Categorial Differences in Affective Picture Perception

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Zusammenfassung

Arbeiten zur affektiven Modulation von Verhaltens- und physiologischen Parametern zeigen häufig einen Verarbeitungsvorteil von erregenden angenehmen und unangenehmen gegenüber neutralen Reizen. Davon ausgehend wurde die Erkennungsleistung von Bildern untersucht, wobei versucht wurde mögliche perzeptuelle Unterschiede zwischen den Kategorien zu minimieren. Eine Auswahl von jeweils 180 angenehmen, neutralen und unangenehmen Schwarzweißstimuli wurde verwendet. Die durchschnittliche Helligkeit und Komplexität der Bilder in diesen Valenzkategorien wurde kontrolliert. Ein sandwichmaskierter Zielreiz wurde präsentiert (13, 27 oder 40 ms). Anschließend mussten die Probanden entscheiden, ob es sich bei einem Kontrollbild um das Zielbild handelt oder nicht, sowie die subjektive Sicherheit ihrer Einschätzung angeben. Es zeigte sich ein linearer Effekt der Präsentationsdauer auf die Erkennungsleistung für alle Bildkategorien: Je länger der Zielreiz gezeigt wurde, desto mehr richtige Antworten gab es und desto kürzer waren die Antwortzeiten. Für die einzelnen Präsentationsdauern zeigte sich kein klarer Effekt der Zielbildvalenz auf die Erkennungsleistung. Bei drei der 19 Versuchspersonen zeigten sich in mindestens einer Präsentationsdauerbedingung signifikante Unterschiede zwischen den Valenzkategorien, die allerdings keine einheitliche Richtung hatten. In Durchgängen mit sehr erregenden Bildern gab es weniger richtige Antworten als in Durchgängen mit niedrig erregenden Bildern. Dieses Ergebnis deutet darauf hin, dass emotionale Prozesse, die in der Gegenwart von vielen Reizen, die um Aufmerksamkeit und Verarbeitung konkurrieren, vermutlich optimal ablaufen, die Bildidentifikation im aktuellen Experiment behindern.

Abstract

The affective modulation of behavioral and physiological parameters has frequently been the topic of studies in experimental psychology. The processing of arousing pleasant and unpleasant pictures has often been found to be facilitated compared to low arousing neutral pictures. Based on these findings, an experiment to study the recognition of briefly presented pictures was designed. There were three stimulus valence categories: pleasant, neutral, and unpleasant. Each category contained 180 grayscale pictures. Efforts were made to minimize low-level perceptual differences between the valence categories. A sandwich-masked target picture was presented for 13, 27 or 40 ms. It was followed by a probe picture after a short pause. Then participants had to decide whether both pictures were the same ones or different ones. They also had to give a confidence rating for their decision. The data revealed a linear effect of target presentation time on recognition performance: longer presentation times yielded more correct responses and faster reaction times. The valence of the target picture had no clear effect on the recognition performance. Signal-detection theory analysis of individual performances revealed that three participants showed an affective modulation of responses in at least one presentation time condition. Still, each valence category received the most correct responses at some point and there was no clear pattern. There were significantly fewer correct responses in trials with highly arousing pictures compared to trials with barely arousing pictures across participants. These findings suggest that the emotional circuits which are possibly involved in competitive situations might interfere with the successful identification of target pictures in the simple task of the present experiment.

1 Introduction

Emotions are ubiquitous. There is a myriad of stories—real and fictitious—about love, hate, joy, sadness and countless other sentiments. This thesis deals with emotions on a rather basic level. After a short glance back at the history of emotion research, I will present an outline of the Lang model (Lang, Bradley, & Cuthbert, 1997), which serves as a theoretical framework for the present study. It integrates animal and human data and focuses on the motivational properties of emotions which have been shaped by evolution (Lang & Davis, 2006). Based on the notion that the processing of emotional stimuli is facilitated compared to neutral ones, a picture recognition task is devised in the second half of this introduction. The aim is to test whether there is an affective modulation of recognition performance that enhances the perception of emotional pictures.

1.1 Emotion

James (1884) already attempted to answer the question "What is an Emotion?" His notion that emotions are physiological processes which do not necessarily depend on conscious experiences still prevails in several current theories of emotion. Despite this early interest, emotion was long excluded from objective scientific study (Damasio, 2000). Behaviorism discarded emotions as evasive ideas blurring the true mechanisms of behavior. Later on, most cognitive psychologists focused on higher-level processes and kept ignoring emotions in their research. Once emotions were back on the research agenda they were still thought to be separate from cognition and motivation (Lazarus, 1999). Finally, coinciding with the advent of more powerful neurophysiological methods, elaborate theories of emotion were developed during the past three decades (Damasio, 2000) which contributed to the understanding and therapy of affective disorders (Davidson, 1998). Also, a number of articles like that from Zajonc (1980) sparkled new interest in the psychology of emotions. The field is still expanding and presumably more diverse than ever (Cacioppo & Gardner, 1999).

An integrative theoretical framework was chosen as the basis for the present study: the Lang model (Lang et al., 1997) is based on findings from cognitive psychology, neurophysiology, animal experiments, and research on motivation. Emotions are regarded as a special form of information processing. They can be characterized as action dispositions. Shaped by evolution emotional states have motivational properties. They can stop ongoing behavior, influence attention, and elicit appropriate reactions. The Lang model approaches emotion not on the level of private, subjective sensations but on levels where there are parallels to animal behavior and other physiological processes (Lang & Davis, 2006).

Although several structures have been proposed, there is no single center of emotions in the brain. The amygdala is supposed to play a key role in fear-related processes (LeDoux, 2000a), but even there many other brain regions are jointly involved. LeDoux (2000a, p. 129) states "that "cognition" and "emotion" do not refer to real functions performed by the brain but instead to collections of disparate brain processes." His studies of fear conditioning in rodents shed light on one of possibly many emotion systems. The main postulate is that incoming information is processed via two different routes: one fast but with a low resolution, the other one slow and with a high resolution. The fast route travels directly to the amygdala and carries mainly affective notions. The slow route carries detailed information via the primary sensory cortices. This information is processed more thoroughly. Activity of the fast route to the amygdala does not necessarily depend on attention or conscious perception. Briefly presented masked fearful faces were found to modulate activity in the amygdala in the absence of conscious awareness (Morris, Öhman, & Dolan, 1998). LeDoux (2000b, p. 129) describes the fear system "as a set of processing circuits that detect and respond to danger, rather than as a mechanism through which subjective states of fear are experienced."

In line with this view Damasio (1999) claims that emotional processes are purely objective. Only if an emotion is experienced consciously there is a subjective feeling. Exploring the unique phenomenology itself remains rather difficult and presumably requires a deeper understanding of consciousness in general (Blackmore, 2003). But there are many ways to study the underlying biological processes, both in humans and animals. Verbal report is not a necessity in order to study emotions, even though it is often used in studies with humans as one measure among many others. We can observe a rat's fear reaction without knowing how (or if) it actually feels fear (LeDoux, 2000a). Animal experiments can be conducted to investigate emotion-related issues using techniques like single-unit recordings within the brain tissue. As a result sophisticated models for emotional processes in animals have been developed. Findings from such experiments also shed some light on emotional processes in humans and are used to refine existing theories (LeDoux, 1996).

Time is an important factor in many situations that involve emotions. As the proverb says: the early bird catches the worm. And if, for example, a lion attacks your village, a quick reaction may help you survive. After all, you don't have to run faster than the beast—just faster than one of the other citizens. Emotional activation can be a critical issue in these situations. In fact, emotions play a part in almost every challenge our ancestors had to meet in order to survive and propagate, e. g., avoiding and escaping life-threatening events, becoming socially accepted, engaging with sexual partners, and nurturing offspring (Tooby & Cosmides, 1990). Evolution shaped the response patterns and action dispositions which now are our emotions (Lang & Davis, 2006). These emotions are complex processes that consist of partly independent components (Öhman, Flykt, & Lundqvist, 2000).

This view implies that emotions can act very fast and possibly without elaborate cognitive processing (LeDoux, 1996). For example, a defense reflex that protects the organism only a minute after a potential threat has been perceived is less useful in promoting survival than one that instantly prompts attention to the predator (Lang & Davis, 2006). In reality motor responses like a rat's "freezing" kick in immediately (Fanselow, 1994).

1.1.1 An evolutionary definition

Viewed from an evolutionary perspective, emotions can be regarded as action dispositions. They can interrupt current behavior and facilitate actions which are congruent to the prevailing affective state (Lang et al., 1997; Öhman et al., 2000).

1.1.2 Motivational organization of emotions

Although there is a vast multitude of emotions, empiric evidence suggests two underlying motivational systems. The defense system is activated by unpleasant arousing stimuli, whereas the appetitive system is activated by pleasant arousing stimuli. Activation of the defense system leads to a disposition for avoidance and protective behavior. Activation of the appetitive system results in a disposition for approach and appetitive behavior. The activation of these two systems can be measured on two non-orthogonal dimensions, valence and arousal (Lang et al., 1997).

The dominant motivational system determines the affective valence. Activation of the appetitive system leads to positive affect. Activation of the aversive system leads to negative affect. Affective arousal depends on the degree of activation of both systems (Lang & Davis, 2006).

Studies about the language of emotion provide evidence for a similar superordinate affective structure. For example, factor analysis of verbal report confirmed the two primary affective dimensions of valence and arousal (see Lang & Davis, 2006, for a review).

1.1.3 Affective picture perception

Emotions can be elicited by a variety of stimuli, e. g., objects, persons, and sounds. Those stimuli may be real or exist only in imagination, e. g., memories of emotional events (Ochsner, 2000). A combination of both aspects can be found in photographs. The picture itself is real and can thus be controlled by the experimenter. At the same time, the impact of the scene shown in the picture resembles that of the original scene, because the emotional quality of the picture lies in the actions implied by the particular scene. The emotional reactions that occur during picture viewing are mainly related to the support of perception and the motivational strategy associated with the stimulus. (Lang et al., 1997). The laboratory also provides a controlled (and safe) context, so observed changes depend primarily on the picture that is presented. Picture viewing is therefore a preferred procedure in experimental psychology (Lang, Greenwald, Bradley, & Hamm, 1993).

1.1.4 Measuring emotion

Emotions can be measured on several different levels. Subjective, verbal reports are just one option to learn about a person's affective state. Expressive, behavioral, and physiological reactions can be indicators for underlying emotions (see Table 1). Different indicators often yield different outcomes for the same stimulus. This flaw makes the study of emotions difficult, but fortunately not impossible.

level of reaction	indicators
subjective feelings	verbal reports, introspection
expressions	facial mimics, gestures, vocalization
body reactions	vegetative and endocrine changes

Table 1: Examples for measures that can indicate human emotions on different levels.

The International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 2005) is a widely used collection of emotional picture stimuli. The main responses have been replicated in various experiments and laboratories (Lang et al., 1997). They are summarized in the next paragraphs.

Subjective experience The Self-Assessment Manikin (SAM) has been used to measure the subjective affect induced by viewing pictures. Due to its pictographic form it is largely culture-free. Pleasure and arousal ratings on the SAM show a high correlation with other affective judgments (Bradley & Lang, 1994). The typical boomerang-shaped distribution of stimuli in a two-dimensional affective space formed by valence and arousal ratings is illustrated in Figure 1. It supports the notion of the two motivational systems described in section 1.1.2.

