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Psychophysiological Responses to Aesthetic Stimuli

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Beauty is no quality in things themselves. It exists merely in the mind which contemplates them;
and each mind perceives a different beauty.
David Hume

1 Introduction – The beginnings of empirical aesthetics

In our culture and time, the term aesthetic is oftentimes used as a synonym for beauty, pleasingness, and the artistically valid (Berube, 2004). The term aesthetics comes from the Greek verb aísthēsis (αἴσθησις), which literally means “sensitive”, “perceptive.” It is in turn derived from the word aisthanesthai, which translates to "to perceive by the senses or by the mind”, “to feel."

Before matters of aesthetics and beauty became an object of psychological research, it had long before been subject to philosophical considerations and debates. As early as the times of ancient Greece, philosophers like Socrates, Plato, and Aristotle have dealt with aesthetic issues and the ideal of beauty. In the 18th century in Germany, it was Alexander Baumgarten who introduced the term “Ästhetik” by setting out a new, independent branch of philosophy. He defined aesthetics to be the science of the sensitive knowledge (“Aesthetica est … scientia cognitionis sensitivae”; Allesch, 1987, p. 177), i.e. a knowledge that is conveyed by the senses, as opposed to the more superior intellectual knowledge that is acquired only by the rational mind. The interpretation of aesthetics to be experienced by the senses offered a first point of contact with the field of psychology. However, the prevalent perspective in those days was dominated by an approach that was later on described as “aesthetics from above”. It was a common belief that only the reflective and rational mind was able to answer the questions about an ideal beauty, similar to questions of morality and ethics. Aesthetic experiences by the “average” man and woman were thought to be negligible since the only valid criterion was an educated expert’s judgment. Any divergences to a “correct aesthetic judgment” were considered to be the result of a lack of education, errors of perception, or even moral defects (Allesch, 2006). In particular, the objectifiable ideal of beauty implied that any individual experience, for example any feeling associated with an aesthetic object, may be considered as a disturbing factor in an aesthetic judgment. It was these normative conceptions of aesthetics that hindered any psychological involvement up to that point in time. However, by the end of the 19th century, the prerogative of philosophy on an aesthetic judgment was challenged by Gustav Fechner who was the first to empirically address aesthetic matters.

In 1876, Fechner published the "Vorschule der Ästhetik", which introduced aesthetics to psychological research. The subtitle of his work read "aesthetics from below" and was therefore an open criticism to the previous approach and its speculative and normative perspective on beauty. Fechner proposed that judgments of aesthetics could be objectively measured rather than only postulated or deduced from philosophical and rational considerations (Hagtvedt, Hagtvedt & Patrick, 2008). He conceptualized an aesthetic experience to be influenced by two groups of synergistic factors, namely the direct factors and the indirect (or associative) factors. The former included object characteristics, such as color, brightness, or proportion, whereas the latter rather involved semantic aspects, like content and meaning. Although many of Fechner's findings had failed to be replicated, he initiated a long standing line of aesthetic research that aimed at disclosing the nature and origin of an aesthetic reception.

One of the first to consider an emotion perspective on art reception was the philosopher and psychologist Theodor Lipps (1903) who was an advocate of the empathy theory of aesthetics. Its gist was the assumption that aesthetic emotions were not mere reactions to objective stimulus features, but rather, that personal feelings and individual perception tendencies were associated with the aesthetic object (Allesch, 2006). An artwork may communicate feelings that are then empathetically experienced by the recipient. This concept was however not empirically pursued for a long time, partly because emotions were then difficult to be operationalized and studied. But Lipps' considerations were later again of increasing relevance, since he was among the first to acknowledge a variety of aesthetic feelings that went beyond mere judgments of preference (Halcour, 2002). Aspects of the empathy theory were later picked up again in a debate on musical emotions, where the emotivists and cognitivists argued about whether an aesthetic stimulus is able to induce emotions that are truly felt (emotivists' position) or simply recognized as being inherent to the stimulus and therefore only perceived (cognitivists' position; Kivy, 1989, 1999).

In line with the behavioristic domination in the first half of the 20th century, the following psychological research of aesthetics focused foremost on the investigation of laws and regularities in an aesthetic preference judgment, which should depend either on the distinct stimulus features or on the similarities of processing these features between groups of individuals (e.g., Birkhoff, 1938; Eysenck, 1971, 1975; Jacobsen & Höfel, 2003; Rawlins, 1940; Wundt, 1908). Back then, aesthetics was considered foremost as the quality of an object that elicits a pleasing experience in any suitable recipient. Researchers were rather interested in "aesthetic behavior" (i.e., judgment of preference) than in the subjective aesthetic experience of the recipients (Halcour, 2002).

Concerned with the formal elements of art, the mathematician George David Birkhoff proposed a basic formula to index an aesthetic value (Birkhoff, 1933). He was convinced that the pleasure that one derives from a work of art (M) depends on the ratio of two variables: the amount of order (O; e.g., symmetry, balance) and the degree of complexity (C; number of specific elements in an object, e.g., lines). Although these variables were measured differently depending on the class of art objects (e.g., polygons, vases, or even poetry), all classes should obey the following formula – Aesthetic Measure: $M = O/C$ – where an increase in the number of elements needs to be met by a skilful orderliness to compensate for the greater complexity. Eysenck (1957), however, criticized its a priori notion and, accounting for its little predictive value, he proposed a modification of the formula to – Aesthetic Measure: $M = O * C$ – which indicated that aesthetic appreciation is both enhanced by increasing order and increasing complexity. However, both formulae were later on discarded due to their lack of theoretical backup, their failure to explain individual differences (e.g., experts, non-experts), and their insufficient support by empirical findings (Allesch, 2006; McWhinnie, 1965).

