carve”, respectively). The neutral arts and crafts verbs were selected from the linguistic verb book “Deutsche Verben. Eine sprachanalytische Untersuchung des Deutschen Verbwortschatzes” (Ballmer, Brennenstuhl, 1986) and from a previous attentional blink study (Ihssen, 2003). In this study by Ihssen (2003) neutral verbs were used as T1s and distractors, neutral verbs as well as affectively arousing (pleasant and unpleasant) verbs were utilised as T2s.

In addition, T2 verbs of the two different categories (eating, arts and crafts) were selected to be matched of word length (that is number of letters and number of syllables) and word frequency in the German language (see Table 2) using the Mannheim Lemma Frequency from the CELEX database (Baayen, Piepenbrock & Gulikers, 1995) in order to avoid confounding effects with linguistic variables. That is, linguistic criteria should not have an effect on the identification accuracy of the target verbs in the RSVP paradigm.

Table 2: Linguistic Parameters for T2 Categories, T1 Verbs, and Distractor Verbs.

	No. of Letters		**No. of syllables**		**Word frequency**	
Stimulus category	*M*	*SD*	*M*	*SD*	*M*	*SE*
T2 eating	8.03	1.54	2.37	0.56	51.10	18.24
T2 arts and crafts	7.89	1.63	2.37	0.72	50.93	28.25
T1 verbs	8.17	1.67	2.51	0.63	53.20	9.59
Distractors	8.02	2.18	2.68	0.81	52.42	7.72

Note. T2 = second target; T1 = first target. For distractor verbs, n = 50; for T2 categories and T1 verbs, n = 29.

Furthermore, a set of 29 first target (T1) stimuli verbs was selected from a pool of neutral German verbs which was constructed in the previous study by Ihssen (2003). Examples for these neutrally rated verbs are “blättern”, “auflisten”, “speichern” (“to browse”, “to list”, “to store”, respectively). Finally, 50 non-rated neutral distractor verbs, which are to be shown before, in-between and after the target stimuli, were selected from a pool of distractor words of the earlier study by Ihssen (2003). Verbs such as “parken”, “senden”, “folgern” (“to park”, “to send”, to conclude”, respectively) are examples of the neutral distractors.

Although a matching in letters, number of syllables, and word frequency is primarily important for the T2 verb categories, the selected T1 verbs and distractor verbs were also matched regarding to word length and word frequency so that they were similar to the T2 stimuli. (According to the hypotheses, possible differences in the identification accuracy should appear between the T2 eating verbs and the T2 arts and crafts verbs due to varied motivational relevance (hungry state vs. satiated state), not due to differences in linguistic criteria.) A list of all employed T1 and T2 verbs can be found in Appendix 9.

All words were presented in lower case letters using a Times New Roman 28 font, which subtended a visual angle of 0.67°. Distractor words were shown in white colour on a black screen, whereas target words were displayed in green colour on a black screen.

Stimulus Onset Asynchrony (SOA) between the stimuli was 115 ms (49 ms presentation of a word, followed by a black blank screen for 66 ms). Hence, 8.7 words per second were presented, resulting in an 8.7-Hz RSVP paradigm.

2.2.3 Telephone Screening and Pre-Experimental Session

The participants were recruited and contacted by telephone in order to carry out the screening interview. If the subject matched the required criteria of the study, an appointment with the interested person for the pre-experimental session (S0) was arranged. The purpose of this pre-experimental session was to explain precisely the procedure of the experimental study. After being informed about the course of events of the experimental study, the persons who were willing to participate signed an informed consent form. Furthermore, the interested participant gave a few personal details (see Appendix 3) and made an appointment for the first experimental session. Additionally, the participants completed the trait-version of the State Trait Anxiety Inventory (STAI, Muthny, 1997). In the laboratory, participants were shown the experimental chamber and stimulus computer.

At the end of the pre-experimental session, the participants received the „Inventar zum Essverhalten und Gewichtsproblemen“(IEG, Diehl & Staufenbiel, 1999), an inventory about eating behaviour and weight problems, and an instruction for the preparation of the first experimental session to take home. The instruction included directives on the preparation of the first experimental session (e.g. permitted foods and drinks etc.) and a form of an “eating diary“ which was to be used as a record of the food intake in the 24 hours prior to the experimental session (see Appendix 4 and Appendix 5). By the use of such an eating diary the undertaken commitment to the experimental study was emphasised. All foods and drinks which were consumed 24 hours prior to the scheduled experimental session had to be noted down in this form. The IEG was used in order to identify persons with specific (problematic) characteristics in their eating behaviour. In particular, during the analysis of the IEG, it was ensured all participants scored within the normal range on the following subscales of the IEG: „Essen und Gewicht als Problem“(eating and weight as a problem), „Zügelung des Essens“ (restraint eating), “Belastung durch Übergewicht” (stress due to overweight), “Angst vor Gewichtszunahme” (fear of gaining weight), “Unzufriedenheit mit der Figur” (discontent with one’s own figure), “Bulimie (Ess-/Fressanfälle)” (bulimia (binge eating behaviour)). Table 3 gives an overview of the consecutive experimental episodes.

Table 3: List of the consecutive experimental episodes.

Episode of the Experimental Study	Subject Matter of the Episode
1. Subject recruitment	placards and flyers
2. Telephone screening interview	required criteria, appointment for the preliminary talk
3. Pre-Experimental Session (S0)	information about the study, informed consent form, instruction, IEG questionnaire
4. First experimental session (S1)	behavioural experiment, several questionnaires
5. Second experimental session (S2)	behavioural experiment, several questionnaires

2.2.4 First and Second Experimental Session

The behavioural attentional blink experiments were performed with 20 participants. The participants attended the same experiment twice. The critical difference between the two experimental sessions was the following: the participants came to one experimental session in a hungry state, and they arrived in a satiated state to the other experimental session. Both of the experimental sessions proceeded on the same day of the week and on the same time of day in order to keep possible effects of time of day and position of day in the week constant. The experimental sessions were conducted from Monday to Friday, either at 2:00 p.m. or at 4:00

p.m. The conditions “hungry-satiated” or “satiated-hungry” were balanced over the all participants. Table 4 shows an overview of the chain of events in both experimental sessions.

Table 4: Scheme of an experimental session.

Sequence of Events in Experimental Sessions S1 and S2
Subject Arrival Subject Returns Eating Diary (S1, S2) Subject Returns IEG-questionnaire (S1 only)
Hunger and Appetite Rating “pre“
Completion of the MDBF-questionnaire
Completion of the questionnaires STAI-state and BDI
Blood Ketone Testing
RSVP Session: Behavioural Attentional Blink Experiment
SAM-Rating of all Target-Stimuli
Hunger and Appetite Rating “post“

To the first experimental session (S1), participants arrived accordingly the agreed order of experimental sessions either hungry or satiated. Firstly, the participants were welcomed upon arrival at the anteroom of the laboratory; they delivered their filled-out eating diary and IEG questionnaire. Next, the participants rated their present hunger and appetite on a multilevel scale, and completed the MDBF (“Mehrdimensionaler Befindlichkeitsbogen”, Steyer R., Notz P., Schwenkmezger P., Eid M., 1994; a multidimensional questionnaire assessing mood). (The MDBF was given to find out whether motivational state influences mood.) Subsequently, the participants completed the State-Version of the STAI and the BDI (Beck Depression Inventory, Hautzinger, 1991). (Participants had to complete the STAI and the BDI in order to find out if any participants showed extreme values concerning these questionnaires.) Thereupon, a drop of blood was taken to measure the ketone concentration. Afterwards, the participants entered the sound-attenuated, dimly lit experimental chamber, and were seated comfortably in an armchair. A standardised written instruction was read to the participants and the opportunity to ask questions was given to the participants (a copy of the instruction can be found in Appendix 7). The experiment started with five test trials to demonstrate the procedure and to ensure that all participants understood the task correctly. The experiment was divided into two blocks, with a break between these two blocks. Depending on the participants’ speed, one experimental block took about 10 to 15 minutes; the entire experiment with the break took about 30 to 35 minutes.

After the computer experiment (i.e. the RSVP session) was completed, the participants were asked to complete subjective ratings regarding pleasure and arousal for each T1 and T2 verb by using a paper-and-pencil version of the SAM (a copy of the instruction for the SAM rating can be found in Appendix 8).

Moreover, participants rated their present hunger and appetite once again. Finally, the written instructions for the second experimental session were handed out to the participants. The second experimental session took place exactly one week after the first one, at the same time of the day. The instructions varied depending on the experimental condition (hungry or satiated) and contained the eating diary form.

One week later, the participants arrived again at the laboratory for the second experimental session. The chain of events of the second experimental session (S2) was identical to the first one (S1). Additionally, after completion of the experimental session, the participants were asked to report their opinion about the experiment and any noticeable problems they had. Finally, the participants were debriefed about the aim of the experiment and were given a financial bonus or class credits.

2.2.5 Stimulus Presentation and Design of the Attentional Blink Experiment

Stimuli were presented on a 22 inch computer screen (ViewSonic, P225f) with a retrace frequency of 60 Hz, located at a 85.5-cm distance from the observer. Presentation and response registration were controlled by a script written with Presentation software (Neurobehavioral Systems Inc., Albany). The experimental session started with five test trials to demonstrate the procedure and ensure that all individuals understood the task correctly.

The schematic of one trail is shown in Figure 5. Responses were recorded during 174 trials organized into two blocks, with each trial containing the following events: A blank screen appeared for 1000 ms. Then, a stream of verbs at a frequency of 8.7 Hz was displayed at the center of the screen. The 8.7-Hz RSVP was effected by alternation the presentation of a word for 49 ms, followed by a blank black screen for 66 ms. That is, Stimulus Onset Asynchrony (SOA) between the stimuli was 115 ms (49 ms presentation of a word, followed by a black blank screen for 66 ms).

The words were shown using a Times New Roman 28 font, which subtended a vertical visual angle of 0.67°. Distractor words were shown in white colour, whereas target words T1 and T2 were displayed in green colour. Target words were isoluminant with respect to the distractor words (8.6 cd/m²). Following the initial black screen, a baseline RSVP of neutral words was displayed, with duration varying randomly between 5 and 25 words (i.e. about 575-2875 ms). This baseline RSVP was followed by the T1 neutral verb, a varying number of neutral distractors, and the T2, followed by 10 distractors. T1-T2 intervals varied to contain one, three, or five intervening distractor verbs (i.e. Lag 2, Lag 4; or Lag 6). Accordingly, SOAs were 230 ms (Lag 2), 460 ms (Lag 4), and 690 ms (Lag 6).

The 174 trials were composed of the combination of the three lags (the three SOAs) and the two word categories (arts and crafts verbs, eating verbs), each word category containing 29 words (3 lags x 2 word categories = 6; 6 x 29 = 174). Thus, there were 29 trials for each combination of SOAs (Lag 2, 4, 6 or SOA 230, 460, 690, respectively) and word category (arts and crafts verbs, eating verbs). By name, the six conditions were: “Lag 2 arts and crafts”, “Lag 2 eating”, “Lag 4 arts and crafts”, “Lag 4 eating”, “Lag 6 arts and crafts”, and “Lag 6 eating”.

The occurrence of these six conditions was randomised with the constraint that immediate repetition of the same condition could not occur. That is, the same randomised vector containing the six conditions was determined once for all participants. However, the order of verbs within each of the six conditions was newly randomized every time at the beginning of an experimental session.