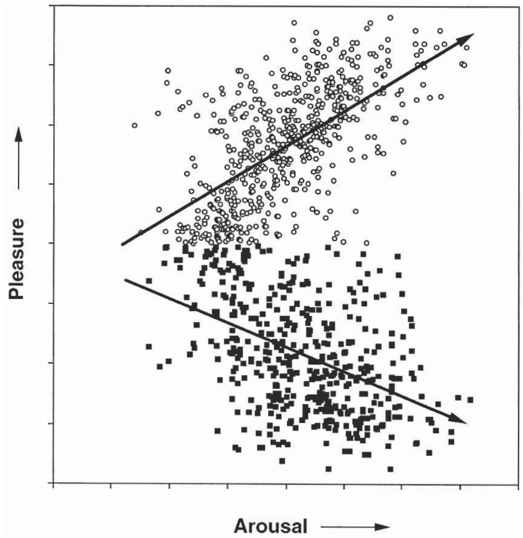

Figure 1: Distribution of IAPS stimuli in affective space and the two underlying motivational systems. Figure taken from Bradley et al. (2001, p. 277).

Physiological correlates Several physiological reactions show characteristic patterns during picture viewing. Facial muscle activity approximately corresponds to the participants' valence ratings. Positive pictures are viewed with relaxed facial muscles. There is also a moderate correlation between heart rate and valence ratings. Unpleasant pictures lead to a higher heart rate, whereas viewing pleasant pictures decelerates it compared to neutral pictures (Lang et al., 1993).

Skin conductance correlates with arousal ratings. It is larger for highly arousing pictures than for barely arousing pictures. Electroencephalogram (EEG) studies show that the cortical slow-wave response to neutral pictures is more negative than to pleasant and unpleasant ones (Lang et al., 1993). There is also evidence of an early affective modulation of the event-related potential (ERP) waveform that sets in about 100 ms after stimulus onset and reaches its peak about 300 ms after stimulus onset (Schupp, Junghöfer, Weike, & Hamm, 2003).

Behavioral correlates Startle reactions elicited in the presence of emotional pictures are modulated by the stimulus valence. Startle potentiation can be observed when the picture being viewed is unpleasant. On the other hand, startle elicited in the presence of pleasant pictures is inhibited compared to a neutral picture condition (Davis, 2006; Lang et al., 1997).

1.2 Aim of the present study

The aim of the present study is to investigate the effects of picture valence, picture arousal and presentation time on recognition performance.

Briefly presented visual stimuli have been widely used in emotion and motivation studies. A prominent example is the work of Öhman et al. (2000) on preattentive processes in fear conditioning. The focus of the present study, however, lies on the initial properties of affective stimuli and their effects on perception. Stimuli that are arousing—either positive/appetitive or aversive/threatening—should have an initial advantage in capturing attention and the ensuing processing (Lang & Davis, 2006).

After a short review of selected studies the conception of the present study will be described in detail.

1.2.1 Related experiments

The first two studies presented below (Keil & Ihssen, 2004; Weber, 2006) illustrate the lack of homogeneous affective modulations in more complex experimental settings. The third study (Pessoa, Japee, & Ungerleider, 2005) deals with the detection of fearful faces. It features a slightly different design than the present study, but the presentation times and the analysis are similar.

Detection of affective verbs Keil and Ihssen (2004) found that emotional verbs had an advantage over neutral verbs in being detected in an attentional blink (AB) design[1]. Their findings suggest a facilitation of briefly presented

[1] The AB usually occurs in a rapid serial visual presentation (RSVP) sequence of stimuli (from 6 to about 20 stimuli/s) which contains two targets: if the second target (T2) appears within 150 to 500 ms after the first target (T1), the detection of the T2 is severely impaired (Raymond, Shapiro, & Arnell, 1992). The modulation of this impairment can be used to

affective stimuli. This result was replicated in a follow-up study (Keil, Ihssen, & Heim, 2006) in which EEG recordings revealed a characteristic early cortical facilitation for arousing targets.

Detection of affective pictures A similar experiment using picture stimuli failed to replicate the findings. Recognition accuracy did not depend on the arousal of the T2 picture but on the valence (Weber, 2006). The recognition performance was worst for unpleasant T2 pictures. This result suggests that pictorial stimuli have different properties than words.

Detection of affective faces About 64 % of the participants were able to reliably distinguish fearful faces from neutral faces presented for 33 ms in the experiment of Pessoa et al. (2005). The target stimulus was backward-masked using a neutral face. Half of the trials contained neutral target pictures. Three target presentation times were implemented: 17, 33, and 83 ms. Two (out of eleven) participants even showed a better-than-chance discrimination performance in the 17 ms condition.

1.2.2 Conception of the present study

Despite the large number of studies on emotion there is little research dealing with the perceptual properties of emotional stimuli. Analyzing the physical properties of the pictures is one option. But since an affective modulation in human perception occurs at a later step when pictures have already been processed to a certain degree, a different approach was required. Still, one prominent aspect of the IAPS pictures roots in low-level physical properties: color. Colors can have a big influence on attentive processes overshadowing other features (Desimone & Duncan, 1995) and affect performance in various contexts (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007). The pictures used in the present study were converted to grayscale to avoid any confounding effects of color.

study attentional processes (e. g., Keil & Ihssen, 2004).

The processing of emotional pictures can be addressed at various levels, because almost all aspects of visual perception are involved. Even with the focus on briefly presented pictures there are still plenty of possibilities, e. g., picture detection, picture categorization, and picture identification (Grill-Spector & Kanwisher, 2005).

The simple task of looking at the pictures has been performed in many experiments, either for normative purposes (e. g., Lang et al., 2005) or as an additional task to confirm the initially reported ratings and to compare the ratings to other measures (e. g., Lang et al., 1993; Schupp et al., 2004). The focus of the present study lay on the perception of briefly presented pictures. In contrast to priming experiments with subliminally presented cues, participants were aware of the presence of a target stimulus.

The pictures were rescaled to have an visual angle of $6.68° \times 5.02°$—big enough to depict the scene adequately but small enough to remain within foveal and parafoveal areas so that no saccades were required (Rayner, 1998). De Cesarei and Codispoti (2006) studied the influence of picture size using stimuli that covered either 100, 50, 25, or 12.5 % of the screen. They found an emotional modulation of ERPs at both earlier and later stages of processing for all sizes. Their data show progressively smaller effects for smaller compared to larger stimuli. The format of the pictures in the present study lies between that of the 50 and the 25 % condition.

A simple picture recognition task was chosen to study the emotional processes involved in picture perception with as few distractions as possible. A target picture was presented briefly. A probe picture followed after a mask and a short pause. The task was to report whether both pictures were the same or different ones. This design allowed the manipulation of presentation time and target picture valence. Three valence groups were used to study the assumed affective modulation of perception and control for arousal effects at the same time. The groups did not differ with respect to their average luminosity and their average complexity.

Three different presentation times were selected in the range between 10 and 40 ms. The presentation time of masked stimuli in conditioning experiments and detection experiments usually lies within this range (Pessoa, 2005). The actual presentation times were a result of restrictions imposed by the monitor.

Although the approach itself was straightforward the challenge was to come up with a balanced distribution of target and probe picture pairs. If a picture is shown repeatedly throughout the experiment participants become familiar with it and are likely to recognize it better than pictures which are presented for the first time. Each picture was shown exactly four times to minimize such effects: twice as target, twice as probe. Presumably, a participant's response depends on the particular probe picture to a certain degree. A correct response is more likely if the probe picture and the target picture look very different. For that reason, the pictures in the present study have been converted to grayscale (see above). Since pictures can differ in various other aspects (e. g., valence, luminosity, number of persons, textures) the most pragmatic way to control confounding effects was to hold the combinations of target and probe constant across participants. Therefore picture triples consisting of one picture from each valence category were created. Every trial contains pictures from only one triple. These restrictions led directly to the trial composition described in section 2.4.

The vast amount of trials required for a proper statistical analysis prevented the use of EEG measures which would have increased the burden on the participants and introduced even longer trial durations. The electrophysiological aspects involved can be the subject of a future experiment with fewer conditions (see section 4.3).

1.2.3 Randomization

An elaborate randomization procedure is conceived to prevent trial order effects from skewing the data. A simple randomization balances these effects in the long run. However, given the limited number of participants, a more pragmatic approach was taken. The major aim is to minimize sequence and habituation effects. These effects can be controlled ad hoc by dividing the experiment into separate blocks which contain all experimental conditions[2].

[2]See Britz, Seifert, Hermes, Hagemann, and Naumann (2007) for a short discussion.

Anticipation effects remain unlikely, because the trials within each block are randomized and participants are ignorant of the actual blocks. A detailed description of the implemented randomization can be found in section 2.4.

1.2.4 Hypotheses

Picture ratings Picture ratings of grayscale pictures will show the pattern which is typical for their colored counterparts.

Picture recognition Longer target picture presentation times will yield better recognition performances. Luminosity and complexity will have no effect on the recognition performance.

Affective modulation of picture recognition Participants will recognize pleasant and unpleasant pictures better than neutral ones, when the pictures are presented for only a short time (i. e., 13, 27, and 40 ms).

Absence of affective modulation in trials with incorrect responses The target picture valence does not have any influence on reaction time if the target could not be identified correctly. Since the responses from correct recognition trials and correct guess trials cannot be dissociated, it will have to suffice to analyze trials with incorrect responses.

2 Method

2.1 Participants

A total of 22 volunteers took part in the experiment. They were all students at the University of Konstanz. People who had previously participated in experiments using affective picture stimuli were not allowed to take part in the study. Participants were paid € 5.00 per hour or given course credit.

The data of three participants were discarded. One of them showed an insufficient performance in the eye test. Another one had previously worked with the IAPS pictures and was therefore familiar with some of them. A third one was presented half of the trials twice due to a computer error. The questionnaire data of one participant was lost due to computer malfunction. His experimental data was still used so that data sets from 19 participants (aged between 19 and 30 years, $\overline{x} = 23.3$, SD = 3.1) were used in the analyses.

2.2 Stimuli

The stimuli used in the experiment were images displaying at least one person. The majority of the pictures was taken from the IAPS. They were initially chosen according to their reported mean valence rating (Lang et al., 2005). They were then inspected by two colleagues and myself, and ambivalent pictures were discarded. Due to the limited amount of unambiguous pictures displaying at least one person, additional pictures similar to those of the IAPS had to be obtained, mainly for the neutral valence category (see Table 2 for details). They were taken from previous experiments and internet picture services (e. g., `www.flickr.com`). Permission to use them in this experiment was either obtained from the copyright owners or granted by the license under which the pictures had been published. Again, two colleagues and myself checked the initially chosen images for affective ambiguity.

A final set of 540 pictures was used in the experiment with 180 pictures for each of the three valence categories. They were rescaled to the size of 326×245 pixels and then converted to 8-bit grayscale. If necessary, horizontal or vertical black borders were eliminated by using an cutting out an excerpt

category	number	proportion
pleasant	15	8,3 %
neutral	106	58.9 %
unpleasant	39	21.7 %

Table 2: Proportion of non-IAPS pictures.

with 4:3 ratio. Finally, they were saved in JPEG (Joint Photographic Experts Group) format using Corel Photo Paint 12 with compression value 10 and smoothing value 10, coded neither in "progressive" format nor in "optimized" format.

Using file size as a crude measure of complexity (Buodo, Sarlo, & Palomba, 2002) and the mean of the luminosity histogram as a measure for luminance, the three sub-groups did not differ significantly in terms of complexity and luminosity ($\alpha = 0.05$). Furthermore, adjusted R^2 values were below 0.01 in both cases (0.007 and 0.003, respectively).