Daniel Berlyne further advocated the strict objectivistic perspective on aesthetics by focusing primarily on the structure of stimulus features in the form of primitive polygons. Aesthetic receptions, Berlyne argued, are "forms of intrinsically motivated stimulus-seeking behavior" (Berlyne, 1980, p. 329). In his psychobiological approach, which he labeled the "new experimental aesthetics", he proposed three sets of variables; so-called collative variables, which were embodied in structural features of art (complexity, novelty, uncertainty, and conflict), psychophysical variables (intensity, brightness), and ecological variables (e.g., meaningfulness; Berlyne, 1971; Berlyne, 1974). In particular, the collative variables should induce a state of organismic arousal which then functions as a mechanism of reward and preference. The hedonic quality of a stimulus then comes from the interplay of two antagonistic reward systems that are differently activated by an increase in arousal (Berlyne, 1971). The emotions that Berlyne rendered important in this context were pleasingness, interest, and aversion. Although influential for the time being, Berlyne's theory on aesthetics was later on criticized for its passive-receptive conception of an aesthetic experience and could in the end not be validated with empirical findings (Silvia, 2005b). Among these and other limitations, Berlyne's work further could not explain diverging findings for different groups of participants (e.g., experts and novices) due to neglecting the person variable in his theoretical implications (Hagtvedt et al., 2008). If nothing else, his theory failed to do justice to the complexity of an artwork, which exceeds simple geometrical structures.

The cognitive turn in psychology resulted in a shift from a behavioristic, mere stimulus-triggered art perception to a more concept-driven experience. Berlyne's theory was contrasted by an increase in valuing cognitive top-down processes, such as searching for associations and meaning, as well as affective components, such as an empathetic engagement with the aesthetic stimulus (Kreitler & Kreitler, 1980). For example, Reber, Schwartz, and Winkielman (2004) proposed that the cognitive processing fluency may be the decisive factor in preference ratings. People render art as being more beautiful and pleasant when it is easy to process by virtue of familiarity or perceptual contrast (Silvia & Brown, 2007). More recently, appraisal theories (Silvia, 2005a) try to explain how subjective evaluations relating to goals, values, and concerns give rise to a variety of aesthetic emotions. Its inclusion of previously unappreciated, unusual, and negative aesthetic emotions, such as anger, disgust, or contempt, and its potential to explain individual differences in the affective reception are considered to be important benefits of the appraisal theories.

Altogether, the focus in empirical aesthetics has broadened in the past years insofar that the various aspects of an aesthetic experience have evolved to be of great interest. Today, there is not only the question about aesthetic qualities of an object but also about its personal impact and how or why people differ in their aesthetic experience. New developments in the field of aesthetics promoted a change in perspective past the object-oriented to a more subject-oriented approach by underlining the importance of individual cognitive and affective aspects.

All in all, the creative act is not performed by the artist alone;
the spectator brings the work in contact with the external world by deciphering and interpreting its inner qualification and thus adds his contribution to the creative act.
Marcel Duchamp

2 An aesthetic experience and its hedonic quality

When asking a visitor of an art museum why he or she is here, one will most likely hear an answer like “because I like looking at art” or “because it makes me feel good.” Without a doubt, looking at art is oftentimes a positive experience and elicits pleasant feelings. It therefore comes as no surprise that the common denominator of all approaches to aesthetics in the past is that art is capable of eliciting something positive and pleasing (Berlyne, Ogilvie & Parham, 1968; Cupchik & Gebotys, 1990; Hagtvedt et al., 2008; Leder, Belke, Oeberst & Augustin, 2004; Martindale, Moore & West, 1988; Russell & George, 1990). The majority of studies have assessed an aesthetic experience as judgments of pleasure (unpleasant – pleasant), likability (dislike – like), or beauty (not beautiful – beautiful), whereas others have used Likert scales of preference. However, the very nature of such an aesthetic experience is a much more complex phenomenon and therefore it may be doubted that it can be grasped by a single, oftentimes dichotomic, item. Today, there is a consensus that the experience of an art object includes both aspects of aesthetic, intellectual, and cognitive appeal as well as emotional responses (Hagtvedt et al., 2008; Leder et al., 2004; Rowold, 2008; Scherer, 2004).

2.1 Cognitive aspects

In order to specify the factors that contribute to an aesthetic experience, Leder et al. (2004) designed a model for the aesthetic appreciation and the aesthetic judgments (see Figure 1). The model focuses primarily on cognitive processes and on how these produce affective and self-rewarding experiences. The authors propose a sequential cascade of five information processing stages that is paralleled by a continuously updated affective evaluation stream, which in the end lead to an aesthetic judgment and an aesthetic emotion, respectively. The various stages comprehensively integrate basal bottom-up analyses (e.g., perceptual features, implicit mnemonic processes) with subsequent higher order cognitive processes, involving for example art-related interpretations and classifications. Bidirectional feedback loops may become active in the case of an ambiguous or unsuccessful result on one of the stages, enabling a reprocessing of the stimulus until a satisfactory outcome is met (Cupchik & László, 1992).

Leder et al. (2004) stressed that a positive aesthetic experience may be primarily dependent on the mastering of the cognitive challenges posed by the artwork. According to the model, successful interpretations and classifications may evoke a positive aesthetic judgment, while a failure may cause a more negative or poor aesthetic judgment. Moreover, an unsuccessful processing at one of the stages may cause a decline in the affective attitude towards the artwork, whereas a successful operation may result in a more positive emotional reception. In a similar vein, Frijda (1986) referred to the interplay of challenge and mastery in the processing of an aesthetic stimulus. He argued, that it is in particular "the achievement of positive outcomes rather than having them that generates positive emotion" (Frijda, 1986, p. 287).