At the end of each trial, participants were asked via a message on the computer screen to report the green words by typing in the words on a computer keyboard. Participants started the subsequent trial after completing the report, via keyboard feedback (press of the return key).

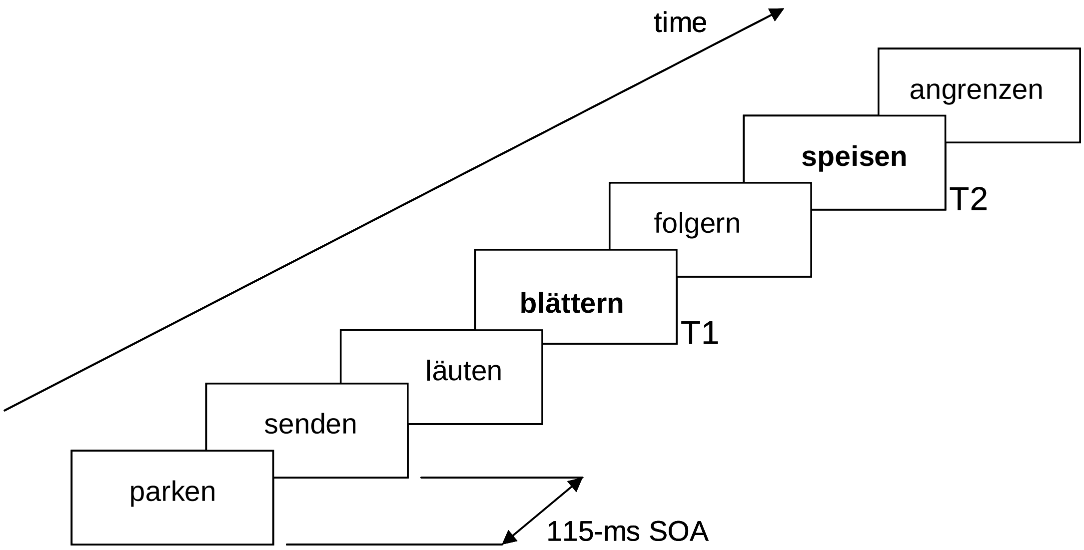

Figure 5: Schematic of one trial of the rapid serial visual presentation task. Target verbs (bold) were shown in green, with second targets (T2s) varying in terms of word category and stimulus onset asynchrony (SOA). parken = to park; senden = to send; läuten = to ring; blättern = to browse; folgern = to conclude; speisen = to dine; angrenzen = to border; T1 = first target.

2.2.6 Blood Ketone Testing

When the human organism is in a prolonged fasting phase, the human body burns fat from the stored body fat in order to ensure sufficient energy supply. The increased usage of body fat is accompanied by the increase of the concentration of ketone molecules in the bloodstream (Biesalski, 1995) which can be detected with a measuring device. It is not possible to verify a complete abdication of food; however, it is possible to detect a broad restriction of food intake. This is also effective for relative short periods of time as the 24-hour-fasting phase (see Lüthy et al., 2003). Blood ketone testing is preferred over urine ketone testing as a more reliable method of diagnosing. Before starting the experiments, the experimenter was trained by medical staff to carry out the blood ketone testing properly.

For taking of a blood sample in order to measure the ketone concentration, sterile expendable lancets „Haemolance Plus" of the HaeMedic company (Munka Ljungby, Schweden) and disposable gloves were used. The concentration of the blood-ketone-body ß-Hydroxybutyrat (ß-OHB) was determined with a "MediSense Precision Xtra" measuring device by the firm "Abbott Diabetes Care" (Abbott GmbH & Co. KG, Wiesbaden). This measuring device is an instrument for measuring the blood sugar level in diabetes patients. Moreover, it offers the opportunity to measure the concentration of the ketone body ß-Hydroxybutyrat with the aid of special test strips without the necessity of a costly laboratory test. Simply one drop of blood is needed. The blood sample was taken from the little finger of the non-dominant hand of the participant. The minimal blood flow was stanched with cotton pads, and an adhesive plaster was applied. All waste was disposed immediately after testing in a bin which was especially provided for this purpose.

2.2.7 Data Analysis

For this study, which displays a repeated measure design for all questions, a level of significance of $\alpha = 0.05$ was determined. If required, significance tests were ε-corrected according to the Greenhouse-Geisser-method (Greenhouse & Geisser, 1959).

Concerning the questionnaires STAI-State and BDI, paired Student's *t* tests were performed in order to compare the difference between means obtained for the first and second experimental session (S1 and S2).

Regarding the MDBF-questionnaire, a paired Student's *t* test was performed for each of the three subscales in order to compare means obtained for the satiated and the hungry experimental session. That is, differences in means of “GS” (Gute-Schlechte Stimmung), “WM” (Wachheit-Müdigkeit), and “RU” (Ruhe-Unruhe) were compared.

The hunger ratings were analysed with a repeated measure ANOVA (analysis of variance) with the factors STATE (2; satiated, hungry) and TIME-OF-MEASUREMENT (2; pre, post; that is before and after the behavioural AB experiment, respectively) as the within-subjects factors. Likewise, the appetite ratings were analysed with a repeated measure ANOVA with the factors STATE (2; satiated, hungry) and TIME-OF-MEASUREMENT (2; pre, post) as the within-subjects factors.

Concerning the blood ketone level, a paired Student’s *t* test was performed in order to compare the difference between means of blood ketone concentration obtained for the satiated and hungry experimental session.

The magnitude of the AB effect and its possible motivational modulation was operationalised via the accuracy of identification of the target words as the dependent variable. Accuracy of identification was measured as the percentage of correct responses for each of the six experimental conditions (3 lags x 2 word categories). The order of the two verbs (T1 and T2) reported was taken into account when scoring correctness, in order to be labelled as correct, a response was required to reflect the temporal position (T1, T2) in the RSVP stream. Furthermore, only trials with correct T1 reports were considered for determining T2 accuracy. Firstly, a repeated measure ANOVA with the within-subject factors STATE (satiated, hungry) and TARGET-POSITION (2; T1, T2) was computed to test the global effectiveness of the AB effect. Subsequently, *F* values were calculated using ANOVAs with the within-subjects factors of STATE (2; satiated, hungry), WORD-CATEGORY (2; arts and craft, eating), and LAG (3; Lag 2 = 230ms SOA, Lag 4 = 460 ms SOA, Lag 6 = 690 ms SOA) for T1 and T2 responses separately. The typical attentional blink pattern – the increase in second target (T2) identification accuracy with growing T1-T2-distance – was tested with a linear trend test. Furthermore, in all computed ANOVAs the between-subject factor SEX (2; male, female) was tested.

Regarding SAM ratings, mean subjective ratings for each target category (T1 neutral, T2 arts and crafts, T2 eating) and participant were determined. The analysis of the dimensions arousal and pleasure was performed in two separate repeated measure ANOVAs with the factors STATE (2; satiated, hungry) and STIMULUS-CATEGORY (3; T1 neutral, T2 arts and craft, T2 eating). Additionally, the between-subject factor SEX (2; male, female) was tested. The significant *F*s from the overall ANOVAs were specified with planned comparisons using *Bonferroni t* tests (see Howell, 2002).

Data of one male participant were rejected because for this participant T1 accuracy was more than three standard deviations below mean T1 performance. Bad T1 performance indicates a lack of compliance; it is common practise to exclude participants showing poor T1 accuracy (e.g. Jolicoeur, 1998; Nieuwenstein et al., 2005). Therefore, analyses were performed with the data of the 19 remaining participants.

3. Results

3.1 Questionaires

3.1.1 STAIt, STAIs, BDI

The analysis of the questionnaires STAI and BDI (STAI-trait version for the pre-experimental session (S0), as well as the STAI-state version and the BDI for both experimental sessions S1 and S2) did not show extreme values altogether. Nevertheless, three subjects showed a value of 14 in the BDI. Two subjects showed the value 14 for both the hungry and the satiated condition. One subject only showed a BDI value of 14 in the satiated condition, for the hungry condition, this subject displayed a value of 13. All other subjects scored below 12 on the BDI scale. (In the BDI, values ranging from 0 to 11 stand for no depression, values ranging from 12 to 19 stand for mild depression, 20 to 25: moderate depression, and from 26 on: intense depression. Values from 21 upwards are regarded as clinically relevant.) The means of the STAI-state did not change significantly between experimental sessions ($t(18) = 0.32$; $p = 0.75$). The mean BDI values only dropped lightly but statistically significant from the first to the second experimental session ($t(18) = 2.31$; $p < 0.05$). Table 5 shows characteristic data of these questionnaires.

Table 5: Key data of the questionnaires STAI and BDI.

	STAI-trait *S0*	**STAI-state *S1***	**STAI-state *S2***	**BDI *S1***	**BDI *S2***
min	29	27	25	0	0
max	47	55	52	14	14
M	37.42	34.74	35.42	4.26	3.58
SD	5.29	6.58	7.49	4.96	5.08
n	19	19	19	19	19

3.1.2 IEG

The analysis of the IEG (n = 19), especially the analysis of the subscales “eating and weight as a problem”, “restraint eating”, “stress due to overweight”, “fear of gaining weight”, “discontent with one’s own figure”, and “bulimia (binge eating behaviour)”did not indicate problematic eating behaviour of particular participants.

3.1.3 MDBF

The MDBF was completed for both experimental sessions (hungry and satiated state), before the behavioural attentional blink experiment. The means of the three MDBF-subscales were compared with t-Tests for dependent samples. (The three subscales of the MDBF are: “GS” (Gute-Schlechte Stimmung), “WM” (Wachheit-Müdigkeit), “RU” (Ruhe-Unruhe); that is “Good-Bad-Mood”, “Awakeness-Sleepyness”, “Calmness-Restlessness” respectively.) The *t* test showed no differences between the satiated and hungry state for all three subscales of the MDBF (see also Figure 6). That is, the *t* test showed no difference between satiated and hungry state for the subscale “GS” ($t(18) = 1.29$; $p = 0.21$). Furthermore, there was neither a difference in the subscale “WM” ($t(18) = 0.62$; $p = 0.54$) nor was there a difference for the subscale “RU” ($t(18) = 1.33$; $p = 0.20$).

Table 6: Means and standard deviations of the MDBF-Subscales GS, WM, and RU for both experimental sessions, that is in a satiated or hungry state.

	Satiated			**Hungry**		
	GS	***WM***	***RU***	***GS***	***WM***	***RU***
M	16.89	15.37	16.32	15.53	14.84	15.57
SD	2.96	3.15	2.63	3.27	2.99	3.27
n	19	19	19	19	19	19

For the employed “MDBF-Kurzform A”, possible scores of all three subscales range from 4 to 20. In the experiment, these MDBF-ratings showed that participants scored relatively high on all three subscales, means for the three subscales ranged from 14.84 to 16.89 (see Table 6). That means participants felt well on both the satiated and the hungry experimental session, although they reported feeling very hungry on the hungry experimental session. In more details, high values on the subscale “GS” suggest a positive mood, the person is happy and contented. High values on the subscale “WM” indicate awake and rested persons. For the subscale “RU” high values show that the person currently feels calm in contrast to low values indicating a person is nervous.