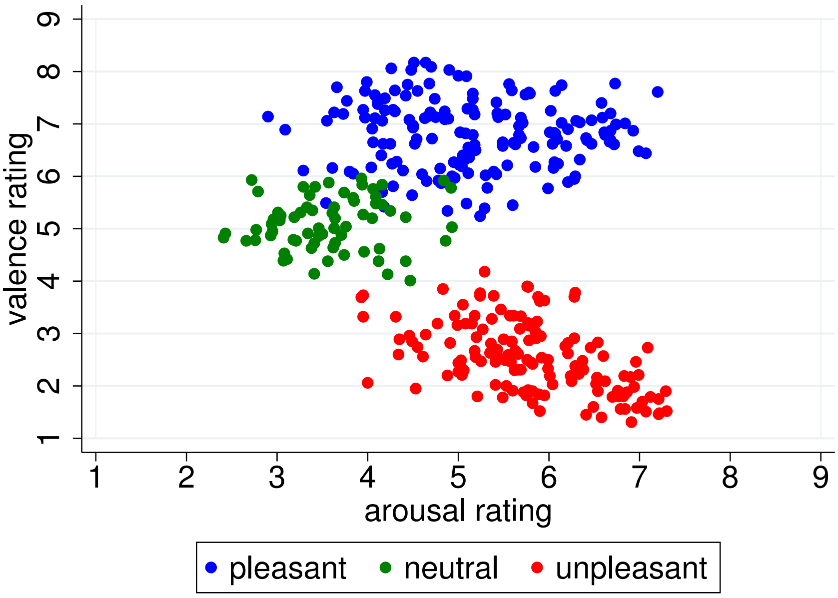

Figure 2: Pleasure and arousal ratings of the IAPS pictures used as reported by Lang et al. (2005). There is almost no overlap of categories.

Figure 2 shows a scatterplot of the IAPS pictures used in the present study with regard to their normative pleasure and arousal ratings. The boomerang-shaped distribution, which is characteristic for the covariation of pleasure and arousal ratings (Lang et al., 1997; Lang, Bradley, & Cuthbert, 1998), is still very obvious, even though pictures located on the border between two of the categories were sorted out.

A mask was created out of magnified white noise. Its luminosity histogram mean (102.8) was modified to resemble the average luminosity histogram mean of all pictures used ($\overline{x} = 102.5$), as well as their median (102.7). A few pictures that were excluded due to their ambivalence were retrieved to serve as stimuli in the training trials.

All stimuli on the computer screen were presented in the center of the screen on a gray background. A 22 in. monitor with a refresh rate of 75 Hz was used. The screen resolution was 1024×768 pixels. The distance between the participants' eyes and the screen was approximately 122 cm. Thus, the stimuli subtended a visual angle of $6.68° \times 5.02°$.

2.3 Procedure

After participants had been greeted by the experimenter, they were given an overview of the task and the scope of the experiment. Then their informed consent was acquired. Their vision was tested to be normal or corrected-to-normal. Next, they were asked to supply demographic information (i. e., age, gender) and to fill in the German version of the State and Trait Anxiety Inventory (STAI) (Laux, Glanzmann, Schaffner, & Spielberger, 1981) on a computer.

The recognition part and the rating part of the experiment were performed using Presentation® software (Version 10.0, `www.neuro-bs.com`). Participants were seated in front of a computer screen in a windowless room.

At the beginning of each trial participants were asked to press the space bar. A fixation point was displayed for 560, 706, 853, or 1013 ms, followed by a mask which was displayed for 107 ms. Then the target picture was briefly shown for 13, 27, or 40 ms, depending on the trial type. The mask was shown

107 ms once again, followed by another presentation of a fixation point for 560, 706, 853, or 1013 ms. Finally, the probe picture appeared for one second. From the onset of the probe on, participants had to decide whether it was the same as the target ("same picture") or not ("different picture"), pressing either the left or the right arrow key on the keyboard. The two response keys were counterbalanced across participants to prevent an uncontrolled response bias. After their first response, participants had to give a confidence rating of their answer. Using the up and down arrow keys they could choose between four options: certain, rather certain, rather not certain, uncertain. Figure 3 shows the schematic trial sequence. After confirming their choice with the space bar, the next trial began.

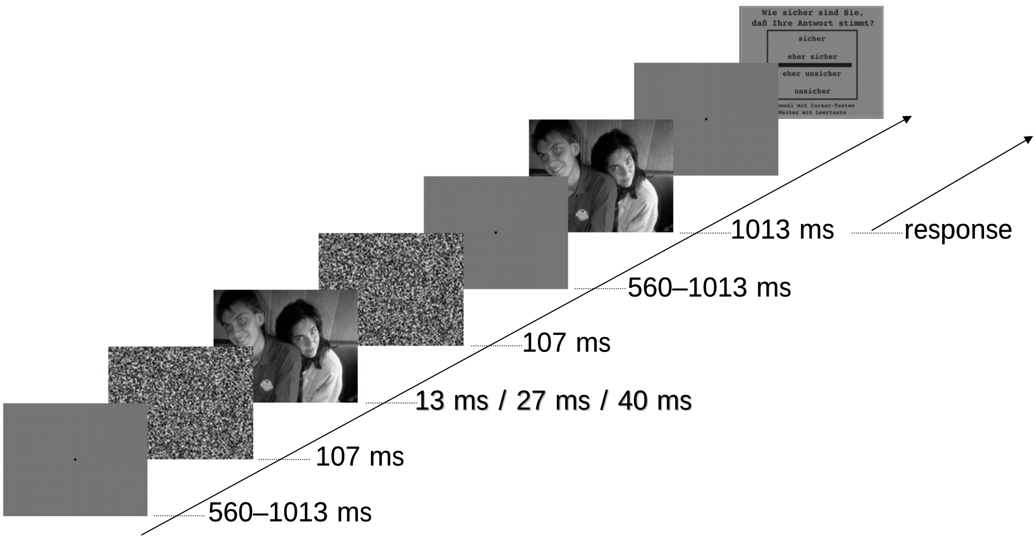

Figure 3: Schematic trial sequence.

In addition to oral explanations, participants were given printed instructions (see Figure 14 in the appendix). First there were two training trials in which the experimenter explained the task and made the responses. Then there were twenty training trials with the participant making the responses. The initial target picture presentation time during the test trials was longer than during the experimental trials, so that participants could get used to the task[3]. The pictures used in the test trials were slightly ambivalent pictures which had been discarded during the picture selection process described in section 2.2. The target presentation time was gradually shortened in order to approach the properties of the actual experiment.

The recognition part of the experiment was divided into six blocks. Each block began with one test trial, followed by 180 experimental trials. In addition to the mandatory breaks between these parts, participants could rest between each trial if necessary.

After finishing the recognition task, each participant rated a subset of 180 pictures for valence and arousal using a computerized version of the Self-Assessment Manikin (SAM) (Bradley & Lang, 1994). Each picture was presented in the center of the screen for 1 s. There were two training trials. See section A.3 in the appendix for the printed instructions and the additional instructions which were presented on the computer screen before the first training trial and before the first regular trial. The intertrial interval was 1.3 s.

In the end, participants were debriefed and paid. The whole experimental session lasted about three hours.

2.4 Trial composition and order

In order to avoid priming effects, a simple randomization approach was rejected. Instead, several steps were implemented to control the order in which the pictures were presented. First, the stimuli were randomly sorted into 180 triples, each of which contained one picture from each category. Once these triples were created, they remained fixed throughout the experiment for all participants. In this way, possible artifacts in the data caused by low-level perception and other non-emotional properties of single pictures became detectable and could be controlled across all participants.

The 180 picture triples were listed in random order for each participant anew and then numbered from 1 to 180.

[3]The target presentation times for the training trials were (in order) 507, 507, 307, 213, 107, 107, 93, 160, 79, 133, 93, 53, 40, 13, 40, 26, 40, 40, 27, 40, 27, and 40 ms.

Each picture was shown four times during the experiment, twice as target, twice as probe. For each picture, there was one trial in which target and probe were the same picture. Therefore, the correct response was "same picture" in 50 % of all trials. The remaining trials featured two different pictures as target and probe (the correct response being "different picture"). This design prevents a response bias towards a dominant answer. At the same time, it makes a complete permutation of conditions for each triple impossible. Once the first picture of a triple (e. g., the pleasant one) appears as a target with a different picture (e. g., the unpleasant one), the remaining two "different picture"-trials of that triple become fixed (e. g., neutral target → pleasant probe and unpleasant target → neutral probe), given a balanced design across all such trials. Table 3 shows the schematic order of trials. The last three rows correspond to these trials, whereas the first three rows depict the "same picture"-trials. Half of the "different picture"-trials were derived from the combination of a pleasant target and an unpleasant probe, whereas the other half were derived from the combination of a pleasant target and a neutral probe.

PP1	PP2	PP3	PP1	PP2	PP3
NN3	NN1	NN2	NN3	NN1	NN2
UU2	UU3	UU1	UU2	UU3	UU1
PU3	PN3	PU2	PN2	PU1	PN1
NP2	NU2	NP1	NU1	NU3	NP3
UN1	UP1	UP3	UN3	UP2	UN2

Table 3: Schematic order of trials. The first letter depicts the valence of the target stimulus (P = pleasant, N = neutral, U = unpleasant), the second one that of the probe. The digit denotes the target presentation time (1 = 12 ms, 2 = 24 ms, 3 = 36 ms). The columns contain the trials for $\frac{1}{6}$ of the triples, respectively. Thus, each "same picture"-trial appears twice.

A vector of the columns of Table 3 was made. The first 36 triples were then assigned to this vector. This procedure was repeated for the second 36 triples, and so on. This resulted in the first 180 trials. This procedure was repeated with the first triple being assigned to the second component of the vector, the second one to the third component, and so on, and the 36th one to the first component (i. e., the partial triple vector was put next to the vector of trial types and shifted by one row). Again, the procedure was repeated with the remaining groups of 36 triples, resulting in 180 more trials. Next, the assignment of triples to trials was shifted by two rows, then by three, up to five, resulting in 1080 trials (Table 4). Last, the order within the first six trials was randomized, then that within the second six trials, up to that within the 180th six trials.

trial type	triple number										
PP1	1	37	⋯	145	36	⋯	180	35	⋯	176
NN3	2	38	⋯	146	1	⋯	145	36	⋯	177
UU2	3	39	⋯	147	2	⋯	146	1	⋯	178
PU3	4	40	⋯	148	3	⋯	147	2	⋯	179
NP2	5	41	⋯	149	4	⋯	148	3	⋯	180
UN1	6	42	⋯	150	5	⋯	149	4	⋯	145
PP2	7	43	⋯	151	6	⋯	150	5	⋯	146
⋮	⋮	⋮	⋱	⋮	⋮	⋱	⋮	⋮	⋱	⋮
UN2	36	72	⋯	180	35	⋯	179	34	⋯	175

Table 4: Assignment of triples to trials.

2.5 Data analysis

2.5.1 Picture ratings

Two analyses of variance (ANOVAs) were performed to assess SAM rating differences between the three picture categories, one using valence ratings as dependent variable, one using arousal ratings as dependent variable. A Scheffé multiple-comparison test was performed in both cases for pair-wise comparisons of picture categories.

2.5.2 Comparison of conditions across participants

The proportion of correct answers within each condition (three valence categories × three presentation times) were used as dependent variable in an ANOVA to test for effects across participants. An analogous ANOVA was performed using reaction times as dependent variable. A third ANOVA tested differences in reaction times for correct and incorrect responses within each valence category. Confidence intervals for each condition were obtained assuming an asymptotic normal distribution.

2.5.3 Signal-detection theory analysis of individual performances

Receiver operating characteristic (ROC) curves play an important role in the analysis of individual participants' performances in the present study. Their basic features will be outlined in a short overview of the relevant signal-detection theory (SDT) elements[4] (Green & Swets, 1966). This section is based on MacMillan and Creelman (1991) and Wickens (2002).

ROC curves are plotted using the hit rate (sensitivity) and the correct-rejection rate (specificity). In the present study, the hit rate is characterized as

$$h = \frac{\text{Number of correct “same picture”-responses}}{\text{Total number of “same picture”-trials}}$$

and the correct-rejection rate as $1 - f$ with

$$f = \frac{\text{Number of incorrect “same picture”-responses}}{\text{Total number of “different picture”-trials}}.$$

The false-alarm rate f is plotted on the abscissa and the hit rate h on the ordinate of a scatterplot. This unit square is called the ROC space. The results of a session can be depicted as a point in this square. Points for chance performances usually scatter around the diagonal that connects the point (0,0) to the point (1,1). Points that indicate at least some successful recognition lie in the upper triangle.