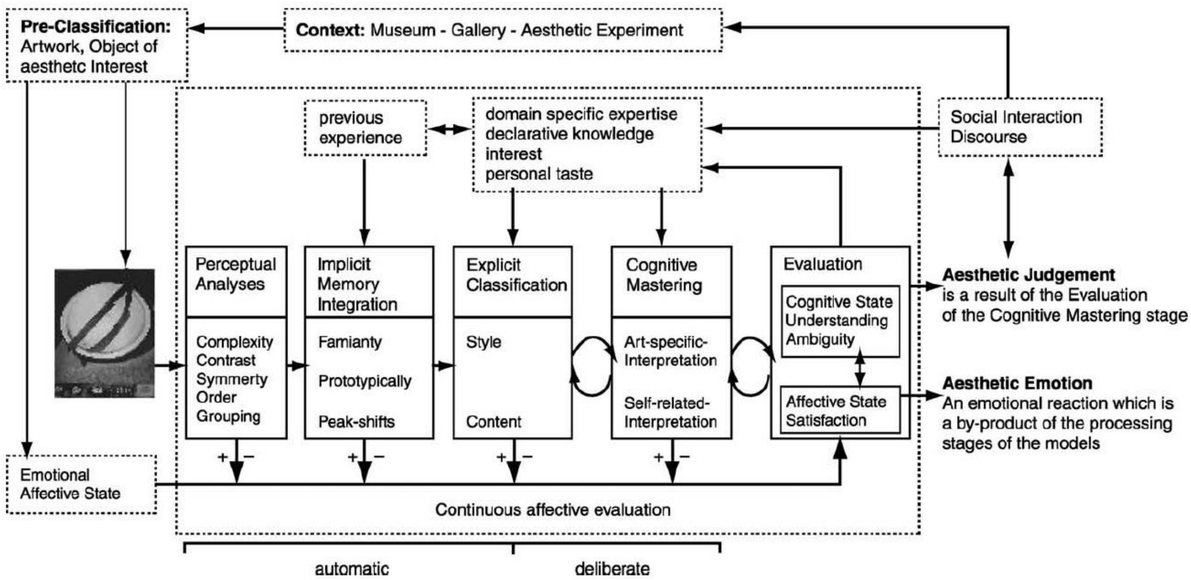

Figure 1. A model of aesthetic appreciation and aesthetic judgments. Taken from Leder et al. (2004).

Empirical findings support the relevance of cognitive mastering. It has been found that preferences for different paintings increased as a function of their perceived meaningfulness (Martindale, Moore & Borkum, 1990). The provision of background information about artist and painting (e.g., explanatory titles, descriptions, and stylistic information) resulted in an increase in aesthetic appreciation, which is supposed to be mediated by a more thorough understanding of the artworks (Belke, Leder & Augustin, 2006; Leder, 2001; Millis, 2001;

Russell, 2003). The idea of an association between successful cognitive operations and a positive attitude towards an artwork has also been proposed by Reber et al. (2004). Their concept of processing fluency proclaims that artworks are rated as being more beautiful the easier, or “fluid” they are cognitively processed: High processing fluency may be associated with “progress toward successful recognition of the stimulus, error-free processing, or the availability of appropriate knowledge structures to interpret the stimulus “ (Reber et al., 2004, p. 366).

Presumably, a successful understanding of the artwork may activate the reward centers in the brain (Blood & Zatorre, 2001; Nadal, Munar, Capó, Rosselló & Cela-Conde, 2008; Ramachandran & Hirstein, 1999; Zeki, 1999) and may therefore help to explain why viewers continue to expose themselves to art (Leder et al., 2004).

2.2 Affective aspects

Of course, the separation of the cognitive and affective aspects of an aesthetic experience is only an artificial one. As already stated above, the two are closely related as cognitive processes have an immediate effect on the affective evaluation of an artwork (Belke et al., 2006; Leder, 2001; Leder et al., 2004; Millis, 2001; Russell, 2003). Leder et al. (2004) have confined their model to the explication of cognitive processes and merely described an aesthetic emotion as its by-product without further specifying the variety of the emotional responses that may be elicited as part of an aesthetic experience. In their model, an aesthetic emotion merely mirrors the success of failure of the cognitive output. A more explicit classification and further elaborate characterization of the affective appreciation, however, may essentially add to our understanding of an aesthetic experience.

The tradition that followed Berlyne’s new experimental aesthetics restricted the range of aesthetic emotions to rather simple positive and negative states, such as pleasure, enjoyment, interest, and aversion (Cupchik & Gebotys, 1990). As Berlyne emphasized on arousal as the underlying mechanism of aesthetic processing, emotional responses were left as being only rewarding or aversive (Silvia, 2005b). Only later, after the emergence of cognitive psychology, the importance of the interplay of thought and emotions in aesthetic contexts came increasingly to the fore. Frijda (1986) has suggested the distinction of two classes of aesthetic emotions, namely between so-called complementing emotions and responding emotions. The former may be elicited by the artwork’s specific content or form (e.g., joy, surprise, and excitement). The responding emotions, on the other hand, are evoked by the artwork's intrinsic quality (e.g., being moved, enthusiastic, pleasure, and admiration) and are especially dependent on the (successful) cognitive processes during the art reception (cf. Leder et al., 2004). In a similar vein, Silvia (2005a, 2005b) acknowledged the importance of meaningfulness by proposing that appraisal theories may help to expand the domain of aesthetic emotions beyond mere pleasant emotions, such as interest and enjoyment. Silvia focused on the viewer's perceived competence to cope with the cognitive challenges that are posed by the artwork, resulting in the appraisal of either a high or a low coping potential. This and other appraisals are suspected to provide the basis for a broad range of possible aesthetic emotions. For example, a feeling of interest towards an artwork involves two appraisals: first, an event or stimulus is appraised as new, complex, and unfamiliar and second, it is simultaneously appraised as comprehensible (high coping potential). Now, a shift in the second appraisal towards less understanding (a lower coping potential), may change interest to a feeling of confusion instead. In addition, Silvia (2009) specified various other (unusual) emotions, such as knowledge-based emotions (surprise, among interest and confusion), hostile emotions (e.g., anger, disgust and even contempt), and self-conscious emotions (e.g., pride, shame, and embarrassment), which may complement the range of aesthetic emotions beyond milder feelings of liking or pleasure.