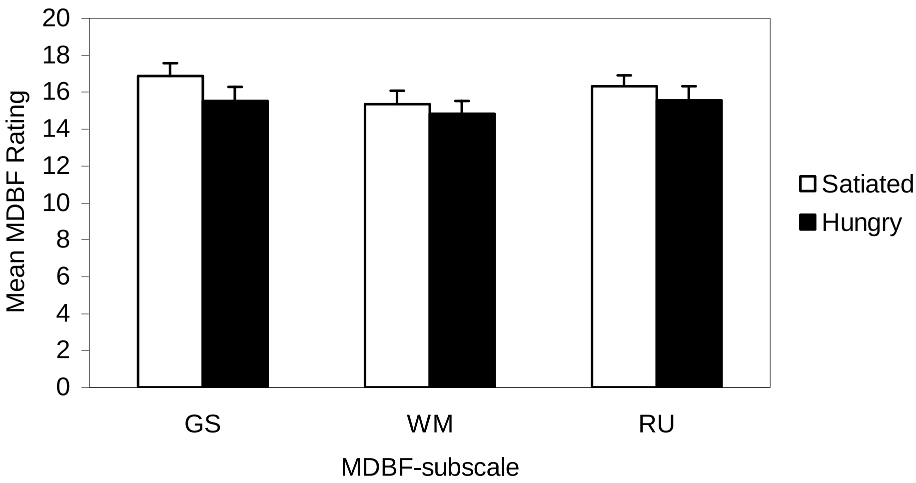

Figure 6: Means of the MDBF-Subscales GS, WM, and RU for both experimental sessions (satiated or hungry state). Error bars indicate standard errors.

3.2 Hunger & Appetite Ratings

Hunger and appetite ratings were ascertained for both experimental sessions, before and after the behavioural attentional blink experiment. The analysis of the hunger ratings using a repeated measures ANOVA showed significant main effects of the factors STATE (hungry vs. satiated) and TIME-OF-MEASUREMENT (pre vs. post). The main effects can be interpreted as follows: the participants rated their feeling of hunger as stronger in the hungry state than in the satiated state ($F_{STATE}(1, 18) = 345.73$; $p < 0.001$). After the behavioural experiment the participants reported overall more hunger than before the experiment ($F_{TIME\text{-}OF\text{-}MEASUREMENT}(1, 18) = 27.38$; $p < 0.001$). Table 7 shows the means, standard deviations of the ratings. Figure 7 displays this information graphically.

Table 7: Means and standard deviations of the subjective ratings of HUNGER [0-8] before and after the behavioural experiment in a satiated or hungry state.

	Satiated		**Hungry**	
	pre	***post***	***pre***	***post***
M	0.95	2.11	6.63	7.21
SD	0.85	1.82	1.34	0.71
n	19	19	19	19

The factors STATE and TIME-OF-MEASUREMENT did not show a significant interaction ($F_{STATE*TIME-OF-MEASUREMENT}$ (1, 18) = 1.14; p = 0.30).

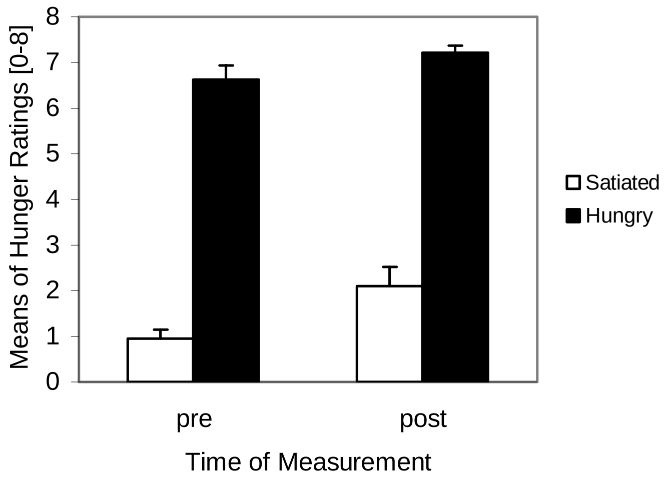

Figure 7: Means and standard errors of the subjective ratings of HUNGER [0-8] before and after the behavioural experiment in a satiated or hungry state.

In addition to the rating of their feeling of hunger the review of the eating diaries of the participants showed that the participants did not consummate food prior to the hungry experimental session whereas to the satiated experimental session plenty of food was consummated.

The analysis of the appetite ratings using a repeated measure ANOVA showed similar results as the analysis of the hunger ratings. For appetite, there are significant main effects of the factors STATE (F_{STATE}(1, 18) = 192.60; p < 0.001) and TIME-OF-MEASUREMENT ($F_{TIME-OF-MEASUREMENT}$(1, 18) = 16.43; p < 0.001). Table 8 shows the means, standard deviations of the ratings. Figure 8 displays this information graphically. The direction of the effects is analogue to the hunger ratings: higher mean values for appetite in the hungry state and higher means for appetite after the experimental session. Likewise, there was no interaction of the factors STATE and TIME-OF-MEASUREMENT ($F_{STATE*TIME-OF-MEASUREMENT}$ (1, 18) = 1.16; p = 0.30).

Table 8: Means and standard deviations of the subjective ratings of APPETITE [0-10] before and after the behavioural experiment in a satiated or hungry state.

	Satiated		**Hungry**	
	pre	***post***	***pre***	***post***
M	1.84	3.16	7.79	8.42
SD	0.90	1.95	2.15	1.50
n	19	19	19	19

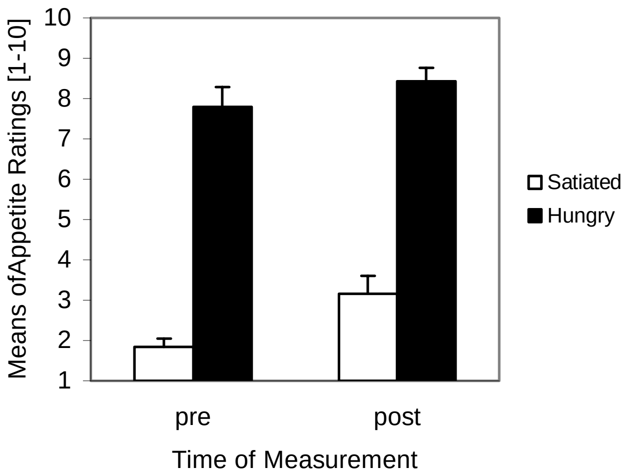

Figure 8: Means and standard errors of the subjective ratings of APPETITE [0-10] before and after the behavioural experiment in a satiated or hungry state.

3.3 Ketone

In addition to the subjective ratings of hunger and appetite as well as the control of the eating diaries the food deprivation was controlled objectively via measuring of the blood ketone level. The means of both measurement groups (see Table 9 and Figure 9) was compared with a *t* test for dependent samples.

As shown in Figure 9, for the hungry state, the participants' blood ketone level was higher than for the satiated state ($t(17) = 5.66$; $p < 0.001$).

The ketone level of two participants did not rise but stayed constant. The data of these two participants were not excluded from the analysis because they assured believably having fasted for 24 hours.

Table 9: Results of blood ketone testing for both experimental sessions.

	Satiated	**Hungry**
M	0.02	0.27
SD	0.04	0.20
n[1]	17	17

[1] For two participants, it was not possible to take a sufficient blood sample (the drop of blood was too little).

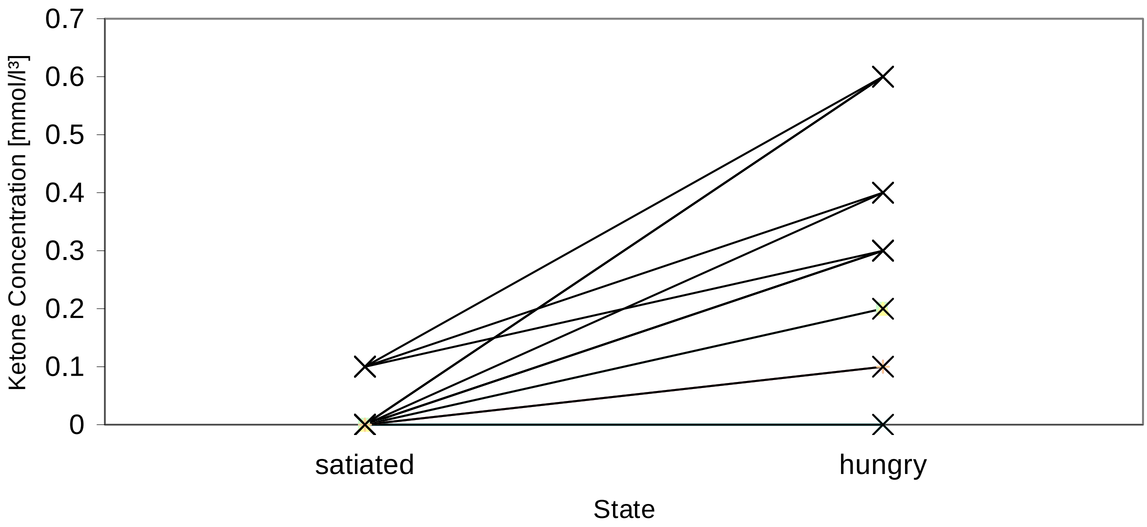

Figure 9: Measured blood ketone concentration of the participants in a satiated and in a hungry state.

3.4 SAM Ratings

Participants had to rate all target stimuli (that is all T1 and T2) after the behavioural attentional blink experiment using the SAM. Table 10 gives an overview of the SAM arousal ratings of participants. Results of the SAM pleasure ratings are shown in Table 11.

Table 10: Means and standard deviations of the self-rated arousal of all target stimuli for both experimental sessions (satiated or hungry state).

	Arousal					
	Satiated			***Hungry***		
	T1 neutral	***T2 eating***	***T2 arts & craft***	***T1 neutral***	***T2 eating***	***T2 arts & craft***
M	3.32	3.74	3.66	3.35	4.41	3.63
SD	1.84	1.24	1.69	1.84	1.57	1.69
n	19	19	19	19	19	19

SAM arousal ratings did not show an effect of STATE (F_{STATE} (1, 18) = 3.21; p = 0.09). There was a significant main effect of STIMULUS-CATEGORY ($F_{\text{STIMULUS-CATEGORY}}$ (2, 36) = 4.19; $p < 0.05$; $\varepsilon = 0.65$) for SAM arousal ratings. However, post-hoc tests with Bonferroni-correction showed that the T2 eating verbs were not significantly more arousing than the neutral T1 verbs (p = 0.15) and not siginificantly more arousing than the T2 arts and craft verbs (p = 0.74).

Furthermore, SAM arousal ratings showed an interaction of STATE and STIMULUS-CATEGORY ($F_{STATE*STIMULUS\text{-}CATEGORY}$ (2, 36) = 9.40; $p < 0.001$; $\varepsilon = 0.61$) reflecting a higher mean arousal score for the T2 eating verbs in a hungry state (*M* = 4.41) than in a satiated state (*M* = 3.74). Means of the T1 neutral verbs (satiated state: *M* = 3.32; hungry state: *M* = 3.35) and means of the T2 arts and craft words (satiated state: *M* = 3.66; hungry state: *M* = 3.63) did not differ concerning state (see also Figure 10). This hunger-modulated arousal effect for the eating verbs only was evidenced in post-hoc testing with Bonferroni-correction: T2 eating verbs were significantly more arousing in a hungry state compared to a satiated one ($p < 0.001$). T2 arts and craft verbs were not more arousing in a hungry state compared to a satiated one ($p = 1.00$). Likewise, T1 neutral verbs were not more arousing in a hungry state as opposed to a satiated one ($p = 1.00$). Finally, for SAM arousal ratings, there were no effects of the between-subjects factor SEX (*F*s < 1).