[4]The notation of the trial types has been slightly modified to suit the present study: “different picture” is used instead of noise and “same picture” is used instead of signal.

If a person's true detection performance remains stable across time, the actual response pattern can still vary depending on a subjective decision criterion (response bias). For example, people might choose to answer "same picture" only when they are absolutely certain that both pictures were the same. Others might prefer to make a random guess when they are uncertain. The response bias may also shift within participants and sessions. The sensitivity will then remain the same for different criteria. One option is to force participants to adopt a certain criterion via instructions which is fairly difficult given the subjective nature of the response bias. However, this is not necessary. It is more convenient to add a confidence rating (e. g., on a four-point scale ranging from "certain" to "uncertain") after each decision. The results can be used to construct several pairs of hit rates and false-alarm rates. For the first pair the numerator of h is the number of correct "same picture"-responses which received the highest confidence rating and the numerator of f is the number of incorrect "same picture"-responses plus the number of correct "same picture"-responses which did not receive the highest confidence rating. For the second pair the number of correct "same picture"-responses is substituted by the number of "same picture"-responses which received either the highest or the second highest confidence rating, and so on. The line which connects the resulting points, the origin (0,0), and the point (1,1) constitutes the empirical ROC curve. The area underneath this curve is A_g. A_g becomes larger when a person's detection performance improves.

It has been argued that measures which are developed directly from the areas can be used as nonparametric measures. But the extrapolation of the data uses implicit assumptions about the distribution of responses. "One has to have some sort of model or description process, and the Gaussian model is a good choice." (Wickens, 2002, p. 74)

In the Gaussian model the distributions of the two trial types, X_{diffpic} and X_{samepic}, follow a "bell-shaped" normal distribution. The first distribution is arbitrarily set to be $X_{\text{diffpic}} \sim \mathcal{N}(0,1)$, which leaves three more unknown parameters: μ_{samepic}, $\sigma^2_{\text{samepic}}$, and the response bias. If the data from a simple experiment with two possible responses provide just h and f, variances are usually assumed to be equal, so that the sensitivity and the response bias can be computed[5].

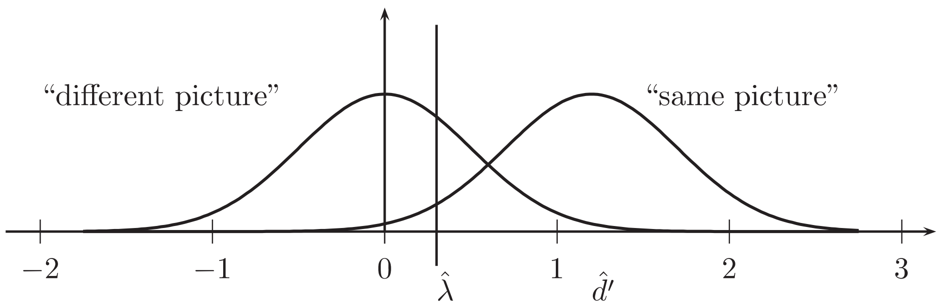

Figure 4: Example of two Gaussian trial type distributions with equal variances. The distance between μ_{diffpic} and μ_{samepic} corresponds to the participant's sensitivity d'. Note that $\hat{d}' = \mu_{\text{samepic}}$ because $\mu_{\text{diffpic}} = 0$. The participant's response bias is denoted by $\hat{\lambda}$. The area beneath each distribution to the right denotes the probability of a "same picture"-response given the respective trial type, and vice versa.

Figure 4 shows two example distributions with equal variances. The sensitivity measure d' is the difference between the means. In general, d' is then defined as

$$d' = z(h) - z(f)$$

where z is the inverse of the normal distribution function. The basic response bias measure for SDT λ is defined as

$$\lambda = -0.5(z(h) + z(f)).$$

The area under the "same picture"-distribution to the right of the response bias estimate $\hat{\lambda}$ corresponds to the probability of a correct "same picture"-response. The area under the "different picture"-distribution to the right of $\hat{\lambda}$ corresponds to the probability of an incorrect "same picture"-response. Vice versa, the area under the "same picture"-distribution to the left of the $\hat{\lambda}$ corresponds to the probability of an incorrect "same picture"-response

[5]There are also other models using different assumptions, but they are beyond the scope of this thesis.

and the area under the "different picture"-distribution to the left of the $\hat{\lambda}$ corresponds to the probability of a correct "different picture"-response.

If d' is held constant, all possible values of λ lie on a so-called isosensitivity curve in ROC space. The multiple points obtained in rating experiments can be used to estimate d' and the corresponding area beneath the isosensitivity ROC curve, A_z. Estimates of the latter show a smaller variability at high values (i. e., sessions with only few incorrect responses) due to the fact that they are bounded by one. The estimates can be tested against given values, most prominently 0.5, which would indicate a recognition performance at chance level.

In the present study A_g was tested for differences between picture categories. A_z was tested against chance performance (H_0: $A_z = 0.5$) to analyze performance and affective modulation of that performance within participants.

2.5.4 Additional analyses

The top and the bottom decile of the pictures ordered by their arousal rating (see section 2.5.1) formed two extreme arousal groups. An ANOVA was performed to test for differences between these two groups within each presentation time condition which might be too subtle to be detected by an analysis of all trials. This was done to test for effects of emotional intensity that are not necessarily tied to a specific valence category.

To control the effect of luminosity and complexity a linear regression with proportion of correct answers as dependent variable was performed for each variable.

3 Results

3.1 Picture ratings

Figure 5 shows the mean picture rating for each picture category. ANOVAs yielded highly significant results for valence ($F(2, 537) = 1095.32$, $p < .001$) and for arousal ($F(2, 537) = 315.15$, $p < .001$). All pair-wise comparisons were also highly significant ($p < .001$). As expected, pleasant pictures received high valence ratings, whereas unpleasant pictures received low valence ratings. Unpleasant pictures received the highest arousal rating, followed by pleasant pictures. Neutral pictures received the lowest arousal rating. This pattern also holds true for the non-IAPS subset of pictures (see section A.1 in the appendix).

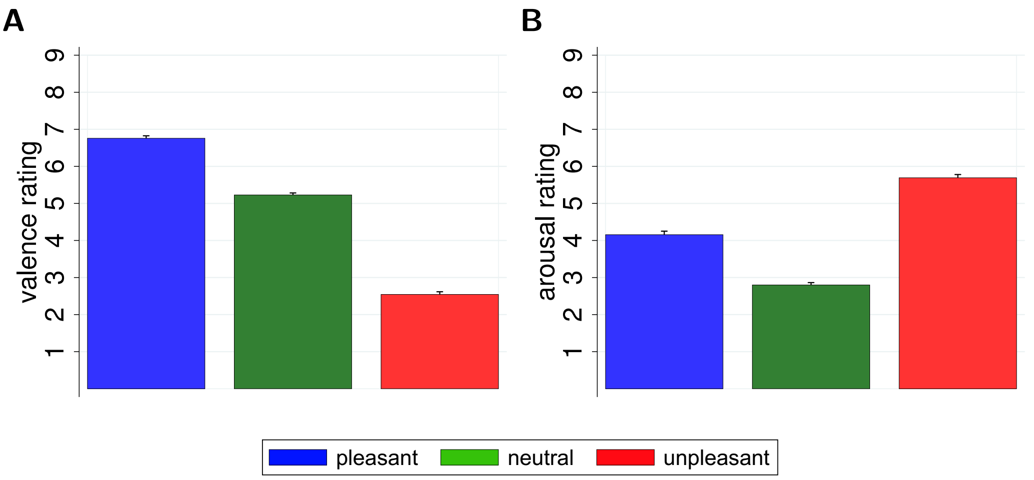

Figure 5: Mean valence (A) and arousal (B) rating of pictures for each picture category. Error bars denote standard errors.

The scatterplot of valence and arousal ratings in Figure 6 resembles the boomerang shape usually found in affective picture ratings (see Figure 2 on page 20), even though there is a certain overlap of the three picture categories. Still, unpleasant pictures are mainly in the lower right quadrant, rated as unpleasant and highly arousing. Neutral pictures received lower arousal ratings and average valence ratings. Some pleasant pictures fell into the same area, but most of them can be found in the upper right quadrant, rated as pleasant and highly arousing.

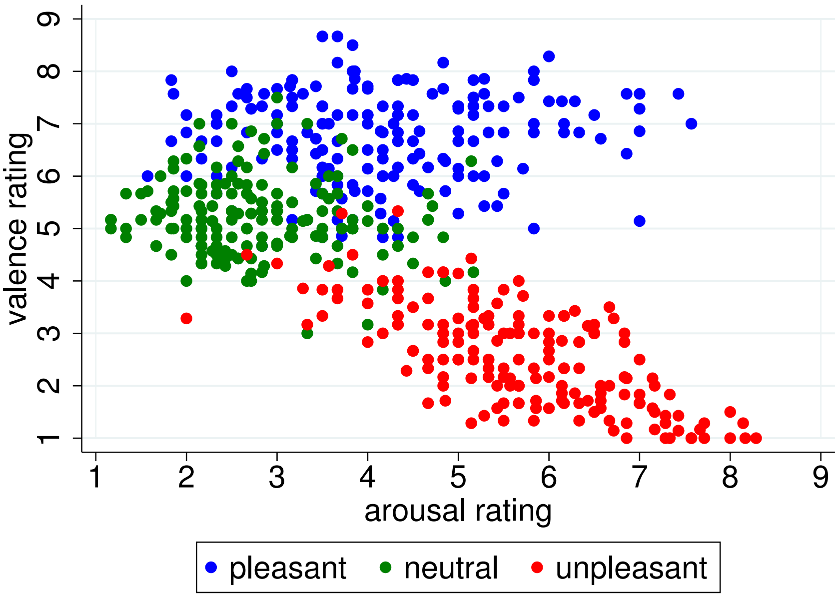

Figure 6: Pleasure and arousal ratings for the pictures used in the experiment.

3.2 Comparison of conditions across participants

The ANOVA using presentation time and picture category as factors predicting the response revealed a clear effect of presentation time ($F(2, 162) = 218.97$, $p < .001$). The effect of picture category was not significant ($p > 0.28$), nor was the interaction term. Figure 7 shows the proportion of correct responses across participants in each presentation time and picture category condition. There were more correct responses in trials with longer presentation times. There was no statistically tangible affective modulation, although unpleasant pictures showed a tendency to yield fewer correct responses with an increase in presentation time.

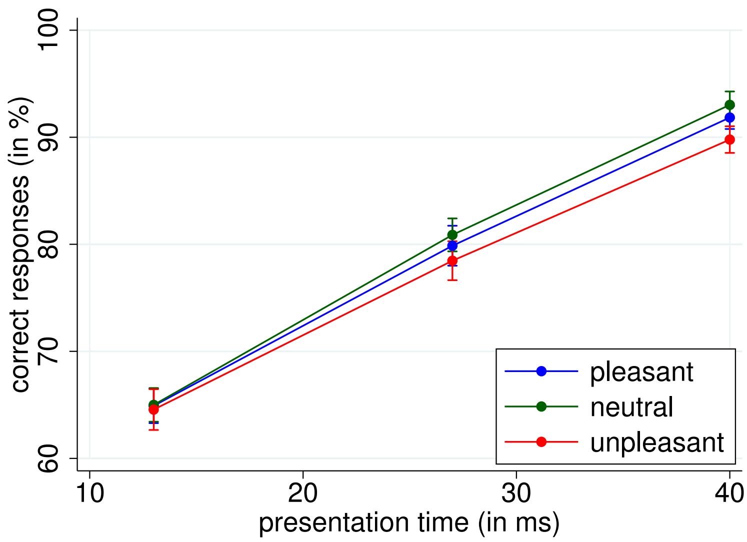

Figure 7: Recognition performance in each presentation time and picture category condition. Error bars denote standard errors.