In a similar vein, Hagtvedt et al. (2008) also advocated the inclusion of negative emotions and further proposed to use a dimensional approach in studying them. Aesthetic emotions may be categorized along the dimensions of valence and arousal (cf. Lang, Greenwald, Bradley & Hamm, 1993), resulting in high and low arousing positive (e.g., enthusiasm and happiness, respectively) and high and low arousing negative emotions (e.g., anxiety and sadness, respectively). Zentner, Grandjean and Scherer (2008) have used an eclectic approach to identify other potential aesthetic emotions. Factor analyses of a large pool of items referring to emotional states revealed a diversified spectrum of aesthetic emotions, including feelings of amazement, tranquility, enthusiasm, melancholy, and loneliness.

Altogether, these findings mirror a contemporary consensus that aesthetic emotions are neither simple nor restricted to pleasant states. Moreover, it may be concluded that aesthetic appreciation is not a unified process, but is rather the result of various underlying cognitive and affective mechanisms (Nadal et al., 2008).

2.3 Other aspects

To date, a preponderance of studies have shown that individual characteristics of the art recipient influence how art is experienced, liked, and judged (Augustin & Leder, 2006; Belke et al., 2006; Furnham & Chamorro-Premuzic, 2004; Furnham & Walker, 2001a, 2001b; McManus & Furnham, 2006). Chamorro-Premuzic, Reimers, Hsu, and Ahmetoglu (2009) found that interindividual variables such as expertise, personality, art-related activities, sex, and age accounted for 17% of the variance of general art preference. Therefore, an aesthetic experience can in part be attributed to individual differences in the art recipients.

Art expertise and knowledge have been identified as influential factors in the process of an aesthetic experience. Leder, Gerger, Dressler, and Schabmann (2012) found a generally greater art appreciation for experts than for naives. In particular, they reported greater ratings of pleasantness, induced arousal, and level of comprehension by art experts compared to art naives. There is evidence that the different levels of art expertise and knowledge may lead to different strategies of art judgment and evaluation (Pihko et al., 2011). The information that art experts and art naives use for a comprehensive understanding of the artwork differs by virtue of their expertise. Art experts, on the one hand, are more challenged by a cognitive mode of reception and are able to use their profound knowledge to relate the artwork to artist, style, epoch, and/or significance. Untrained recipients, on the other hand, cannot use this approach and rather refer to a more emotional mode of reception. They usually relate the artwork's content to their own emotional state or biography (Augustin & Leder, 2006; Nodine, Locher & Krupinski, 1993; Parsons, 1987; Winston & Cupchik, 1992). In this respect, Cupchik and Laszlo (1992) distinguished between a cognitive-based and a pleasure-based reception of art, respectively.

A variety of studies have found predictable associations between personality measures and specific art preferences. In particular, higher scores of conservatism, conscientiousness and agreeableness were positively correlated with a preference for traditional and representational art (e.g., impressionism), rather than for modern styles (e.g., abstract, cubist, or pop art). Openness to experience has been associated with preferences for modern, non-traditional art styles (Chamorro-Premuzic et al., 2009; Furnham & Walker, 2001a, 2001b). Additionally, open individuals have a more positive attitude towards art, an increased artistic self-perception, and further engage themselves more in art-related free-time activities as opposed to closed individuals (McManus & Furnham, 2006). In general, openness to experience has been found to be the strongest predictor for an overall positive reception of art (Chamorro-Premuzic et al., 2009; Furnham & Walker, 2001b). Consequently, McCrae and

Costa (1997) proposed that that “artists can be considered prime examples of individuals high in openness to experience” (p. 825).

Demographic variables also have an influence on art preferences. In particular, a study by Chamorro-Premuzic et al. (2007) showed that males and younger participants like cubist and renaissance paintings, whereas women prefer traditional and representational paintings. Moreover, age appeared to be the second strongest predictor for general art preference after openness to experience: The older the participants the more positive the attitude towards art is in general.

I organize all works of art into two groups: the ones that I like and the ones that I do not.
I can't think of a different criterion […].
Anton Tschechow

3 Measuring an aesthetic experience (manuscript 1)

Recent findings in aesthetic research suggest that various affective and cognitive aspects play a central role in the perception, evaluation, and appraisal of visual art (Hagtvedt, et al., 2008; Leder et al., 2004; Scherer, 2004; Silvia, 2005b). The identification of these relevant constituents may enable a construction of an adequate instrument that is capable of comprehensively assessing an aesthetic experience. Its value for the field of aesthetic research would be great, considering its expansion in the recent years to various psychological disciplines, such as personality or neuroaesthetics (e.g., Chamorro-Premuzic et al., 2009; Jacobsen & Höfel, 2003; Lengger, Fischmeister, Leder & Bauer, 2007; McCrae, 2007; Nadal et al., 2008).