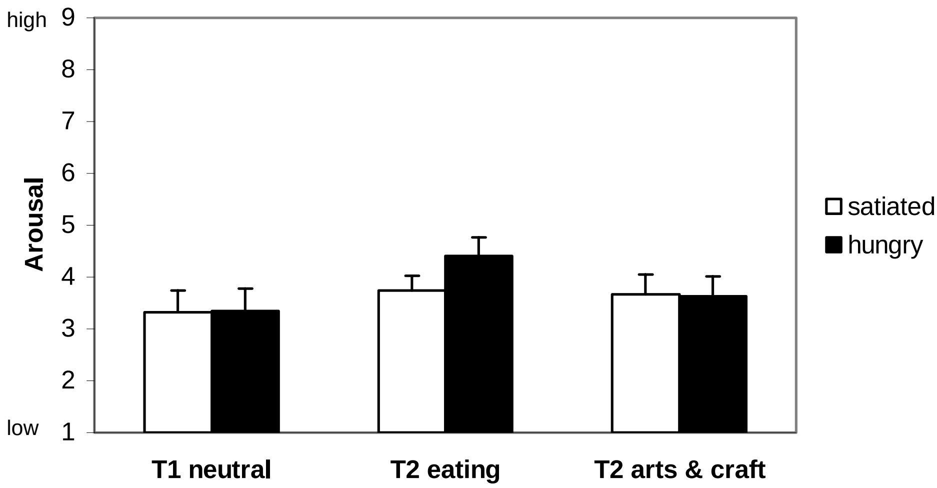

Figure 10: Self-rated arousal as a function of stimulus category for all target stimuli in a satiated or hungry state. Values represent a mean of 19 participants. Error bars indicate standard errors.

Regarding the pleasure dimension, SAM pleasure ratings displayed a significant main effect of STATE (F_{STATE} (1, 18) = 8.47; $p < 0.01$). However, Bonferroni-corrected post-hoc testing did not confirm this effect ($p = 0.11$). SAM pleasure ratings also showed a significant main effect of STIMULUS-CATEGORY ($F_{STIMULUS\text{-}CATEGORY}$ (2, 36) = 57.73; $p < 0.001$; $\varepsilon = 0.80$). Post-hoc tests with Bonferroni-correction showed that the T2 eating verbs were rated as significantly more pleasant than the neutral T1 verbs ($p < 0.001$) and were rated as significantly more pleasant than the T2 arts and craft verbs ($p < 0.001$).

Table 11: Means and standard deviations of the self-rated pleasure of all target stimuli for both experimental sessions (satiated or hungry state).

	Pleasure					
	Satiated			***Hungry***		
	T1 neutral	***T2 eating***	***T2 arts & craft***	***T1 neutral***	***T2 eating***	***T2 arts & craft***
M	5.11	6.14	4.76	5.26	6.59	4.79
SD	0.33	0.61	0.54	0.45	0.89	0.46
n	19	19	19	19	19	19

Furthermore, SAM pleasure ratings showed an interaction of the factors STATE and STIMULUS-CATEGORY ($F_{STATE*STIMULUS\text{-}CATEGORY}(2, 36) = 6.59$; $p < 0.01$; $\varepsilon = 0.68$). Bonferroni-corrected post-hoc tests showed that the T2 eating verbs were rated as significantly more pleasant in a hungry state compared to a satiated one ($p < 0.001$). T2 arts and craft verbs were not rated as more pleasant in a hungry state compared to a satiated one ($p = 1.00$). T1 neutral verbs were also not rated as more pleasant in a hungry state as opposed to a satiated one ($p = 1.00$). Figure 11 pictures the self-rated pleasure as a function of stimulus category and motivational state. Just as for the SAM arousal ratings, for SAM pleasure ratings no effects of the between-subjects factor SEX were found (*F*s < 2).

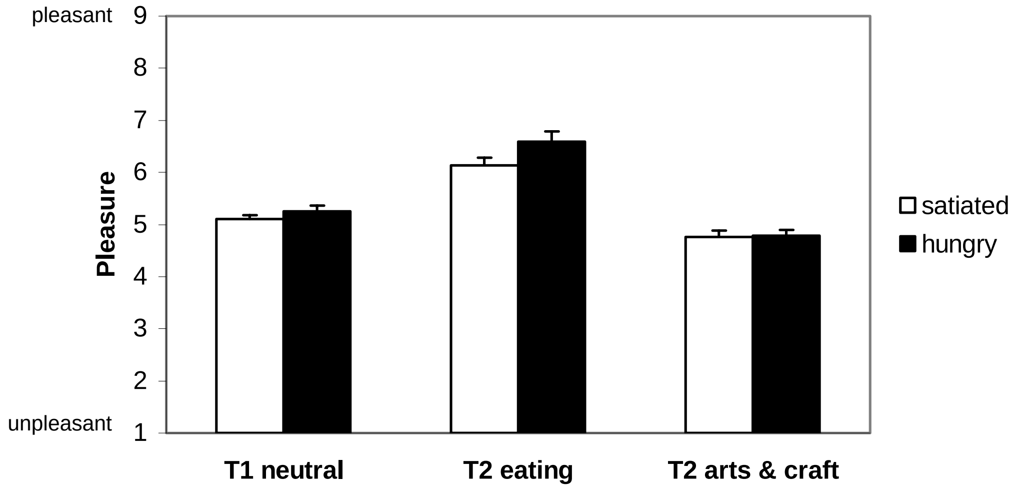

Figure 11: Self-rated pleasure as a function of stimulus category for all target stimuli in a satiated or hungry state. Values represent a mean of 19 participants. Error bars indicate standard errors.

3.5 Behavioural AB Experiment

In general, averaged over all conditions (i.e., across state, lag and word category) the global effectiveness of the AB effect could be demonstrated with a clearly higher identification accuracy for the T1-stimuli (mean percent correct responses = 94.40 %; *SE* = 0.85) compared to T2-stimuli (*M* = 76.47 %; *SE* = 2.37). In an ANOVA with the factors TARGET-POSITION (T1, T2) and STATE (satiated, hungry) this difference showed in a significant main effect of TARGET-POSITION ($F_{TARGET\text{-}POSITION}$ (1, 1, 17) = 94.62; $p < 0.001$). The ANOVA neither showed a main effect of STATE (F_{STATE} (1, 1, 17) = 0.88; p = 0.36) nor an interaction of the factors TARGET-POSITION and STATE ($F_{TARGET\text{-}POSITION*STATE}$ (1, 1, 17) = 0.88; p = 0.36) (see Figure 12). In this analysis of the global effectiveness of the AB, there were no effects of the between-subjects factor SEX (*F*s < 1).

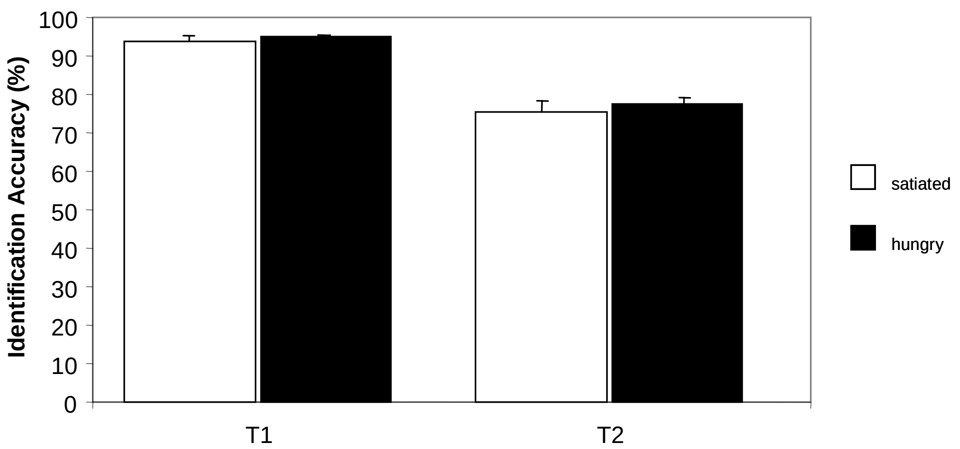

Figure 12: Identification accuracy (mean percent of correct responses) for T1- and T2-words in a satiated and in a hungry state. Error bars indicate standard errors.

For T1-stimuli an ANOVA with the within-subject factors STATE, WORD-CATEGORY and LAG and the between-subject factor SEX was computed. The ANOVA for T1 did not show an effect of STATE, WORD-CATEGORY or LAG (*F*s < 2); see Figure 13 and Figure 14. As mentioned before, the accuracy of T1 reports was high with a mean of 94.40 (*SE* = 0.85) percent correct responses across state, lags and word categories of T2. The ANOVA for T1-stimuli did not show effects of the between-subjects factor SEX (*F*s < 1).

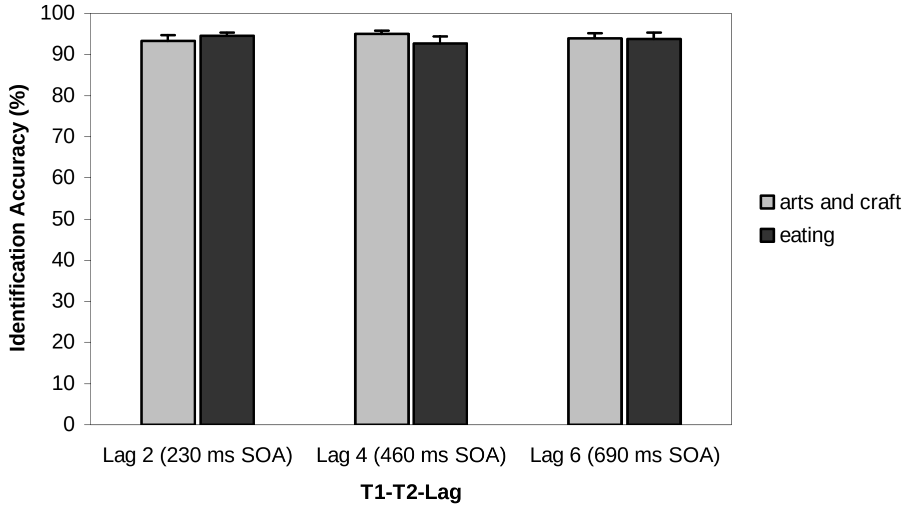

Figure 13: Identification accuracy of T1-stimuli (mean percent of correct responses) as a function of T1-T2-SOAs and word categories in a satiated state. Error bars indicate standard errors.