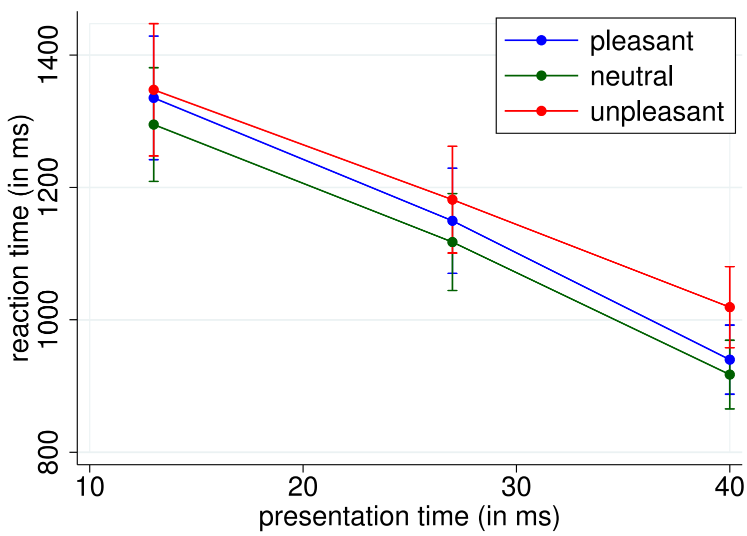

Figure 8: Mean reaction times in each presentation time and picture category condition. Error bars denote standard errors.

The ANOVA testing for differences in reaction times in each presentation time and picture category condition showed a highly significant effect of presentation time ($F(2, 162) = 17.04$, $p < .001$). The affective modulation factor failed to reach significance ($p \approx 0.511$). The interaction of both factors was not significant. Figure 8 illustrates these results. The longer the presentation time, the shorter were the participants' reaction times. Responses to unpleasant pictures appear to be slightly longer than to neutral pictures, but the effect is not significant.

The ANOVA comparing the reaction times of correct responses with that of incorrect ones for each picture category revealed a highly significant effect of correctness ($F(1, 20514) = 482.05$, $p < .001$) and a significant effect of picture category ($F(2, 20514) = 4.33$, $p < .02$). Still, the explained variance remained low ($R^2 = 0.0245$) and the interaction term did not achieve significance ($p \approx 0.080$). Figure 9 illustrates the findings that correct re-

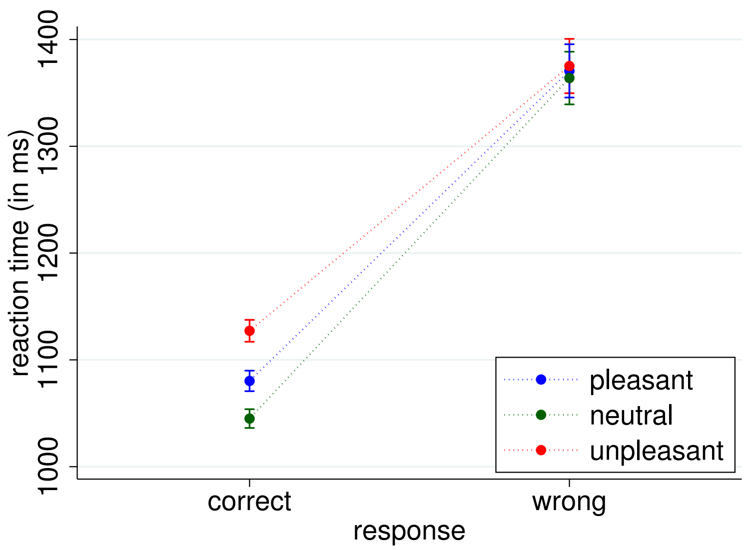

Figure 9: Comparison of reaction times of correct and incorrect responses. Error bars denote standard errors.

sponses were made a lot faster than incorrect responses. Responses were the fastest for neutral target pictures and the slowest for unpleasant target pictures. This pattern is clearly visible given correct responses. Although the interaction term did not reach significance, the plot suggests a much smaller valence effect given incorrect responses. The analysis should be interpreted with care, because the proportion of correct answers (78.7 %) is much larger than that of incorrect answers (21.3 %).

Section A.2 in the appendix contains supplementary data for the results presented above.

3.3 Analysis of individual performances

ROC curves from three participants are presented in Figure 10. It shows the data from the participants with the fewest, average, and the most correct responses to illustrate the differences between participants. Again, there is a clear effect of presentation time on the recognition performance: longer presentation times yielded a higher proportion of correct responses.

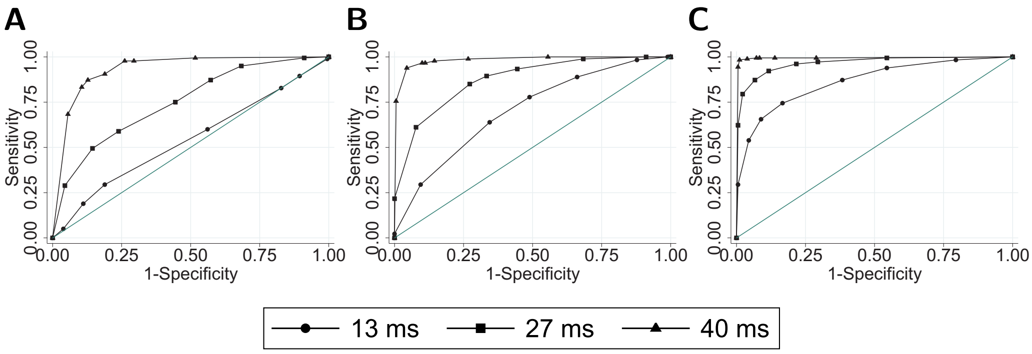

Figure 10: Examples of individual recognition performance. ROC curves of each presentation time condition from the participants with the fewest (A), average (B), and the most correct responses (C) are presented from left to right.

The area under the ROC curves was significantly modulated by the picture category for three (out of 19) participants within the presentation time conditions. One showed significant differences depending on the picture category in the 13 ms condition, one in the 40 ms condition, and one in the 27 ms condition as well as in the 40 ms condition. There is no consistent pattern of differences. All three picture category conditions showed the best recognition performance in at least one case. There were no significant differences in recognition performance between picture categories for the remaining 16 participants. The complete ROC data is reported in Table 11 in the appendix.

The area under the ROC curve was significantly different from 0.5 (i. e., chance level) for 16 (out of 19) participants in the 13 ms and for all participants in the other presentation time conditions. Thus, most participants were able to recognize some of the briefly presented pictures even in the shortest presentation time condition. Figure 11 shows the ROC curves of an average participant to illustrate the variability of the effect of picture category on recognition performance.

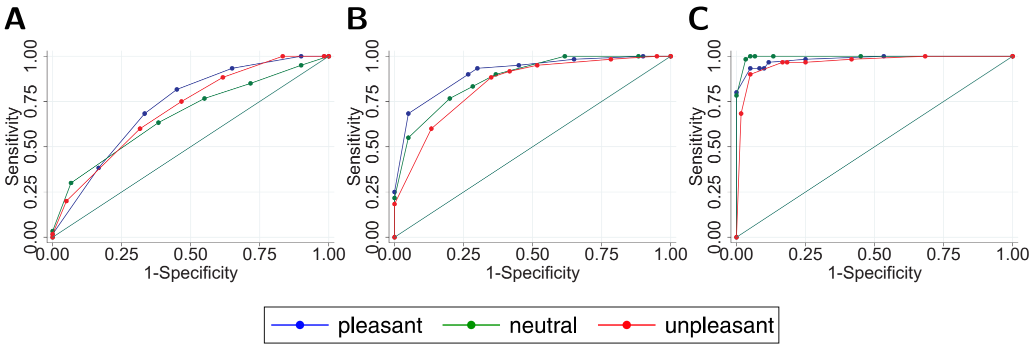

Figure 11: Example of effects of picture category on recognition performance. ROC curves of each picture category from the participant whose performance was closest to the overall mean are shown. Separate plots were created for each presentation time (from left to right: 13, 27, and 40 ms).

3.4 Comparison of highly and barely arousing pictures

The trials were ordered by the average arousal rating of the target picture as obtained in the SAM rating part of the experiment. Then the top and the bottom decil of that list were used to create two groups, one containing highly arousing target pictures, the other one containing barely arousing target pictures. The ANOVA results were significant for both the presentation time factor ($F(2, 108) = 110.50$, $p < .001$) and the arousal group factor ($F(1, 108) = 4.36$, $p < .04$). Figure 12 shows the proportion of correct responses for both groups across presentation time condition. There were more correct responses in trials with barely arousing target pictures than in trials with highly arousing target pictures. The graph suggests a small ceiling effect in the 40 ms presentation time condition, but the interaction term of the ANOVA was not significant.

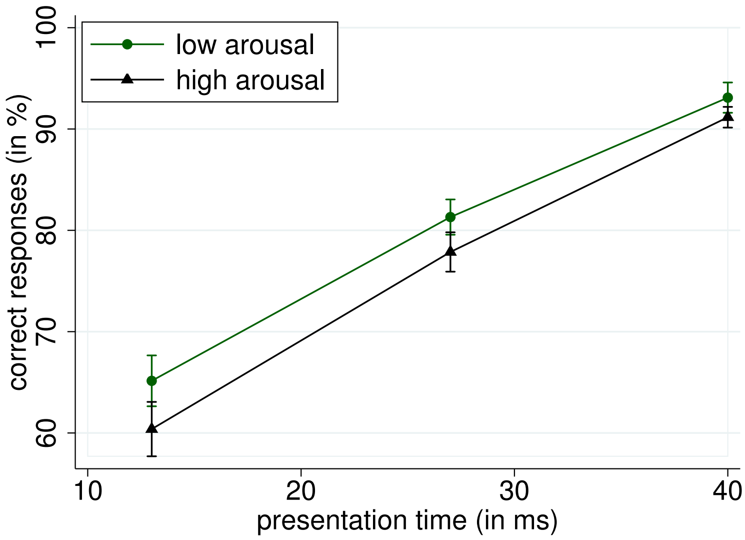

Figure 12: Recognition performance for very highly and barely arousing pictures in each presentation time condition. Error bars denote standard errors.

3.5 Control of luminosity and complexity

Two linear regressions were performed in order to test for effects of target picture luminosity and complexity on picture recognition. Both variables failed to explain any substantial variance. Despite the large amount of pictures none of the variables came even close to becoming significant. The plots in Figure 13 illustrate the findings. Neither luminosity nor complexity had any tangible effect on participants' responses. There are also no signs of interactions with picture category.