We constructed the Art Reception Survey (ARS) using a multidimensional approach to an aesthetic experience. Following an extensive literature research and a visitor poll at an art museum in Mannheim, we generated a pool of 76 items that assessed various direct and concomitant components of an aesthetic experience. These items can roughly be subsumed under several categories. First, a subset of the items described affective reactions towards a work of art (Frijda, 1986; Hagtvedt et al., 2008; Rowold, 2008; Silvia, 2009; Zentner et al., 2008). Other items related to important cognitive aspects as, for example, outlined by the model of aesthetic appreciation and judgments (see, Figure 1; Leder et al., 2004). Here, we chose items that emphasized the interpretation of the artwork and the successful extraction of meaning and understanding. Moreover, we included items referring to beauty, pleasantness, and "being aesthetic", which in the past have been commonly used for assessing an aesthetic judgment. Picture-specific characteristics were limited to the description of creativity and skillfulness (Kozbelt, 2004; Hagtvedt et al., 2008). Additional items were associated with art expertise or expert knowledge, describing whether the recipient recognized the particular painting or artist, possesses knowledge about its style, its art historical context, or artistic relevance. Although such items do not directly describe the outcome of an aesthetic judgment per se, they have an immediate impact on the artwork's reception and consequently on the outcome of the aesthetic experience (Augustin & Leder, 2006; Belke et al., 2006; Chamorro-Premuzic & Furnham, 2004). At last, several items described self-referential associations (e.g., memories, emotions) between the recipient and an artwork (Leder et al., 2004; Parsons, 1987; Rowold, 2008).

We analyzed the underlying factor structure with a principal component analysis (PCA, direct oblimin) and reduced the item pool based on psychometric and rational grounds. Altogether, we selected 29 items which loaded on six factors.[1] All of them showed sufficient internal consistencies (Cronbach's Alpha > .83), adequate item difficulties (p_{mean} = .54, p_{SD} = .15), and item-test correlations (r_{mean} = .67, r_{SD} = .10).

The factor that explained most of the variance was *cognitive stimulation*. It describes the viewer's intellectual engagement with the artwork. Its importance corresponds well to Berlyne's concept of curiosity, describing the search for knowledge and meaning (Berlyne, 1949; Cupchik & Gebotys, 1990) and Martindale's "hedonic calculus", which relates the pleasure derived from an aesthetic stimulus to the cognitive processes involved in the striving for meaning (Cupchik & Gebotys, 1990; Martindale, 1984). Moreover, Leder et al. (2004) have explicitly stressed the relevance of cognitive operations in the processing of artworks and its self-rewarding experience. The second factor, *negative emotionality*, describes the arousal of unpleasant emotions elicited by the artwork. It supports recent considerations about the existence of other aesthetic emotions beyond the mere positive responses towards art (Scherer, 2004; Silvia, 2009). Silvia and Brown (2007) stressed the importance of rather "unusual aesthetic emotions" since they might be helpful in understanding people's diverse reactions towards art, including also confusion, surprise, or sometimes even rejection. The results further correspond to the findings of Hagtvedt et al. (2008) who included negative emotions as an underlying dimension of an aesthetic response. The third factor, *expertise*, subsumes the recipient's recognition of the painter and its work, as well as the level of understanding about its underlying meaning. Despite the fact that these aspects are no immanent features of an aesthetic experience, a positive aesthetic judgment profoundly depends on such successful classifications and comprehensive interpretations, presumably by its self-rewarding character (Augustin & Leder, 2006; Belke et al., 2006; Belke, Leder, Strobach & Carbon, 2010; Frijda, 1986; Russell, 2003; Winston & Cupchik, 1992). In particular, *expertise* assesses the relative success of these operations and therefore provides additional information beyond the mere cognitive involvement with an artwork. The fourth

[1] A subsequent second-order PCA suggested the subsumtion of the first-oder factors under a three second-order factor structure. Focusing explicitely on the diversified facets of an aesthetic experience, we did not further proceed on the second-order factor structure, which in the future might need some further clarification and validation.

factor, *self-reference*, assesses the viewer's perceived emotional and biographic connection with the artwork (cf. Rowold, 2008). Martindale (1984) proposed that the pleasure derived from an aesthetic stimulus stems from the extraction of its meaning, which is closely related to the activation of various semantic connotations and memory associations. Similarly, Leder et al. (2004) described self-referential interpretations, besides art-related interpretations, to be a major source of information that particularly art naive recipients use in their formation of an aesthetic judgment. Therefore, *self-reference* might capture a different facet of the cognitive mastering of an artwork beyond matters of art-related knowledge (factor *expertise*), which presumably depends on individual differences in art expertise. Items of the fifth factor, *artistic quality*, refer to the uniqueness and the innovative character of the painting and support findings of an underlying quality dimension in an aesthetic experience. Kozbelt (2004) found that creativity and skillfulness loaded on the paintings' overall quality and its aesthetic value, and jointly accounted for 90% of its variance. It can therefore be presumed that the level of a painting's artistry has a profound influence on its overall appreciation. Although, quality aspects are not explicitly described in the model by Leder et al. (2004), it is likely that they are in part incorporated the stages of explicit classification and cognitive mastering. At least, this may be indicated by the shared variance of *cognitive stimulation* and *expertise* with *artistic quality* (r = .41 and .26, respectively). Items of the last factor, *positive attraction*, assess a positive attitude towards an artwork, describing it as beautiful, pleasant, and valuable. This factor comes closest to the uni-dimensional conceptualization of an aesthetic experience as it is commonly assessed by scales of preference, likability, or beauty (e.g., Berlyne et al., 1968; Cupchik & Gebotys, 1990; Leder et al., 2004). *Positive attraction* further describes feelings of excitement and inspiration, which reveal a profound relationship with the artwork, maybe even bridging the gap between the cognitive and affective evaluation of the artwork. The correlations of *positive attraction* with *cognitive stimulation* (r = .30) and *expertise* (r = .24) may support the close relationship between an aesthetic judgment and an aesthetic emotion as proposed by Leder et al. (2004). Successful classifications and interpretations are suspected to enhance the affective evaluation of the artwork, presumably by its self-rewarding character (Reber et al., 2004). Moreover, the positive association of *positive attraction* with *artistic quality* (r = .20) underlines the importance of quality judgments as an underlying dimension of an overall positive aesthetic judgment and experience.