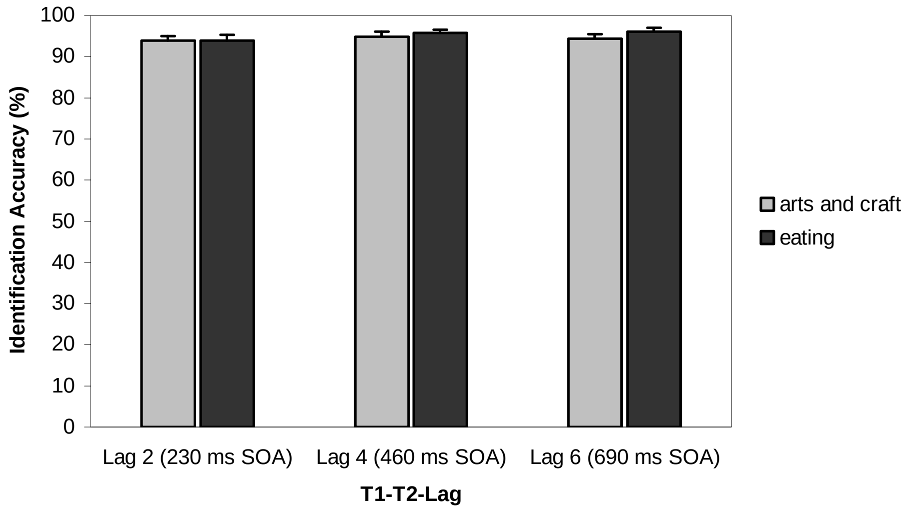

Figure 14: Identification accuracy of T1-stimuli (mean percent of correct responses) as a function of T1-T2-SOAs and word categories in a hungry state. Error bars indicate standard errors.

For T2-stimuli an ANOVA with the within-subject factors STATE, WORD-CATEGORY and LAG and the between-subject factor SEX was computed. As expected, the ANOVA for T2-Stimuli showed sensitivity to the T1-T2-SOA, a main effect of LAG ($F_{LAG}(2, 36) = 94.65$; $p < 0.001$; $\varepsilon = 0.62$), being only slightly impaired for the long SOA of 690 ms (mean percent correct responses = 86.66, *SE* = 1.87). Shorter SOAs displayed an increasing impairment for the 460-ms (*M* = 82.89, *SE* = 2.40) and 230-ms SOAs (*M* = 51.04, *SE* = 4.74). This main effect of LAG (i.e., the AB effect) was supported by a linear trend (F (1, 18) = 99.99; p < 0.001).

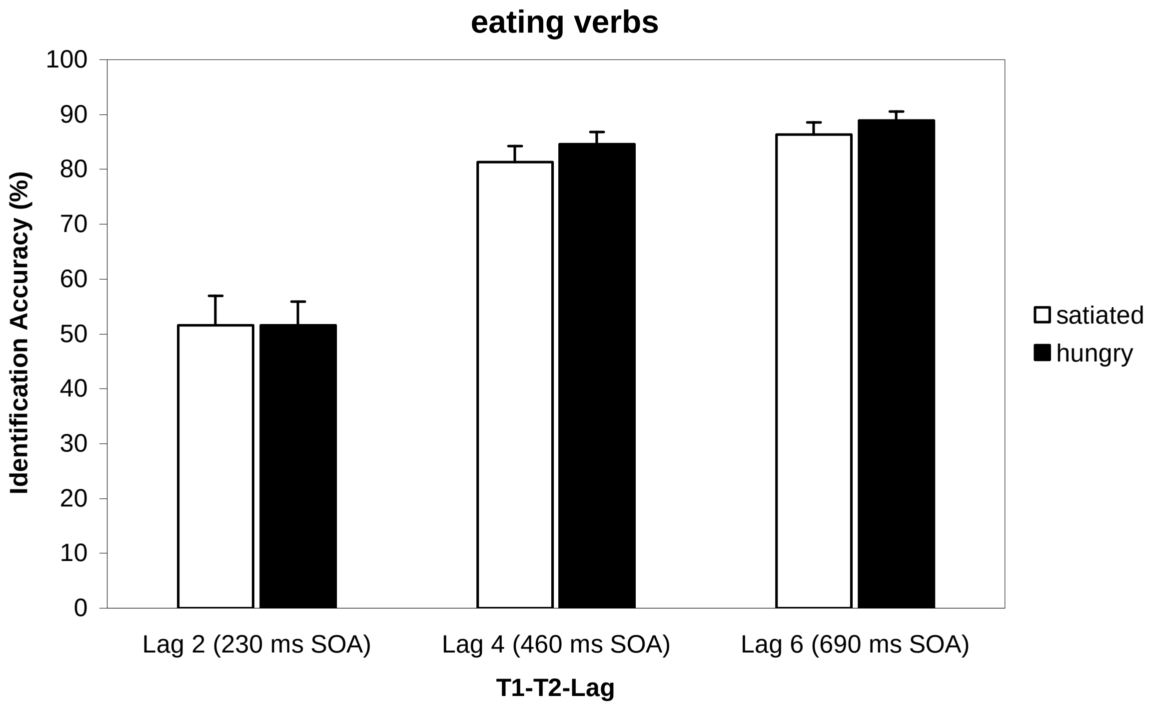

Figure 15: Identification accuracy of T2 eating verbs (mean percent of correct responses) as a function of motivational state (satiated vs. hungry) and T1-T2-SOAs. Error bars indicate standard errors.

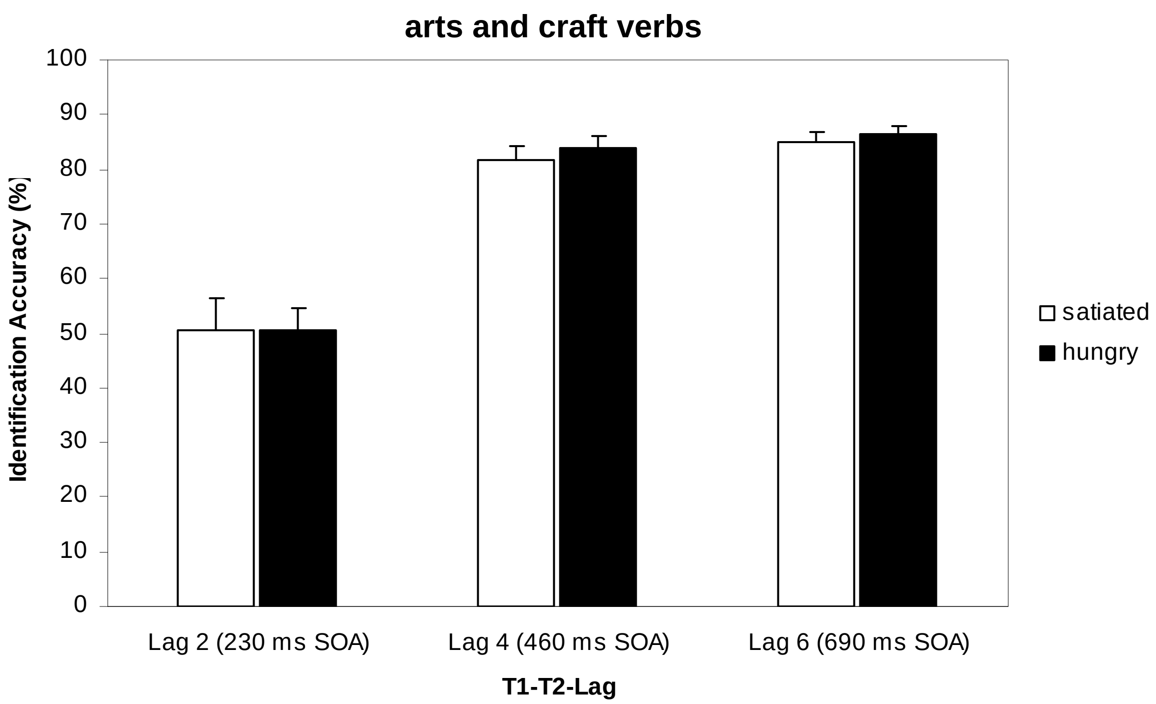

Figure 16: Identification accuracy of T2 arts and craft verbs (mean percent of correct responses) as a function of motivational state (satiated vs. hungry) and T1-T2-SOAs. Error bars indicate standard errors.

A motivational modulation of the AB effect was not found. As shown in Figures 15 and 16, the ANOVA for T2-Stimuli did not show an effect of STATE ($F < 1$); there were also no significant interactions of STATE x WORD-CATEGORY or STATE x LAG (Fs < 2). The ANOVA for T2-Stimuli also did not show an effect of WORD-CATEGORY ($F < 1$); there was no significant interaction of WORD-CATEGORY x LAG ($F < 1$), see Figures 15 and 16. The ANOVA for T2-stimuli did not show effects of the between-subjects factor SEX (Fs < 2).

4. Discussion

The present study's aim was to investigate if and to what degree motivationally-behaviourally relevant material – operationalised via the impact of food deprivation on two different word categories – is selected preferentially from a temporal stream of information. The experimental design to investigate this possible postperceptual facilitation for motivationally relevant stimuli was a so-called attentional blink (AB) paradigm. The crucial experimental question was whether food deprivation modulates the AB effect. In particular, the hypothesis of a facilitated identification of eating verbs compared to arts and craft verbs in a hungry state was tested in a RSVP-paradigm in which these verbs acted as T2-stimuli.

4.1 Successful manipulation of motivational state

Firstly, if one looks at the present results, the hunger and appetite ratings show that the manipulation of motivational state via food deprivation was successful. The participants stated to be hungrier and to have a greater appetite when being in the hungry state compared to the ratings of hunger and appetite in the satiated state. In food deprivation studies, it is a consistent finding that participants report to be hungrier after they have fasted (e.g. Mogg et al., 1998; Placanica et al., 2002; Schmälzle, 2005). Controlling the food deprived state with the measurement of the blood ketone concentration contributed to more reliable results. As expected, the measurements of the blood ketone level resulted in higher ketone levels for the hungry state. Although one cannot be sure that for each individual compliance with 24-hour fasting was given, it is safe to say the participants restricted their ingestion of food considerably in the hours before the "hungry" experimental session.

4.2 Effect of food deprivation on subjective ratings

Regarding subjective ratings of the target stimuli the results showed a specific effect for the T2 eating verbs in the hungry state compared to the satiated one. In the hungry state, T2 eating verbs revealed higher self-rated arousal and higher self-rated pleasure than in the satiated state. Neither for the arousal dimension nor for the pleasure dimension a difference of motivational state (satiated versus hungry) for the T1 neutral verbs and the T2 arts and craft verbs was found. That is, the assumption of a specific hunger-modulated change in subjective rating only for eating verbs is confirmed.

The results of the SAM-ratings showed that being in a hungry state led to higher self-rated arousal and higher self-rated pleasure of verbal eating relevant material. That indicates that only T2 eating verbs became more motivationally-behaviourally relevant when participants were in a hungry state. Compared to studies with affectively arousing stimuli as T2s such as emotional verbs (see Keil and Ihssen, 2004), the T2 eating verbs in a hungry state also show higher subjectively rated arousal similar to the ratings of pleasant and unpleasant verbs. Nevertheless, compared to the arousal ratings of the affectively arousing verbs, the eating verbs in this study were not as arousing as the employed affective stimuli in the study by Keil and Ihssen (2004). For instance, in their study, subjective ratings reflected higher arousal for pleasant (mean arousal rating = 6.84) and unpleasant (mean arousal rating = 7.90) compared to neutral verbs (mean arousal rating = 2.79) (Keil and Ihssen, 2004). In the present study, the eating verbs "only" reflected a mean subjectively rated arousal of 3.74 in the satiated state and a mean arousal score of 4.41 in the hungry state. Regarding pleasure ratings, the data of the affective verb categories in the study by Keil and Ihssen (2004) suggest that the verbs were experienced according to their affective category. In the present study, pleasure ratings indicated that the stimulus class of eating relevant verbs were perceived as being overall more pleasant. This is in line with other studies using eating-related (food) stimuli; eating stimuli are perceived as more pleasant than neutral stimuli. For instance, in a study by Drobes and colleagues (2001), pleasure ratings showed that pictures of food stimuli were rated as more pleasant than pictures of neutral stimuli. Additionally, in the present study, the eating verbs were rated as even more pleasant when being in the hungry state compared to the satiated one. There was no such specific hunger-modulated change in pleasure ratings for the other stimulus classes (neutral verbs, arts and craft verbs).