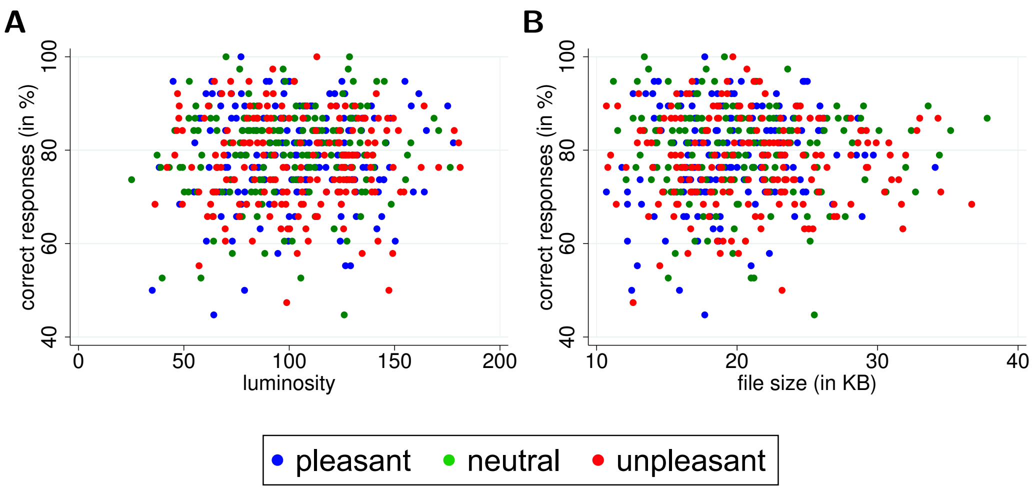

Figure 13: Control of luminosity (A) and complexity (B). Both variables appear to be independent from answer correctness. There are no signs of interactions with picture category.

3.6 Precision of confident responses

The performance in trials that were rated as certain was above chance level (50 % correct responses) for all three presentation times ($p < 0.001$ for each one-sample t-test). There were several trials in which the participants gave confident and correct responses (see Table 5 for the actual numbers). The findings from the ROC curves analysis support this notion (see section 3.3 and also Table 11 in the appendix). Since the amount of trials per cell is rather large ($n = 120$), these results should not be overestimated. They underscore the aspect that the actual degree of awareness varies a lot between participants.

presentation time	amount of trials (proportion)	correct responses
13 ms	1,499 (21.9 %)	71.2 %
27 ms	2,822 (41.3 %)	89.4 %
40 ms	4,658 (68.1 %)	97.2 %

Table 5: Amount of and performance in trials that were rated as certain.

4 Discussion

The present study was designed to test whether the recognition of briefly presented pictures is influenced by the affective properties of the depicted scenes. First, a sandwich-masked target picture was presented for 13, 27 or 40 ms, followed by a probe picture after a short pause. Participants had to decide whether both pictures were the same ones or different ones. Because emotions facilitate the processing of stimuli that are potentially relevant for the survival and well-being of the organism (Lang & Davis, 2006), the recognition of pleasant and unpleasant pictures was predicted to be superior to that of neutral pictures.

Affective modulation of recognition performance The predicted affective modulation of the recognition performance did not occur. The effect of target picture valence is very unstable across participants and not significant. The emotional circuits that facilitate the processing of pleasant and unpleasant stimuli appear to have no immediate effect on the successful identification of briefly presented pictures. The findings that the recognition of very arousing pictures is worse compared to the recognition of barely arousing neutral pictures even suggests that these systems interfere with the successful identification of target pictures. The increase of reaction times for unpleasant pictures compared to neutral pictures lends further support to this speculation.

Validity of picture material Although the pictures used in the present study were rather small in size and converted to grayscale, their affective properties remained intact. The vast majority of the valence ratings corresponds to the respective valence category. The arousal ratings show the typical pattern of the two underlying motivational systems: while pleasant pictures were rated as arousing and unpleasant pictures as very arousing, neutral pictures received low arousal ratings. IAPS and non-IAPS pictures were rated similarly. The picture ratings will be discussed further in the next section, followed by a discussion of the performance in the recognition task.

4.1 Affective picture properties

The SAM ratings confirm the expected characteristics of the stimulus material. Pleasant pictures received high arousal and high valence ratings. Neutral pictures received low arousal and average valence ratings. Unpleasant pictures received high arousal and low valence ratings. Rescaling, conversion to gray-scale, and inclusion of non-IAPS pictures did not fundamentally affect the rating. The distribution of pictures in affective space has the characteristic boomerang-shaped form, leaving gaps where highly arousing neutral pictures and pleasant or unpleasant but not very arousing pictures would be. The three subgroups dominate their respective quadrant, although the distinction is not always clear (see Figure 6). A possible explanation for the overlap of valence categories is the presence of at least one partially visible person in each picture. While the original IAPS pictures with the highest arousal rating usually feature humans, many neutral and barely arousing pictures show inanimate objects. In contrast to this, almost all of the neutral pictures in the present experiment contained human faces. Although they were chosen to have neutral expressions, faces in general have been argued to be "evolved modules for social interchange" (Öhman, Lundqvist, & Esteves, 2001, p. 394). They can be used as a source to infer behavioral strategies and affective inclinations. This could give them some ambiguous emotional quality. The absence of threat and fear in the expressions might have led participants to infer a rather positive valence and develop a tendency to rate the respective pictures high in terms of valence.

Since there was only a small number of ratings per picture, outlier ratings of a single person for a single picture have more impact than in other studies where all—and sometimes also more—participants rate all pictures.

The normative IAPS ratings helped to create the three picture subgroups. Since these ratings show some variation, ambiguities in the SAM ratings in the present experiment might partly be due to regression to the mean (e. g., Huck & Sandler, 1979). If some of the overlap is the result of chance variation, the data are perfectly consistent with the main differences between valence categories, which were found in the SAM ratings of the present experiment.

Finally, the actual content of the pictures was also considered in choosing the stimuli. A few pictures with slightly incongruent ratings were included due to this procedure. Their effect on the rating is at worst very small given the huge amount of pictures used in the present study.

4.2 General discussion

4.2.1 Awareness and interpretation of visual cues

The depicted scenes offer more cues than more homogeneous stimuli like faces. The overall performance suggests that some features of the pictures can be perceived even when they are shown for only 13 ms. Performance was above chance level (50 % correct responses) for all presentation times. So there is a considerable proportion of trials in which the participants were confident about their decisions and gave sound responses. The ROC curves analysis underscores these findings. It implies that masked pictures of complex scenes used in conditioning experiments (e. g., Öhman et al., 2000) might be partially perceived. A recent study by Einhäuser, Koch, and Makeig (2007) shows similiar results. Faces and watches were used as targets in an RSVP sequence of grayscale pictures. Although recognition performance decreased with increasing presentation rate, participants were able to reliably recognize some of the face targets even for image presentations as short as 25 ms.

It cannot be ruled out that selective features facilitated the recognition of certain pictures compared to others. All participants remarked that they had used this strategy in some trials. Still, the data in Table 5 implies that even with these cues their judgment was far from perfect in the two shortest presentation time conditions. Out of all responses rated as certain in the 13 ms condition 29.8 % were incorrect. So even if selective features were used to recognize a picture, they were not very helpful.

Things look different in the 40 ms condition. The very good recognition performance might be partly attributed to specific features. At the same time, global properties are probably more salient here. Some participants' responses also show clear ceiling effects which might be responsible for the slightly decreased slope in the right half of Figure 12. It might also be possible that the features that facilitated recognition are unrelated to the affective content of the respective picture. This would explain the lack of affective modulation in the overall analysis.

The large variability between participants might be partly responsible for the lack of a significant effect of target valence on recognition performance (Wiens, 2006). Still, the comparison of trials with only very arousing pictures to trials with barely arousing pictures reveals a different scenario. Highly arousing picture content seemed to impair the recognition of briefly presented pictures. These findings will be discussed in the next section.

4.2.2 Arousal-induced impairment of rapid feature analysis

The present results do not show the hypothesized facilitation of recognition of very arousing pictures. In contrast, highly arousing pictures elicited significantly fewer correct responses compared to barely arousing pictures (see section 3.4). The underlying motivational process appears to be different from those studied in picture viewing experiments with longer presentation times (e. g., Lang et al., 1997). According to Lang and Davis (2006, p. 23), emotions "reflect sequenced, somatic and autonomic reflexes," indicating that the sequence of reflexes is in some way depending on the stimulus properties, the experimental task and context, and possibly also the presentation time. Very brief stimulus exposure (e. g., 13 ms) provides limited input which might be processed in different ways depending on their affective properties. Perhaps the arousal elicited by emotional pictures impedes the processing of picture details which facilitate recognition. Such an arousal-accuracy trade-off could explain the results of the present study. If early cortical facilitation for arousing targets—which is maximally pronounced around 250–300 ms (Schupp, Flaisch, Stockburger, & Junghöfer, 2006; Keil et al., 2006)—is merely indicating a preparatory step in processing affective stimuli, perception of barely arousing pictures that does not require this preparatory step and concentrates on the actual visual features is more detailed—and the ensuing responses more accurate.

Since the perceptual input is very limited in the present study, any intermediate perception process might be handicapped by a lack of sufficient stimulus activation. Arousing pictures might lead to such a lack by activating the stimulus category instead of the stimulus identity. Evans and Treisman (2005) studied detection and identification performance in an RSVP sequence using pictures of animals and vehicles as targets. Participants frequently failed to identify targets that they had correctly detected. This suggests that detection was based only on partial processing. Evans and Treisman (2005) argue that a rapid feature analysis mediates detection. This initial analysis is followed by attention-demanding binding for identification. A lack of sufficient activity of separate stimulus features is likely to interfere with successful binding. This model could therefore account for the results of the present study, given that high arousal hampers early feature processing in the first place.

The findings that reaction times were the slowest for unpleasant pictures and the fastest for neutral pictures are in line with this hypothesis. The affective modulation of reaction times can be interpreted as a sign of more sophisticated processes triggered by emotional pictures. Such processes would most likely require more resources and as a consequence more time. This seems to contradict the tenet that emotions are action dispositions which facilitate congruent reflexes.

The first reaction to a newly registered stimulus is an "orienting reflex" which habituates for neutral stimuli and adjusts for emotional stimuli (Lang & Davis, 2006). For example, unpleasant stimuli elicit a defense reflex—a deceleration in heart rate ("fear bradycardia") and an initial inhibition of movement ("freezing")—in rats[6] (Fanselow, 1994) and a similar action readiness and shift of attention in humans (Lang & Davis, 2006). The affective property of a stimulus that elicits the defense reflex (or some reflex preparing consumption behavior if the stimulus is appetitive) certainly facilitates con-

[6]Fanselow (1994) studied fear behavior in rats and describes a defense response cascade which consists of three stages of increasing prey-predator proximity: pre-encounter defense (pre-emptive threat vigilance), post-encounter defense (freezing and orienting after detection of a specific predator cue), and circa-strike defense (overt defensive actions).

gruent responses and cues about which of these responses to execute, e. g., fight or flight (Lang et al., 1997). The results of the present study point out the possibility that these processes—or some of their side effects like the induction of defensive nonopiate analgesia (Lang et al., 1997)—interfere with the identification of the briefly presented target in return. If this is the reason for the lower amount of correct responses in trials with highly arousing pictures, there should be no such impairment if the identification task was replaced by an categorization task. Some further possible follow-up studies will be outlined in section 4.3.

Note that high arousal is confounded unpleasantness in the present results: there were 45 unpleasant pictures among the 54 pictures with the highest arousal rating, and only nine were pleasant pictures. So what looks like an arousal effect might in reality be a valence effect.

4.2.3 Affective modulation in competitive situations

The lack of distractor stimuli, which compete for attention and subsequent processing capacities might have led to the absence of an affective modulation in the present study. If the experimental task was repeated using electrophysiological measures, EEG recordings should still show the early posterior negativity and increased late positive potentials, which are typically elicited by emotional stimuli (Schupp et al., 2006).

Öhman, Flykt, and Esteves (2001) found that a deviant snake or spider picture among flowers or mushrooms can be easier detected than vice versa. The same goes for schematic faces with angry and neutral expressions (Öhman et al., 2000). So possibly affective facilitation of briefly presented emotional pictures occurs only if distracting stimuli are present which compete for attention or a difficult task induces a high attentional load. This option is considered among others in the next section.

4.3 Outline of possible future studies

Any study with fewer trials is going to require fewer pictures. Pictures which received ambivalent or even incongruent rating can be discarded in order to render the picture categories more homogeneous. This should enhance a possible affective modulation of picture perception.