We tested the validity of the ARS scales by comparing the experience to art with the experience to non-art (photographs taken from the International Affective Picture Systems;

IAPS; Lang, Bradley & Cuthbert, 2008). Significant differences were found for all ARS scales except for *self-reference* and *negative emotionality*, which may be a consequence of the sample characteristics and picture selection, respectively. A median split revealed that only participants who increasingly engage in art-related activities (e.g., visiting art museums, painting, reading art literature) were able to perceive a personal connection to the artworks. This suggests that the ARS may be able to distinguish between persons with different art-related interests and backgrounds. Furthermore, it might be possible that the artworks presented were altogether not suitable to elicit any negative emotions. The items of *negative emotionality* assess rather unpleasant and anxious feelings, which have been found to be foremost elicited by rather controversial or offensive paintings (Silvia & Brown, 2007). Such paintings had not been included in our picture set. Altogether, the specificity of the greater ARS scores for most of the ARS factors for art paintings suggests the validity of the instrument.

In sum, the psychometric results of the ARS factors and its corresponding items, their specificity with respect to artworks, the comprehensive coverage of important aspects of an aesthetic experience, and the embeddings within existing literature altogether point towards the validity and the usefulness of the ARS instrument. In particular, it validates the importance of cognitive aspects in the processing of aesthetic stimuli. A specific focus lies on matters of intellectual engagement, curiosity, and understanding, which are all positively related to the positive reception of an artwork. Furthermore, the ARS underlines the presence of nuanced positive and negative emotional experiences (e.g., feeling thrilled, inspired, and feeling troubled, lonesome, respectively), that go beyond such basic emotions as being happy, sad, angry (Ekman, 1992). As a consequence, the question arises whether affective responses to aesthetic stimuli are comparable to emotional experiences to other classes of stimuli, for example such that evoke said basic emotions. One approach to address this issue is to compare further characteristics of emotional experiences, such as psychophysiological indicators.

A work of art which did not begin in emotion is not art.
Paul Cezanne

4 Aesthetic emotions vs. utilitarian emotions

As it has been previously elaborated, an aesthetic experience includes a diversified spectrum of emotional feelings, including differentiated pleasant as well as unpleasant states, as indicated by subjective ratings (Hager, Hagemann, Danner & Schankin, 2012; Silvia, 2009; Hagtvedt et al., 2008; Zentner et al., 2008).

In music research a distinction is made between perceived emotions and felt emotions in the context of aesthetic appreciation (Kivy, 1989). The cognitivists' position suggests that emotions in response to musical excerpts are but only perceived and not truly felt. Its advocates argue that listeners but merely attribute emotions to musical stimuli. They only recognize the underlying emotional quality of the music and misleadingly report them as being one's own emotional experience. Proponents of the emotivists' position, however, object this notion by proposing that emotional pieces of music may indeed produce emotions which are then felt by its listeners. With respect to visual art, the question of perceived versus felt emotions may arise as well. To date, there are little findings that unambiguously answer the question whether visual artworks only represent emotions that are then perceived and reported as being one's own, or if art is indeed able to induce emotional states. It is evident that a conclusion between these two opposing hypotheses cannot be drawn by a restriction to subjective ratings only.

As a matter of fact, verbal reports of aesthetic feelings have increasingly been challenged to be a valid and sufficient criterion for the presence of an emotional response. Ramachandran and Hirstein (1999) argued that subjective feelings for an artwork are always prone to being filtered, edited, and even censored by the recipient, may it be consciously or unconsciously. For example, many people might rate a particular painting as being aesthetically pleasing simply because they know that the painter's name is Picasso, and that he is a highly reputable and popular artist. Therefore, the painting has to be good/beautiful/creative, doesn't it? Others might rate modern art as being highly innovative and cognitively stimulating although they cannot relate to the artwork at all but prefer to respond in a way they think is socially desirable. Scherer and Zentner (2001) share these concerns and further doubt "whether verbal reports can really be considered the gold standard as a criterion for genuine emotional experience" in an aesthetic context (p. 372). Instead, the authors suggest a broader approach to the study of emotions beyond mere verbal reports. They promote the conceptualization of emotions as multicomponential phenomena, including physiological arousal, facial expressions, action tendencies, concomitant cognitive processes involving emotion-constituent appraisals, as well a subjective feelings (Scherer, 1984, 2004). An emotional experience is then constituted by the interplay of the coordinated changes in these essential components.