4.3 Successful replication of the classic AB effect

As expected the so-called attentional blink (AB) effect was replicated in the present study. The identification accuracy for first target stimuli (T1s) was generally high, both for the satiated and the hungry state. This indicates participants complied with the instruction to attend to the target stimuli. This is also consistent with findings in attentional blink studies that the detection of a T1-stimulus in a stream of distractors is virtually unimpaired (e.g. see Raymond, Shapiro, and Arnell, 1992; Keil and Ihssen, 2004).

In line with the typical attentional blink pattern (e.g. Raymond et al., 1992; Chun and Potter, 1995), a marked reduction in identification accuracy for second target stimuli (T2s) was found, especially for the shortest T1-T2-interval (230-ms-SOA). In the 230-ms-SOA, the mean percent of correct responses was 51%. A better performance arose in the medium 460-ms-SOA with mean percent correct responses of 82 %. For the longest T1-T2-interval (690-ms-SOA), mean identification accuracy was 86 %.

Moreover, in the present study the aim was to reduce variance caused by linguistic parameters by matching word length (that is, number of letters and number of syllables) and word frequency (word frequency of the verbs in the German language). In the preliminary study no significant differences were found with respect to these variables, which should rule out the possibility that they produced any effects in the present study.

4.4 Effect of food deprivation on the AB pattern: no motivational modulation

In the present study, the results did not show that being in a hungry (food deprived) state leads to a better identification of eating-relevant verbs. Although the successful manipulation of motivational state (satiation versus food deprivation) was demonstrated in this study, food deprivation did not influence the attentional blink pattern. There was no enhancement in identification accuracy for the eating verbs in the hungry state. Furthermore, there was no special identification facilitation for the shortest 230ms-SOA for T2 eating verbs in the hungry state. Instead, a very similar, almost identical pattern of the AB effect for eating verbs was found for both the satiated state and the hungry one. The T2 arts and craft verbs also showed a very similar pattern of identification accuracy across lags for both motivational states.

Interestingly, in the subjective ratings of the target verbs, a significant difference specifically for the eating verbs in the hungry state was found (see above). In the hungry state, participants rated eating verbs as more arousing and as more pleasant compared to the satiated state. This state-dependent difference was found only for the stimulus category of eating verbs. The neutral target words as well as the arts and crafts words did not show this state-dependent difference. This indicates that although the eating verbs differed state-dependently concerning pleasure and arousal in the self-ratings, this did not lead to better performance in the behavioural attentional blink experiment. Affectively arousing stimuli such as emotional verbs (see Keil and Ihssen, 2004, for instance Experiment 1) reflect a higher subjectively rated arousal for pleasant (mean arousal rating = 6.84) and unpleasant (mean arousal rating = 7.90) compared to neutral verbs (mean arousal rating = 2.79). The eating verbs in the present study, however, only reflected a mean subjectively rated arousal of 3.74 in the satiated state and only a mean arousal of 4.41 in the hungry state. That means, even in the hungry state the eating verbs did not exceed a mean arousal score of 5. (The arousal scale of the employed Self-Assessment-Manikin ranges from 1 (low) to 9 (high)). Possibly, the applied stimuli of eating verbs were not arousing enough to produce an enhancement in the AB performance.

If one compares the results of other paradigms dealing with attention biases towards motivationally significant stimuli, there are two paradigms which have been used frequently in the visual modality: the “emotional Stroop” task and the “dot probe” task. Both paradigms have shown hunger-related biases in selective attention for food-relevant stimuli.

The “emotional Stroop” task is a variation of the well-known colour naming task (Stroop, 1935). In the emotional Stroop, participants name the colour in which emotionally salient and emotionally neutral words are displayed, typically needing more time for the emotional words. This same approach has been used to reveal biases towards food-related word meanings in individuals with eating disorders. Food Stroop effects have also been found in normal subjects, although generally not without prior food deprivation (Channon and Hayward, 1990; Lavy and van der Hout, 1993; Formea and Burns, 1996; Francis et al., 1997). While the emotional Stroop task has proved fruitful in the investigation of motivation-based attention biases, there are limitations to the interpretation of results (MacLeod, 1991; Mogg et al., 1998; Placanica et al., 2002). Stroop effects might result from sensory inhibition or from response competition. Furthermore, while the original Stroop task comprises congruent and incongruent conditions, there is no congruent condition using words that are not colour names. Therefore, while the task can reveal the cost of selective attention to semantic content via slowed shifting to other stimulus features, it is impossible to know whether a motivationally salient stimulus biases attention by enhancing attention toward itself or by suppressing attention to other events.

From the difficulties in interpreting the results of the modified Stoop task, it became clear that the Stroop task does not provide a direct measure of attentional bias. A more direct measure of deployment of visual attention is the “dot probe” task. With the dot probe task it is possible to investigate whether a transient motivational state, such as hunger, is associated with an attentional bias for drive-relevant stimuli, such as food-related words. For instance, Mogg and colleagues (1998) used a dot probe task in which a series of word pairs was presented on a computer screen, one word above the other. Immediately after the display of each word pair, a small dot probe appeared in one of two locations on the screen which had just been occupied by one of the words. Participants indicated the position of the probe (i.e. upper or lower) by pressing one of two response keys as quickly as possible. Mogg and colleagues (1998) used food-related words and control words as experimental probes. Participants with high levels of hunger were more likely to shift their attention towards food-related words than control words, whereas those with low hunger showed no attentional bias for food-related stimuli. The results by Mogg and colleagues (1998) suggest that a non-emotional motivational state, such as hunger, is associated with a bias in certain aspects of information processing, such as selective attention, for stimuli that are relevant to the motivational state.

Further support for a hunger-related bias for food words in a dot probe task comes from a study by Placanica and colleagues (2002). The authors used the dot probe paradigm with low-calorie and high-calorie food words as targets; they found support for their hypothesis that fasting increases attentional bias for high-calorie food words.

In conclusion, the results from the Stroop and the dot probe experiments revealed hunger-related biases in selective attention for food words.

The present study investigated whether food deprivation modulates the attentional blink (AB) effect. However, the present attentional blink study did not show hunger-related biases in selective attention for food words. It is possible to modify the present attentional blink study in order to further examine if a hunger-related bias might affect the attentional blink paradigm, too.

The present study used a within-subjects design: each participant came to the laboratory twice, once in a satiated and once in a hungry, 24-hour-food-deprived state. Other food deprivation studies used between-subjects designs (e.g. Channon and Hayward, 1990; Mogg et al., 1998), but there are also studies which preferred this type of statistically more powerful and recommendable experimental design (e.g. Placanica et al., 2002). Thus, future studies should also use a repeated measure design instead of a group comparison design.

In the present study, the hypothesis of a facilitated identification of eating verbs compared to arts and craft verbs in a hungry state was tested in a RSVP-paradigm in which these verbs acted as T2-stimuli. Another possibility of testing whether food deprivation has an influence on the AB effect would be the presentation of eating-relevant nouns as target stimuli in the RSVP stream. Eating relevant nouns, rather than eating verbs, such as “bread”, “apple”, “pizza”, or “salad” might represent the “actual targets” of a food-deprived person. Therefore, these nouns might show enhanced identification accuracy in an AB paradigm.

In addition, one could select eating-relevant nouns with a high incentive value such as "cake", "chocolate", "chips" or "ice cream". As the eating verbs in the present study were relatively low arousing, selecting nouns representing foods with high incentive values could increase subjective arousal ratings, therewith effecting identification facilitation in the AB paradigm. In a study by Placanica and colleagues (2002) using the dot probe paradigm with low-calorie and high-calorie food words as targets, the authors found support for the hypothesis that fasting increases attentional bias for high-calorie food words. It appeared that relatively short-term starvation causes attention to be directed toward food stimuli perceived as more likely to reduce hunger (i.e. high-calorie food). Usually, high-calorie food also has a high incentive value, because the combinations of fat and sugar (e.g. as found in chocolate or cake) or fat and protein (e.g. as found in a burger or a steak) are both high in calories and are perceived as being very tasty. That is, in a fasted condition, a person might exhibit an attentional bias especially for food words which are high in calories and which have a high incentive value.

In an EEG-study conducted by Schmälzle (2005) participants had to look at pictures of foods and flowers, once in a satiated state and once in a hungry state. Schmälzle (2005) found differences in processing of the food pictures in the hungry compared to the satiated state. Results showed enhanced positive potentials bilaterally over parietal-occcipital sites when participants looked at food pictures whilst being hungry (Schmälzle, 2005). For an AB experiment, it would be possible to show pictures of foods and pictures of flowers as T2-stimuli. Pictures of food could be quite realistic representations of real food stimuli. Therefore, food pictures in an attentional blink paradigm might have an influence on perception and attention of a food-deprived person, possibly showing enhanced identification accuracy for food pictures compared to neutral pictures.

In addition to varying the stimulus material in an attentional blink paradigm, it is also possible to vary the realisation of the fasting condition. In general, the deprivation effect is difficult to control; one has to rely on the participant's statement having fasted and on the data given in hunger ratings. In the present study, the measurement of blood ketone level contributed to more reliability of the food deprivation condition. Therefore, measuring blood ketone is recommended for the conduction of further food deprivation studies. Moreover, a 24-hour-fasting condition like it was used in the present study seems to be efficient in inducing hunger in participants (see also Channon and Hayward, 1990; Drobes et al., 2001; Schmälzle, 2005). However, inducing hunger by fasting is not the only experimental method to induce a hungry state. In a newer Stroop study investigating selective processing of food words (Brody, Keller, Degen, Cox, & Schächinger, 2004), the authors aimed to find out whether participants show greater cognitive interference for food words during insulin-induced hypoglycemia. Actually, the authors found that reaction times for food words are increased greater than for non-food control words (Brody, Keller, Degen, Cox, & Schächinger, 2004). Brody et al. (2004) argue that hypoglycemia leads to undernutrition of the brain and generally results in increased hunger. Moreover, the authors state that their data indicate that attention is directed selectively to food-relevant stimuli during hypoglycemia and that this hypoglycaemia leads to an adaptive selective attention to food cues. Participants in this study reported feeling much more hunger during the hypoglycemic than during the normoglycemic state. This indicates that the used hypoglycemic clamp procedure might be another method for studying effects of hunger / food deprivation on attentional processes. However, it is unknown whether the manipulation of motivational state with the hypoglycaemic method results in stronger feelings of hunger or a greater effect of motivational state than fasting does.