The simplest approach would be to replicate the experiment using only a target duration of 40 ms to study a possible valence effect. This design would require fewer trials so that EEG recordings become feasible. Still, possible ceiling effects are likely to limit the scope of the results by reducing the amount of trials with incorrect responses. Instructing participants to give their answer as fast as possible might help to counteract this tendency. It would also yield faster reaction times with less variation.

A similar experiment could be designed to study the impaired recognition of highly arousing pictures. The use of two arousal categories instead of three valence categories reduces the amount of trials required. Target duration could still be manipulated using either two or three different presentation times somewhere in the range between 10 and 40 ms.

A transition from the present picture identification task to a more general picture categorization task[7] should also shed light on the processing of briefly presented pictures. The performance in both tasks can be compared if all other parts of the experiment remain unchanged. Possibly, the categorization of affective pictures is facilitated by early perceptual processes (Stolarova, Keil, & Moratti, 2006), but without modulating the processing of details required for successful picture identification.

In a recent attentional blink (AB) study, Einhäuser et al. (2007) used complex visual stimuli as targets (e. g., faces and watches) and distractors (e. g., scenes that did not contain faces or watches). They found that the duration of the AB depends on target category. The AB appeared later and lasted longer for watch targets than for face targets. Parts of the design of the present experiment could be integrated into an AB study similar to that of Weber (2006, see section 1.2.1) to explore how emotional pictures modulate the AB depending on their valence and arousal. The present response format could be put after an RSVP sequence with two target pictures.

[7] For example, using a simple question like "(Was the picture) unpleasant?" as probe. Categorization tasks yield less errors and faster reaction times than identification tasks (Grill-Spector & Kanwisher, 2005).

4.4 Conclusions

The SAM ratings of grayscale pictures showed the pattern which is typical for their colored counterparts.

Longer target picture presentation times led to more correct responses and faster reaction times. Neither the luminosity nor the complexity of the pictures had any effect on the recognition performance.

Participants did not recognize pleasant and unpleasant pictures better than neutral ones, when the pictures are presented for only a short time (i. e., 13, 27, and 40 ms). The comparison of trials with highly arousing target pictures and barely arousing target pictures revealed that there were fewer correct responses if the target picture was highly arousing. These results are a challenge for the tenet that emotionally intense stimuli facilitate processing. Possibly, the emotional processes facilitate only the initial categorization of affective stimuli but interfere with the successful identification in the present experimental setting due to the brief stimulus exposure and the lack of distractors.

A Appendix

A.1 Picture ratings

category	mean valence rating (SD)	mean arousal rating (SD)
pleasant	6.76 (0.90)	4.16 (1.28)
neutral	5.23 (0.72)	2.80 (0.85)
unpleasant	2.54 (0.97)	5.69 (1.17)

Table 6: SAM rating results for each valence category.

	IAPS pictures			non-IAPS pictures		
category	n	valence	arousal	n	valence	arousal
pleasant	163	6.76 (0.92)	4.25 (1.28)	17	7.12 (0.60)	3.29 (0.83)
neutral	73	5.20 (0.75)	3.03 (0.91)	107	5.25 (0.71)	2.64 (0.77)
unpleasant	145	2.55 (0.98)	5.75 (1.20)	35	2.53 (0.94)	5.45 (1.03)

Table 7: Separate mean SAM ratings for IAPS and non-IAPS pictures (standard deviations in brackets).

A.2 Recognition performance

	proportion of correct answers (SD)		
presentation time	pleasant	neutral	unpleasant
13 ms	64.9 % (7.0 %)	65.0 % (6.9 %)	64.6 % (8.3 %)
27 ms	79.9 % (8.1 %)	80.9 % (6.7 %)	78.5 % (7.9 %)
40 ms	91.8 % (4.7 %)	93.0 % (5.4 %)	89.8 % (5.4 %)

Table 8: Proportion of correct answers in each presentation time and picture category condition.

	average reaction times (SD)		
presentation time	pleasant	neutral	unpleasant
13 ms	1335 (407)	1295 (374)	1347 (436)
27 ms	1150 (346)	1118 (319)	1182 (351)
40 ms	940 (228)	917 (226)	1019 (267)

Table 9: Average reaction time in each presentation time and picture category condition.

	average reaction times (SD) [n]		
response	pleasant	neutral	unpleasant
correct	1371 (948) [1,445]	1364 (921) [1,393]	1375 (996) [1,532]
wrong	1080 (705) [5,395]	1045 (649) [5,447]	1127 (747) [5,308]

Table 10: Average reaction time for correct and incorrect responses in each picture category condition. The number of trials per cell (n) is reported, as well.

ID	target valence	A_g	std. err.	95 % CI		χ^2	$p > \chi^2$
			13 ms target presentation time				
	pleasant	0.8794	0.0298	0.82101	0.93787		
1	neutral	0.8699	0.0326	0.80596	0.93377	0.71	0.6995
	unpleasant	0.8404	0.0363	0.76933	0.91151		
	pleasant	0.8454	0.0344	0.77793	0.91290		
2	neutral	0.8232	0.0365	0.75157	0.89482	0.69	0.7092
	unpleasant	0.8633	0.0318	0.80104	0.92562		
	pleasant	0.7553	0.0418	0.67340	0.83716		
3	neutral	0.7579	0.0407	0.67820	0.83764	1.31	0.5183
	unpleasant	0.8090	0.0353	0.73994	0.87812		
	pleasant	0.7674	0.0417	0.68561	0.84911		
4	neutral	0.7747	0.0423	0.69181	0.85763	10.55	0.0051
	unpleasant	0.9013	0.0270	0.84832	0.95418		
	pleasant	0.5739	0.0520	0.47206	0.67572		
5	neutral	0.6693	0.0482	0.57479	0.76382	2.08	0.3528
	unpleasant	0.6568	0.0494	0.56000	0.75361		
	pleasant	0.7426	0.0452	0.65409	0.83119		
6	neutral	0.7586	0.0433	0.67380	0.84342	4.18	0.1238
	unpleasant	0.6310	0.0502	0.53250	0.72945		
	pleasant	0.8218	0.0368	0.74973	0.89388		
7	neutral	0.7849	0.0417	0.70309	0.86664	1.80	0.4061
	unpleasant	0.7443	0.0448	0.65656	0.83205		
	pleasant	0.7903	0.0405	0.71085	0.86971		
8	neutral	0.6976	0.0481	0.60341	0.79187	2.72	0.2570
	unpleasant	0.7108	0.0459	0.62088	0.80079		

(Table 11 continued)

ID	target valence	A_g	std. err.	95 % CI		χ^2	$p > \chi^2$
	pleasant	0.7264	0.0453	0.63762	0.81515		
9	neutral	0.6728	0.0479	0.57891	0.76665	0.67	0.7150
	unpleasant	0.7065	0.0455	0.61735	0.79570		
	pleasant	0.7699	0.0421	0.68734	0.85238		
10	neutral	0.7110	0.0465	0.61978	0.80216	1.10	0.5784
	unpleasant	0.7175	0.0463	0.62673	0.80827		
	pleasant	0.6607	0.0477	0.56725	0.75414		
11	neutral	0.7144	0.0444	0.62747	0.80142	0.74	0.6904
	unpleasant	0.6753	0.0480	0.58111	0.76944		
	pleasant	0.6233	0.0503	0.52478	0.72189		
12	neutral	0.6783	0.0480	0.58420	0.77247	0.63	0.7310
	unpleasant	0.6501	0.0495	0.55308	0.74720		
	pleasant	0.6817	0.0479	0.58776	0.77558		
13	neutral	0.7782	0.0416	0.69673	0.85966	2.35	0.3090
	unpleasant	0.7267	0.0461	0.63631	0.81703		
	pleasant	0.6622	0.0368	0.59014	0.73430		
14	neutral	0.6432	0.0385	0.56777	0.71862	1.88	0.3901
	unpleasant	0.5901	0.0394	0.51286	0.66742		
	pleasant	0.7000	0.0476	0.60673	0.79327		
15	neutral	0.6099	0.0515	0.50899	0.71074	1.77	0.4137
	unpleasant	0.6381	0.0500	0.53999	0.73612		
	pleasant	0.6932	0.0473	0.60049	0.78590		
16	neutral	0.7124	0.0458	0.62265	0.80207	1.45	0.4838
	unpleasant	0.6331	0.0501	0.53495	0.73116		
	pleasant	0.5618	0.0488	0.46615	0.65746		
17	neutral	0.5456	0.0477	0.45214	0.63897	1.13	0.5689
	unpleasant	0.6147	0.0483	0.51998	0.70946		

(Table 11 continued)

ID	target valence	A_g	std. err.	95 % CI		χ^2	$p > \chi^2$
	pleasant	0.6944	0.0455	0.60517	0.78372		
18	neutral	0.6235	0.0492	0.52695	0.72000	3.92	0.1408
	unpleasant	0.5597	0.0509	0.45987	0.65957		
	pleasant	0.5754	0.0527	0.47215	0.67868		
19	neutral	0.5342	0.0520	0.43233	0.63600	0.64	0.7259
	unpleasant	0.5182	0.0513	0.41771	0.61868		
		27 ms target presentation time					
	pleasant	0.9771	0.0117	0.95408	1.00000		
1	neutral	0.9635	0.0158	0.93249	0.99445	1.51	0.4710
	unpleasant	0.9514	0.0183	0.91554	0.98723		
	pleasant	0.9611	0.0149	0.93198	0.99024		
2	neutral	0.9560	0.0152	0.92618	0.98576	2.73	0.2558
	unpleasant	0.9136	0.0254	0.86381	0.96341		
	pleasant	0.9367	0.0208	0.89595	0.97738		
3	neutral	0.9578	0.0146	0.92911	0.98644	0.81	0.6663
	unpleasant	0.9582	0.0176	0.92370	0.99269		
	pleasant	0.8890	0.0307	0.82888	0.94917		
4	neutral	0.9551	0.0174	0.92113	0.98915	4.13	0.1268
	unpleasant	0.9576	0.0182	0.92200	0.99328		
	pleasant	0.9540	0.0199	0.91509	0.99296		
5	neutral	0.9642	0.0166	0.93170	0.99663	1.62	0.4457
	unpleasant	0.9267	0.0245	0.87872	0.97461		
	pleasant	0.9001	0.0288	0.84368	0.95660		
6	neutral	0.9249	0.0220	0.88167	0.96806	1.25	0.5349
	unpleasant	0.8851	0.0297	0.82688	0.94339		

(Table 11 continued)

ID	target valence	A_g	std. err.	95 % CI		χ^2	$p > \chi^2$
	pleasant	0.8799	0.0311	0.81891	0.94081		
7	neutral	0.9167	0.0249	0.86787	0.96546	1.19	0.5521
	unpleasant	0.9199	0.0234	0.87408	0.96564		
	pleasant	0.8733	0.0332	0.80823	0.93844		
8	neutral	0.8754	0.0337	0.80944	0.94140	0.08	0.9593
	unpleasant	0.8851	0.0295	0.82726	0.94302		
	pleasant	0.9079	0.0255	0.85787	0.95796		
9	neutral	0.8776	0.0293	0.82017	0.93511	2.57	0.2763
	unpleasant	0.8393	0.0346	0.77144	0.90717		
	pleasant	0.8006	0.0386	0.72494	0.87618		
10	neutral	0.9033	0.0284	0.84776	0.95891	6.45	0.0398
	unpleasant	0.8078	0.0375	0.73437	0.88119		
	pleasant	0.8388	0.0369	0.76636	0.91114		
11	neutral	0.8654	0.0325	0.80167	0.92917	0.61	0.7384
	unpleasant	0.8288	0.0375	0.75531	0.90219		
	pleasant	0.8940	0.0277	0.83974	0.94831		
12	neutral	0.9208	0.0239	0.87395	0.96771	0.54	0.7642
	unpleasant	0.9082	0.0255	0.85830	0.95809		
	pleasant	0.7881	0.0399	0.70979	0.86632		
13	neutral	0.8636	0.0338	0.79736	0.92987	3.41	0.1821
	unpleasant	0.7749	0.0426	0.69141	0.85831		
	pleasant	0.8474	0.0312	0.78628	0.90844		
14	neutral	0.8550	0.0304	0.79550	0.91450	0.70	0.7034
	unpleasant	0.8190	0.0328	0.75482	0.88323		
	pleasant	0.8560	0.0349	0.78749	0.92445		
15	neutral	0.8536	0.0340	0.78695	0.92027	0.14	0.9345
	unpleasant	0.8392	0.0351	0.77034	0.90800		