Ramachandran and Hirstein (1999) agree with Scherer on the essentiality of physiological measures in the context of an aesthetic experience. They suggested in particular the skin conductance response (SCR) to be a more valid and reliable measure for an emotion elicited by an artwork than simply asking art recipients how they feel while looking at it. They argue that the emotional significance of the artwork is gauged by the amygdala and further relayed to the autonomic nervous system, causing an increase in skin conductance. Importantly, Ramachandran and Hirstein (1999) stress that this autonomic activation may be initiated by “any (emotional) evocative picture” (p. 32) and is not restricted to artworks alone. Thus, the emotional responses should be similar between aesthetic and other emotional stimuli, at least in terms of an SCR as a physiological correlate of an emotion.

This particular hypothesis, however, is contradicted by Scherer (2000, 2004) by marking a distinct difference between affective responses to aesthetic stimuli and other emotional events or stimuli. He proposes a design-feature approach to conceptually distinguish between aesthetic emotions and other, so-called, utilitarian emotions (see Table 1). The distinctive feature of utilitarian emotions is their evolutionary inherited functionality (or utility) in the adaptation and adjustment of an individual to important environmental challenges. They are high-intensity emergency responses, which often involve synchronized psychophysiological changes (Bradley, Codispoti, Cuthbert & Lang, 2001). To a great extent they are influenced by the appraisal of the situation regarding personal goal relevance and coping potential within the context (Hagemann, Waldstein & Thayer, 2003). Aesthetic emotions, on the contrary, are devoid of any functionality. They are generally less embodied than utilitarian emotions, being less organismically synchronized and of lesser intensity per se. Scherer (2004) argues that aesthetic emotions are less in the service of proactive action tendencies and of behavioral preparedness, but are “rather diffusely reactive” (p. 244). Moreover, aesthetic emotions are less concerned with personal needs or goals, specific action tendencies, or coping strategies. They rather entail an increased cognitive and intellectual involvement with the stimulus and are foremost triggered by positive evaluations of their intrinsic qualities, based on forms and relationships (cf., Leder et al., 2004).

Table 1

Design features of utilitarian and aesthetic emotions.

Type of affective state: brief definition (*examples*)	Design Feature							
	Intensity	Duration	Synchro-nization	Event focus	Intrinsic appraisal	Transactional appraisal	Rapidity of change	Behavioral impact
Utilitarian emotions: relatively brief episodes of synchronized response of all or most organismic subsystems in response to evaluation of an external or internal event as being of major significance for personal goals or needs (*angry, sad, joyful, fearful, ashamed, proud, elated, desperate*)	H	L	VH	VH	M	VH	VH	VH
Aesthetic emotions: evaluations of auditory or visual stimuli in terms of intrinsic qualities of form or relationship of elements (*moved, awed, surprised, full of wonder, admiration, bliss, ecstasy, fascination, harmony, rapture, solemnity*)	L-M	L	M	H	VH	L	H	M

VL = very low; L = low; M = medium; H = high; VH = very high. Taken from Scherer (2004; excerpt of Table 1, p. 242).

By now, various attempts have been made to evaluate the physiological correlates of the affective processing of aesthetic stimuli. As for music, it has been found that musical excerpts that have been classified as sad evoke a different physiological response pattern compared to excerpts rated as being happy. Krumhansl (1997) found that sad music induced significant increases in heart rate, blood pressure, and skin conductance. Lundqvist, Carlsson, Hilmersson, and Juslin (2009), on the other hand, reported greater activity in the zygomaticus major muscle, an increase in skin conductance, and lower finger temperature for happy musical excerpts compared to sad ones. Again, others have studied so-called aesthetic chills, goose bumps or body shivers that are commonly elicited by emotional music excerpts and reported as being highly pleasurable (Grewe, Katzur, Kopiez & Altenmüller, 2011; Grewe, Kopiez & Altenmüller, 2009; Nusbaum & Silvia, 2011; Panksepp, 1995). Findings are that they coincide with significant increases in skin conductance and heart rate and are therefore regarded as reliable indicators of individual emotional peaks (Grewe et al., 2009). In particular, persons high in openness to experience and with a greater level of art expertise report to experience aesthetic chills in a higher frequency than others (Silvia & Nusbaum, 2011). Furthermore, some researchers have investigated the pupil size as a measure of the emotional processing of visual artworks. Kuchinke, Trapp, Jacobs and Leder (2009) measured the pupil dilation of participants following the point of object recognition for aesthetic stimuli differing in their level of abstractedness. Stimuli of high processing fluency were associated with larger pupil dilations after the point of object recognition and further elicited higher preference ratings than stimuli of low processing fluency. The authors concluded that pupillary responses may be indicative of affective processes in response to explicit classification in an aesthetic experience as outlined by the model by Leder et al. (2004). Most recently, Tschacher et al. (2012) have assessed physiological responses to visual artworks in an ecologically valid setting – an art museum. Visitors were equipped with electronic gloves that wirelessly monitored their heart rate, skin conductance, and locomotion during their stay at the museum. The authors found significant changes of the heart rate and the skin conductance variability while visitors were looking at artworks that were rated high in aesthetic quality.

Altogether, a variety of findings so far support the idea that aesthetic stimuli – may it be music or visual art – are capable of inducing physiological responses in the participants that go beyond the report of subjective feelings. These findings may further point towards the emotivists' position that aesthetic emotions are indeed rather felt than only perceived. However, to date it had never been empirically investigated how these physiological indices to an aesthetic emotion differ from utilitarian emotions.

5 The psychophysiology of utilitarian emotions

In contrast to the relatively new field of the psychophysiology of aesthetic emotions, there is an abundance of empirical finding substantiating the physiological signature of utilitarian emotions.