Moreover, it is possible to manipulate the motivational state of a participant by giving the participant an “appetizer” just before the experimental task. In a study by Overduin, Jansen, and Louwerse (1995), unrestrained and restrained participants were randomly allocated to two conditions: one “appetizer” and one “no-appetizer” condition. The appetizer was a bit of pudding to be ingested just before a Stroop task containing neutral, food, and body shape-related words. The results showed that Stroop interference for food word was only found in the appetizer condition for unrestrained, normal participants. Restrained participants, however, showed a permanent interference for food words (Overduin, Jansen, and Louwerse, 1995). These findings indicate that ingestion of an appetizer seems to evoke an attentional bias for food words in nonrestrained subjects. Therefore, administrating an appetizer before an experimental task dealing with food stimuli seems to be another way of manipulating the motivational state of a subject. Consequently, one could also try to combine an appetizer condition with a dot probe task or an attentional blink paradigm.

Finally, it is possible to investigate hunger-related biases in selective attention with other experimental paradigms such as the visual search paradigm. For instance, Öhman and colleagues (2001) used the visual search paradigm with affective stimuli. Öhman and colleagues (2001) presented their subjects with schematic face stimuli arranged in 3 x 3 matrices. At one of the nine positions in the matrix a discrepant target face was shown amongst identical distractor faces. If the deviant target was a threatening face, detection was faster and more accurate (Öhman et al., 2001). Thus, a motivationally significant, fear-relevant stimulus is analysed more quickly. Thus, it is possible to conduct a similar study in which hungry participants would have to search visually for food stimuli. These food stimuli should be motivationally significant to the hungry participants; therefore they might detect these stimuli faster than control stimuli.

4.5 Conclusions

The present study provides major insights about hunger-related biases in selective attention for food words. For the first time, an attentional blink design was used to investigate if and to what degree food deprivation influences the attentional blink (AB) effect. In particular, the hypothesis of a facilitated identification of eating verbs compared to arts and craft verbs in a hungry state was tested in a RSVP-paradigm in which these verbs acted as second target (T2) stimuli.

The results of the present study did not show that being in a hungry state leads to a better identification of eating-relevant verbs. Instead, a very similar, almost identical pattern of the AB effect for eating and arts and craft verbs was found for both the satiated state and the hungry one.

Future studies using different stimuli and paradigms will be necessary in order to further investigate the interesting question concerning the motivational modulation of attention processes.

5. References

Anderson, A. K., & Phelps, E. A. (2001). Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature, 411*(6835), 305-309.

Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1995). *The Celex lexical database (Release 2) [CD-ROM]*: Philadelphia, PA: Linguistic Data Consortium University of Pennsylvania [Distributor].

Ballmer, T., & Brennenstuhl, W. (1986). *Deutsche Verben. Eine sprachanalytische Untersuchung des Deutschen Verwortschatzes.* Tübingen: GNV Gunter Narr Verlag.

Biesalski, H.-K. (1995). *Ernährungsmedizin*. Stuttgart: Thieme.

Bradley, M. M. L., Peter J. (1994). Measuring emotion: The Self-Assessment Manikin and the semantic differential. *Journal of Behavior Therapy & Experimental Psychiatry, 25*(1), 49-59.

Broadbent, D. E. (1958). *Perception and communication*. Oxford: Oxford University Press.

Brody, S., Keller, U., Degen, L., Cox, D. J., & Schächinger, H. (2004). Selective processing of food words during insulin-induced hypoglycemia in healthy humans. *Psychopharmacology, 173*((1-2)), 217-220.

Channon, S., & Hayward, A. (1990). The effect of short-term fasting on processing of food cues in normal subjects. *International Journal of Eating Disorders, 9*(4), 447-452.

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

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

Diehl, J. M., & Staufenbiehl, T. (1999). *IEG: Inventar zum Essverhalten und Gewichtsproblemen.* (2.Auflage). Eschborn: Verlag Dietmar Klotz.

Driver, J. (2001). A selective review of selective attention research from the past century. *British Journal of Psychology, 92*(Pt 1), 53-78.

Drobes, D. J., Miller, E. J., Hillman, C. H., Bradley, M. M., Cuthbert, B. N., & Lang, P. J. (2001). Food deprivation and emotional reactions to food cues: Implications for eating disorders. *Biological Psychology, 57*(1), 153-177.

Dudenredaktion, Die. (2001). *Duden – Deutsches Universalwörterbuch* (4. Auflage). Mannheim: Dudenverlag.

Formea, G. M., & Burns, G. L. (1996). Selective processing of food, weight, and body-shape words in nonpatient women with bulimia nervosa: Interference on the Stroop task. *Journal of Psychopathology and Behavioral Assessment, 18*(2), 105-118.

Francis, J. A., Stewart, S. H., & Hounsell, S. (1997). Dietary restraint and the selective processing forbidden and nonforbidden food words. *Cognitive Therapy and Research, 21*(6), 633-646.

Greenhouse, S. W., & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika, 24*, 95-112.

Hautzinger, M. (1991). Das Beck-Depressioninventar (BDI) in der Klinik. *Der Nervenarzt, 62*(11), 689-696.

Howell, D. C. (2002). *Statistical Methods for Psychology*. (5th ed.) Pacific Grove, CA, USA: Duxbury Thomson Learning.

Ihssen, N. (2003). *Affektive Modulation des Attentional Blink.* Universität Konstanz, Konstanz, Germany: Diplomarbeit.

Jolicoeur, P. (1998). Modulation of the attentional blink by on-line response selection: Evidence from speeded and unspeeded task1 decisions. *Memory and Cognition, 26*(5), 1014-1032.

Keil, A., & Ihssen, N. (2004). Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion, 4*(1), 23-35.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). Motivated attention: Affect, activation, and action. In P. J. Lang, R. F. Simons & M. Balaban (Eds.), *Attention and Emotion: Sensory and Motivational Processes* (pp. 97-135). Mahwah, NJ: Erlbaum.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30*(3), 261-273.

Lavy, E. H., & van den Hout, M. A. (1993). Attentional bias for appetitive cues: Effects of fasting in normal subjects. *Behavioural & Cognitive Psychotherapy, 21*(4), 297-310.

Lüthy, M., Blumenthal, T. D., Langewitz, W., Kiss, A., Keller, U., & Schachinger, H. (2003). Prepulse inhibition of the human startle eye blink response by visual food cues. *Appetite, 41*(2), 191-195.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin, 109*(2), 163-203.

Milliken, B., & Tipper, S. P. (1998). Attention and inhibition. In H. Pashler (Ed.), *Attention* (pp. 191-221). Hove, England: Psychology Press/Erlbaum (UK) Taylor & Francis.

Mogg, K., Bradley, B. P., Hyare, H., & Lee, S. (1998). Selective attention to food-related stimuli in hunger: Are attentional biases specific to emotional and psychopathological states, or are they also found in normal drive states?, *Behaviour Research & Therapy* (Vol. 36, pp. 227-237): Elsevier Science.

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

Muthny, F. A., Glanzmann, P., & Laux, L. (1997). Testrezension zu State-Trait-Angstinventar (STAI). *Zeitschrift für Differentielle und Diagnostische Psychologie, 18*(1-2), 72-74.

Nieuwenstein, M. R., Chun, M. M., van der Lubbe, R. H., & Hooge, I. T. (2005). Delayed attentional engagement in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance, 31*(6), 1463-1475.

Öhman, A. (1986). Face the beast and fear the face: Animal and social fears as prototypes for evolutionary analyses of emotion. *Psychophysiology, 23*(2), 123-145.

Öhman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. *Journal of Personality and Social Psychology, 80*(3), 381-396.

Overduin, J., Jansen, A., & Louwerse, E. (1995). Stroop interference and food intake. *International Journal of Eating Disorders, 18*(3), 277-285.

Pashler, H. E. (1998). *The Psychology of Attention*. Cambridge, MA: MIT Press.

Placanica, J. L., Faunce, G. J., & Soames Job, R. F. (2002). The effect of fasting on attentional biases for food and body shape/weight words in high and low Eating Disorder Inventory scorers. *International Journal of Eating Disorders, 32*(1), 79-90.

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

Schaer, T. (2004). *Motivationsgesteuerte Aufmerksamkeit: Visuelle Verarbeitung von Nahrungsreizen im Hungerzustand*. Ernst-Moritz-Arndt Universität Greifswald, Greifswald, Germany: Diplomarbeit.

Schmälzle, R. (2005). *Effekte von Nahrungsdeprivation auf die Verarbeitung visueller Reize: eine ERP-Studie.*, Universität Konstanz, Konstanz, Germany: Diplomarbeit.

Shapiro, K. L., Arnell, K. M., & Raymond, J. E. (1997). The attentional blink: A view on attention and a glimpse on consciousness. *Trends in Cognitive Sciences, 1*(8), 291-296.

Shapiro, K. L., Caldwell, J., & Sorensen, R. E. (1997). Personal names and the attentional blink: A visual "cocktail party" effect. *Journal of Experimental Psychology: Human Perception and Performance, 23*(2), 504-514.

Shapiro, K. L., Raymond, J. E., & Arnell, K. M. (1994). Attention to visual pattern information produces the attentional blink in rapid serial visual presentation. *J Exp Psychol Hum Percept Perform, 20*(2), 357-371.

Steyer, R., Schwenkmezger, P., Notz, P., & Eid, M. (1994). Testtheoretische Analysen des Mehrdimensionalen Befindlichkeitsfragebogen (MDBF). *Diagnostica, 40*(4), 320-328.

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

Treisman, A. M. (1960). Contextual cues in selective listening. *Quarterly Journal of Experimental Psychology, 12*, 242-248.

Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology, 12*(1), 97-136.

Vogel, E. K., Luck, S. J., & Shapiro, K. L. (1998). Electrophysiological evidence for a postperceptual locus of suppression during the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance, 24*(6), 1656-1674.

6. Appendixes

Appendix 1: The 50 German verbs from the preparatory rating study

Appendix 2: Screening Interview

Appendix 3: Personal details of participant

Appendix 4: Eating diary with instructions (hungry)

Appendix 5: Eating diary with instructions (satiated)

Appendix 6: Hunger and appetite rating

Appendix 7: Instruction for RSVP-task

Appendix 8: Instruction for SAM-rating after the RSVP-task

Appendix 9: List of all targets in the RSVP-task (T1s and T2s)