(Table 11 continued)

ID	target valence	A_g	std. err.	95 % CI		χ^2	$p > \chi^2$
	pleasant	0.8442	0.0345	0.77663	0.91170		
16	neutral	0.9137	0.0248	0.86510	0.96240	4.63	0.0989
	unpleasant	0.8328	0.0358	0.76268	0.90287		
	pleasant	0.7306	0.0427	0.64684	0.81427		
17	neutral	0.7208	0.0437	0.63521	0.80646	0.14	0.9307
	unpleasant	0.7443	0.0443	0.65752	0.83109		
	pleasant	0.8222	0.0370	0.74968	0.89477		
18	neutral	0.7817	0.0397	0.70385	0.85948	6.52	0.0384
	unpleasant	0.6711	0.0469	0.57917	0.76305		
	pleasant	0.7275	0.0449	0.63947	0.81553		
19	neutral	0.8058	0.0395	0.72851	0.88315	2.46	0.2923
	unpleasant	0.7251	0.0452	0.63657	0.81371		
40 ms target presentation time							
	pleasant	0.9807	0.0137	0.95382	1.00000		
1	neutral	0.9999	0.0002	0.99948	1.00000	3.06	0.2165
	unpleasant	0.9981	0.0017	0.99472	1.00000		
	pleasant	0.9972	0.0020	0.99335	1.00000		
2	neutral	0.9819	0.0116	0.95918	1.00000	2.32	0.3140
	unpleasant	0.9925	0.0050	0.98266	1.00000		
	pleasant	0.9890	0.0056	0.97812	0.99993		
3	neutral	0.9987	0.0013	0.99619	1.00000	5.41	0.0668
	unpleasant	0.9846	0.0085	0.96790	1.00000		
	pleasant	0.9869	0.0099	0.96752	1.00000		
4	neutral	0.9911	0.0089	0.97368	1.00000	0.13	0.9373
	unpleasant	0.9871	0.0103	0.96695	1.00000		

(Table 11 continued)

ID	target valence	A_g	std. err.	95 % CI		χ^2	$p > \chi^2$
	pleasant	0.9992	0.0009	0.99737	1.00000		
5	neutral	1.0000	0.0000	1.00000	1.00000	1.33	0.5150
	unpleasant	0.9999	0.0002	0.99948	1.00000		
	pleasant	0.9917	0.0049	0.98202	1.00000		
6	neutral	0.9969	0.0023	0.99237	1.00000	1.46	0.4813
	unpleasant	0.9917	0.0056	0.98076	1.00000		
	pleasant	0.9715	0.0131	0.94584	0.99722		
7	neutral	0.9513	0.0185	0.91507	0.98743	1.99	0.3705
	unpleasant	0.9808	0.0102	0.96076	1.00000		
	pleasant	0.9685	0.0162	0.93681	1.00000		
8	neutral	0.9715	0.0135	0.94498	0.99808	1.16	0.5610
	unpleasant	0.9469	0.0193	0.90917	0.98472		
	pleasant	0.9835	0.0085	0.96674	1.00000		
9	neutral	0.9960	0.0029	0.99023	1.00000	5.26	0.0722
	unpleasant	0.9651	0.0159	0.93395	0.99632		
	pleasant	0.9750	0.0140	0.94761	1.00000		
10	neutral	0.9478	0.0212	0.90625	0.98930	6.64	0.0361
	unpleasant	0.8932	0.0291	0.83608	0.95031		
	pleasant	0.9703	0.0113	0.94810	0.99245		
11	neutral	0.9133	0.0261	0.86226	0.96441	4.43	0.1093
	unpleasant	0.9447	0.0236	0.89837	0.99107		
	pleasant	0.9837	0.0081	0.96794	0.99956		
12	neutral	0.9633	0.0177	0.92865	0.99802	1.36	0.5061
	unpleasant	0.9725	0.0133	0.94647	0.99853		
	pleasant	0.9521	0.0186	0.91571	0.98845		
13	neutral	0.9833	0.0106	0.96252	1.00000	4.31	0.1157
	unpleasant	0.9438	0.0195	0.90545	0.98204		

(Table 11 continued)

ID	target valence	A_g	std. err.	95 % CI		χ^2	$p > \chi^2$
	pleasant	0.9660	0.0165	0.93360	0.99835		
14	neutral	0.9917	0.0083	0.97533	1.00000	10.99	0.0041
	unpleasant	0.9015	0.0272	0.84820	0.95486		
	pleasant	0.9535	0.0194	0.91540	0.99154		
15	neutral	0.9297	0.0237	0.88331	0.97613	2.01	0.3653
	unpleasant	0.9061	0.0280	0.85115	0.96107		
	pleasant	0.9782	0.0112	0.95630	1.00000		
16	neutral	0.9919	0.0046	0.98297	1.00000	3.47	0.1767
	unpleasant	0.9622	0.0184	0.92625	0.99820		
	pleasant	0.9672	0.0153	0.93730	0.99714		
17	neutral	0.9633	0.0179	0.92823	0.99843	2.41	0.3003
	unpleasant	0.9222	0.0256	0.87204	0.97241		
	pleasant	0.8389	0.0358	0.76882	0.90896		
18	neutral	0.8789	0.0314	0.81728	0.94050	1.41	0.4935
	unpleasant	0.8950	0.0322	0.83190	0.95810		
	pleasant	0.9635	0.0163	0.93156	0.99538		
19	neutral	0.9332	0.0238	0.88656	0.97983	5.98	0.0504
	unpleasant	0.8804	0.0304	0.82081	0.94003		

Table 11: ROC data of all participants. The area under the multi-point ROC curve, the standard error, and the 95 % confidence interval (assuming an asymptotic normal distribution) are reported for each participant, presentation time, and target valence, along with χ^2-scores and the propability of the respective (or higher) score under the H_0: $A_{g,\text{pleasant}} = A_{g,\text{neutral}} = A_{g,\text{unpleasant}}$. Every row contains data from 120 trials. ID corresponds to the rank in the list of participants sorted by overall correct responses.

presentation time	proportion of correct answers (SD)	
	low arousal	high arousal
13 ms	65.1 % (10.9 %)	60.4 % (11.7 %)
27 ms	81.3 % (7.6 %)	77.9 % (8.5 %)
40 ms	93.1 % (6.5 %)	91.2 % (4.5 %)

Table 12: Proportion of correct answers in each presentation time for pictures which obtained a very low arousal rating and a very high arousal rating, respectively.

A.3 Instructions

Figure 14 shows the printed instructions for the picture recognition task. Figure 15 shows the printed instructions for the SAM rating task. The following instructions were also presented on the computer screen before the first training SAM rating trial and before the first regular SAM rating trial: „Bitte sehen Sie sich die folgenden Bilder an, und bewerten Sie die Bilder anhand des SAM-Männchens. Bewegen Sie dazu bitte die Maus über die Felder und geben Ihre Einschätzung durch einen Linksklick an (grüner Punkt), ein weiterer Linksklick bestätigt Ihre Auswahl und zeigt das nächste Bild. Ein Rechtsklick gibt ihnen die Möglichkeit, Ihre Entscheidung zu ändern. Bitte beachten Sie, dass die Bilder sehr schnell dargeboten werden!“

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Instruktion Experiment

Liebe Versuchsperson,

in diesem Experiment geht es um **Bilderkennung** am Computer. Dir wird in jedem Durchgang kurz ein Bild präsentiert. Vor und nach dem Bild erscheint kurz eine Maske. Anschließend erscheint ein weiteres Bild. Du sollst entscheiden, ob es die gleichen Bilder sind. Wenn du meinst, dass es die gleichen Bilder sind, drücke bitte auf die linke Pfeiltaste (←). Wenn du meinst, dass es zwei unterschiedliche Bilder waren, drücke bitte auf die rechte Pfeiltaste (→). Treffe deine Wahl möglichst zügig und genau.

←-Taste:	**→-Taste:**
gleiche Bilder	**unterschiedliche Bilder**

Anschließend musst du mit den Pfeiltasten nach oben und unten (↑ und ↓) angeben, wie sicher du dir deiner Antwort bist. Den nächsten Durchgang startest du mit der Leertaste. Bei Bedarf kannst du gerne kurze Pausen einlegen, bevor du mit dem nächsten Durchgang weitermachst.

Zuerst gibt es einige Übungsdurchgänge. Wenn etwas unklar ist, kannst du dabei Fragen stellen. Das Experiment dauert insgesamt etwa drei Stunden. Zwischendurch gibt es drei längere Pausen.

Damit der Versuch für uns aussagekräftig ist, bitte ich dich einige Dinge zu beachten:
Während die Bilder gezeigt werden, solltest du

- möglichst entspannt sitzen,
- dich nicht nach vorne beugen,
- die Augen auf den Monitor richten. Der Punkt in der Mitte soll dir dabei helfen die Bilder zu fixieren.

Hast du hierzu noch Fragen?
Dann können wir mit den Übungsdurchgängen beginnen.

Figure 14: Printed instructions for the picture recognition task.

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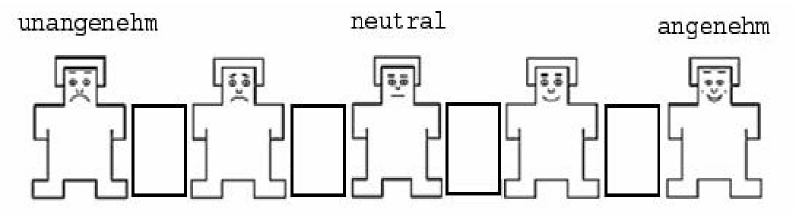
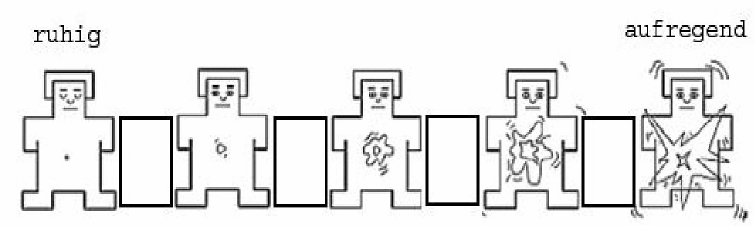
Instruktion für den SAM

Im letzten Teil des Experiments geht es um deine persönliche Einschätzung der dir nun gezeigten Bilder. Hierzu werden die zwei Dimensionen der Valenz und der Erregung verwendet. Diese werden durch den „SAM" dargestellt.

Die erste Dimension zur Beschreibung der Bilder ist die **Valenz**. Sie reicht von „sehr unangenehm, unglücklich, traurig" bis zu „sehr angenehm, glücklich, erfreut".



Die zweite Dimension zur Beschreibung der Bilder stellt die **Erregung** dar. Sie geht von „sehr ruhig und entspannt" bis zum anderen Extrem „sehr aufgeregt, rasend, angeregt, erregt".



Weitere Instruktionen zur Bewertung der einzelnen Bilder folgen am Bildschirm.

Figure 15: Printed instructions for the SAM rating.

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