Verb	Pleasure (*M*)	Pleasure (*SD*)	Arousal (*M*)	Arousal (*SD*)
abbeißen	5.44	1.48	4.06	1.85
abschmecken	6.35	1.70	3.76	1.73
aufessen	4.68	1.74	3.97	1.92
dinieren	6.65	1.83	4.15	1.97
einnehmen	4.00	1.86	4.06	2.26
einverleiben	3.68	1.41	4.47	1.65
ernähren	5.24	1.09	2.91	1.62
essen	6.41	1.46	3.71	1.82
fressen	3.44	2.00	5.97	1.60
frühstücken	7.18	1.58	3.68	1.53
futtern	4.79	2.03	4.53	1.88
genießen	8.35	1.19	3.85	2.35
kauen	5.09	1.12	3.85	1.68
knabbern	6.85	1.11	4.03	1.87
knuspern	7.00	1.57	4.68	2.14
konsumieren	4.41	1.70	3.68	1.60
kosten	6.06	1.64	3.88	1.97
löffeln	5.24	1.52	3.85	1.72
lunchen	6.21	2.21	3.56	1.61
lutschen	6.29	1.77	4.53	2.32
mampfen	4.29	2.01	4.47	1.94
mümmeln	5.91	1.82	3.74	1.63
naschen	7.56	1.38	5.24	2.25
picknicken	7.71	1.27	4.53	2.06
reinstopfen	2.18	1.15	5.71	2.11
schlabbern	4.26	2.39	4.91	1.96
schlecken	6.32	1.68	4.47	1.79
schlemmen	7.12	1.59	3.88	2.10
schlingen	2.53	1.31	5.65	2.13
schlucken	4.82	0.71	3.94	1.63
schlürfen	3.88	2.31	4.71	2.19
schmatzen	2.56	1.83	5.41	2.13
schmausen	6.85	1.72	4.29	1.62
schmecken	6.59	1.63	4.15	2.02
schnabulieren	5.79	1.69	3.88	1.68
schwelgen	6.82	1.69	4.29	2.12
spachteln	3.68	1.97	4.94	1.66
speisen	6.21	1.43	3.24	1.65
stärken	6.12	1.30	4.18	1.74
tafeln	6.38	1.51	3.68	1.92
verdrücken	3.94	1.63	4.76	1.72
verputzen	5.29	1.62	4.68	1.86
verschlingen	2.74	1.31	5.56	1.82
verschlucken	2.29	1.52	6.18	2.32
verspeisen	5.47	1.22	3.94	1.53
vertilgen	3.38	1.16	5.09	1.92
verzehren	5.26	1.22	3.65	1.62
vespern	6.21	1.59	3.56	1.90
völlen	3.29	1.72	4.88	2.32
vollpropfen	2.59	1.37	4.85	2.22

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AB DEPRIVATION SCREENING

Datum des Anrufs: _______________ ***Anrufer:*** _______________

Ich möchte Dir zunächst einige Fragen stellen, um zu sehen, ob du für die Untersuchung in Frage kommst. Alle Deine Angaben werden selbstverständlich streng vertraulich behandelt.

Name, Vorname	
Telefon	
Email-Adresse	
Alter	
Geschlecht	

Ist Deine Muttersprache Deutsch?	
Hast oder hattest Du ernste Probleme mit Deiner Gesundheit (welche) ?	
Nimmst Du derzeit Medikamente? (verschrieben oder unverschrieben) (welche und wofür?)	
Leidest Du unter einer Stoffwechselerkrankung? z. B: Diabetes Mellitus	
Leidest Du unter einer Schilddrüsenerkrankung?	
Leidest Du unter Epilepsie?	

Wie groß bist Du?(cm)	
Wieviel wiegst Du?(kg)	
$BMI = \frac{Gewicht(kg)}{(Größe(m))^2}$	
Führst Du gerade eine Diät durch?	
Hast Du schon einmal eine Diät durchgeführt? (welche, wie oft, wie lange)	
Ernährst Du Dich vegetarisch oder nach einer anderen besonderen Kostform?	
Hattest Du schon einmal Essanfälle oder Heißhungeranfälle während derer Du in kurzer Zeit sehr viel gegessen hast?	
Hattest oder hast Du eine Essstörung?	
Hast Du sonst irgendwelche Schwierigkeiten mit Deinem Essverhalten?	
Bist Du Raucher? (Wie stark? Zigaretten/Sonstiges)	

Erfüllt Kriterien: Ja Nein *Termin für erstes Treffen:* ____________

Vp.-Nr.: ___

Universität Konstanz – Allgemeine Psychologie

ANGABEN ZUR PERSON

VP-Nr.*: __________________

- Hast Du schon einmal an einer Nahrungsdeprivationsstudie teilgenommen?

ja ☐ *nein* ☐

Wenn ja, welche: ____________________

- Bist Du Brillenträger oder trägst Du Kontaktlinsen:

ja ☐ *nein* ☐

Wenn ja: Dioptrien rechts: _______ *Dioptrien links:* _______

- Sind irgendwelche Erkrankungen diagnostiziert (insbes. neurologische)?

ja ☐ *nein* ☐

Wenn ja, welche: _______________________

- Leidest Du unter irgendeiner Form von Ängsten (z. B. vor Tieren, Blut o. ä.)

ja ☐ *nein* ☐

Wenn ja, welche: _______________________

** vom Versuchsleiter auszufüllen: VPNr.: __ HS/SH: __*

Universität Konstanz – Allgemeine Psychologie - Ernährungstagebuch

Experimenttermin: ________________________ Uhrzeit: ________ Uhr

Raum: __________

Termin muss unbedingt eingehalten werden !

Zustand: **Hungrig**

zu beachten:

Am Vortag des Termins, also ab _________________

- normal essen
- mittags etwas zu sich nehmen
- um ca. ________ Uhr noch einmal eine Kleinigkeit essen
- ab ________ Uhr nichts mehr essen

dann 24h lang nichts essen:

- nur kalorienfreie Getränke (Wasser, Kaffee, Tee, ohne Milch, ohne Zucker)
- kein Alkohol
- Kaffee – wenn überhaupt – nur maßvoll
  und nicht mehr unmittelbar vor dem Termin
- ausreichend Schlaf in der Nacht vor dem Termin
- 48 Std. vor dem Termin keine psychoaktiven Substanzen einnehmen
- untenstehendes Esstagebuch führen

Ich bin zu erreichen unter:

Büro: 07531-88-5118 oder 0179-4236909 (Nadine Petrovsky)

e-mail: wortverarbeitung@gmx.de

Uhrzeit	Art und Menge der Nahrungsmittel / Getränke
Datum:	
Datum:	

** vom Versuchsleiter auszufüllen: VPNr.: __ T1/T2: __ HS/SH: __*

Universität Konstanz – Allgemeine Psychologie - Ernährungstagebuch

Experimenttermin: ________________________ Uhrzeit: ________ Uhr

Raum: __________

Termin muss unbedingt eingehalten werden !

Zustand: **Satt**

zu beachten:

- am Tag des Experiments normal essen
- mittags etwas zu sich nehmen
- gegen ________ Uhr nochmals eine Kleinigkeit essen
- ausreichend Schlaf in der Nacht zuvor
- am Vortag kein Alkoholkonsum
- kein Alkohol am Messtag
- 48 Std. vor dem Termin keine psychoaktiven Substanzen einnehmen
- ab dem Tag vor der Messung untenstehendes Esstagebuch führen

Ich bin zu erreichen unter:

Büro: 07531-88-5118 oder 0179-4236909 (Nadine Petrovsky)

e-mail: wortverarbeitung@gmx.de

Uhrzeit	Art und Menge der Nahrungsmittel / Getränke
Datum:	
Datum:	

** vom Versuchsleiter auszufüllen: VPNr.: __ T1/T2: __ HS/SH*

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HUNGER UND APPETIT

Wie hungrig bist Du im Moment?

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4 sehr hungrig	-3	-2	-1	0	1	2	3	4 sehr satt

Hast Du im Moment Appetit?

☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
1 wenig	2	3	4	5	6	7	8	9	10 viel

** vom Versuchsleiter auszufüllen: VPNr.: __ T1/T2: __ H/S: __ PRÄ*

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INSTRUKTION

Während der folgenden Untersuchung bist du alleine im Messraum, wobei ich dich über eine Kamera sehen kann. Falls es Probleme gibt, solltest du dich durch Winken bemerkbar machen.

Auf dem Monitor werden dir weiße und grüne Wörter in schneller Abfolge dargeboten. Du sollst auf die grünen Wörter achten und dir diese merken. Nach einem Durchgang sollst du die grünen Wörter, die du gesehen hast, vollständig eintippen.

Damit das Experiment nicht verfälscht wird, bitte ich Dich, folgende Dinge zu beachten:

- Du sollst die Wörter aufmerksam betrachten
- den Blick möglichst immer auf die Bildschirmmitte gerichtet lassen.

Zunächst fangen wir mit ein paar Übungsdurchgängen an, damit du dich mit dem Ablauf vertraut machen kannst.

Falls Du noch Fragen hast, so kannst mich jetzt noch fragen.

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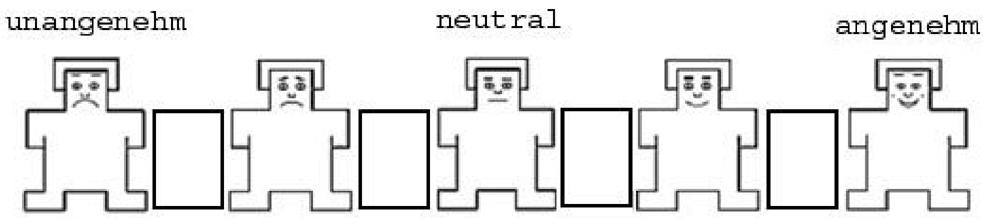
INSTRUKTION

In dieser Studie geht es um deine persönliche, spontane Einschätzung von Wörtern. Hierzu werden die zwei Dimensionen „Valenz“ und „Erregung“ verwendet. „Valenz“ steht dafür, wie unangenehm bzw. angenehm etwas ist.

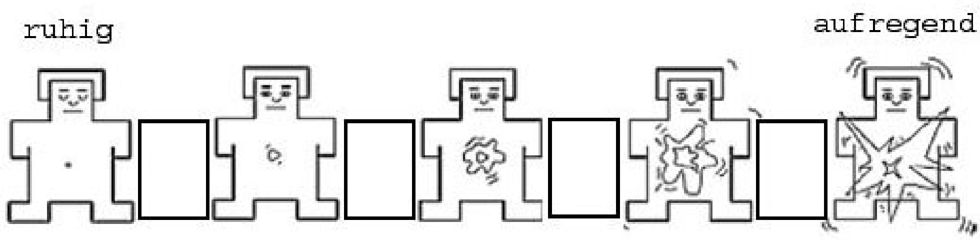
„Erregung“ steht dafür, wie ruhig bzw. aufregend etwas ist.

Das Self-Assessment-Manikin (SAM-Männchen) stellt diese Dimensionen graphisch dar.

Die erste Dimension zur Beschreibung der Wörter ist die Dimension „Valenz“:



Die zweite Dimension zur Beschreibung der Wörter stellt die Dimension „Erregung“ dar:



Bitte mache ein Kreuz an der Stelle, die deiner subjektiven Einschätzung des Wortes am ehesten entspricht! Du kannst dabei sowohl die SAM-Männchen als auch die Zwischenräume ankreuzen.

Bitte arbeite die Liste der Wörter in der vorgegebenen Reihenfolge zügig und sorgfältig durch!

T1 neutral	***T2 eating***	***T2 arts and crafts***
anbringen	abbeißen	basteln
anschauen	abschmecken	bauen
auflisten	aufessen	bohren
aufsetzen	dinieren	flechten
befestigen	einnehmen	gießen
berechnen	ernähren	hämmern
beschriften	essen	hobeln
blättern	futtern	kitten
blinken	kauen	kleistern
buchstabieren	knabbern	lackieren
einsteigen	konsumieren	malen
erblicken	kosten	meißeln
falten	löffeln	möblieren
filtern	lunchen	montieren
graben	lutschen	polstern
heizen	mampfen	renovieren
kurbeln	schlabbern	reparieren
leihen	schlecken	sägen
markieren	schlucken	schleifen
mischen	schmausen	schmieden
notieren	schmecken	schneidern
rollen	schwelgen	schnitzen
schälen	speisen	schrauben
schichten	stärken	schustern
speichern	tafeln	schweißen
sprühen	verputzen	tapezieren
stapeln	verspeisen	töpfern
stempeln	verzehren	verglasen
versenden	vespern	zimmern