5.1 The motivational organization of utilitarian emotions

Many theorists believe that emotional reactivity is generally founded on a biphasic organization structure of motivation that is manifested in two motivational systems in the brain (Dickinson & Dearing, 1979; Konorski, 1967; Lang et al., 1992; Schlosberg, 1952). The appetitive system is activated in any context promoting species survival (e.g., nurturance and reproduction), and the defensive system is engaged when the organism faces threat or danger. Both systems are associated with corresponding behavioral responses that initiate either approach, defense, or escape, respectively. The motivational approach suggests two basic determinants of emotions: (1) hedonic valence, i.e. pleasure (appetitive motivation) and aversion (defensive motivation), and (2) arousal, i.e. the level of motivational activation. Correspondingly, subjective ratings of pleasure or displeasure indicate which motivational system is activated and subjective ratings of arousal indicate the level of intensity of the motivational activation (Bradley et al., 2001).

Both systems are implemented in neural circuits in the cortex and their outputs presumably innervate the somatic and autonomic physiological systems that are involved in attention and behavior (Bradley et al., 2001). Activity in these circuits leads to a motivationally tuned state of readiness and alertness in the organism and manifests itself in measurable bodily symptoms, such as changes in skin conductance or increased activity in the muscles of facial expressions (Lang, et al., 1993). The intensity of activation of the respective system serves as an amplification factor for the activity in the physiological correlates. Moreover, once a system has been activated, the affective responsiveness towards subsequent stimuli of comparable valence (pleasant or unpleasant) is enhanced, and the responsiveness towards subsequent stimuli of the opposing valence is diminished (Bradley et al., 2001). It has been found that the blink response to an aversive, secondary startle probe is diminished in amplitude during pleasant picture presentation, and potentiated in amplitude during unpleasant picture presentation.

5.2 An experimental paradigm to study utilitarian emotion

Lang, Bradley, and Cuthbert (1990) established a valid and reliable paradigm to study the physiological correlates of utilitarian emotions, which may correspond to the affective components of an emotional experience that have been outlined by Scherer (2004).

The experimental procedure (see, Bradley et al., 2001, for an overview) involves the presentation of emotional picture stimuli that are taken from the International Affective Picture System (IAPS; Lang et al., 2008), a large pool of several hundreds of color photographs of various content. For each of these pictures, there are normative ratings of pleasure and arousal. In general, pictures rated as being of extreme valence (i.e., pleasant or unpleasant pictures) usually go along with high arousal ratings, whereas pictures of medium valence (i.e., neutral pictures) are usually associated with low arousal ratings. Figure 2 presents a sample of IAPS pictures, which is distributed along the arousal and valence dimensions, spanning the affective space.

The experiment involves the presentation of various IAPS pictures for several seconds, while different physiological signals are recorded from the participants, such as the SCR and the facial EMG responses of the zygomaticus major and the corrugator supercilii. In some of the trials, an unexpected, short, and loud acoustic startle probe is presented shortly after the picture onset, which is usually followed by a reflexive blink response that can be measured with the EMG of the orbicularis oculi, the ring muscle around the eye. In addition, on trials with or without a startle probe, the cortical activity may be recorded using an EEG, locked to the onset of the picture or the probe, respectively. After the picture offset, the participants usually indicate its valence and arousal with a subjective rating on the self-assessment manikin (SAM; Bradley & Lang, 1994). For better clarity, it may be noted that some of the physiological measures are primarily influenced by the valence of the stimulus whereas others are foremost modulated by the arousal of the stimulus.

An example of the latter is the *skin conductance response* (SCR). The SCR is greatest during emotional pictures that are rated as being of great subjective arousal, irrespective of their valence. It is innervated by the sympathetic nervous system and sensitive to stimulation and physiological arousal of an organism. In general, the SCR is thought to reflect the intensity with which either of the motivational systems is activated. It may therefore represent the physiological arousal component of an emotion.

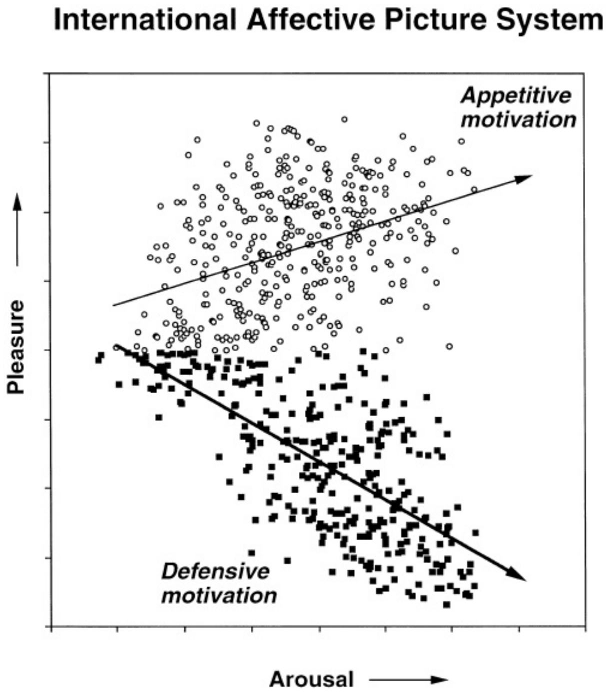

Figure 2. Pictures from the IAPS, plotted in a two-dimensional affective space on the basis of their mean arousal (x-axis) and pleasure (y-achsis) ratings. The boomerang-form of the picture distribution is thought to reflect the two underlying motivational systems. Taken from Bradley et al. (2001).

In contrast to the SCR, the *facial muscular activity* is associated with the stimulus valence. EMG activity in the zygomaticus major, which is located between the corner of the mouth and the pre-auricular point and is involved in smiling, is greatest during the presentation of pleasant pictures. EMG activity in the corrugator supercilii, which is located right above the eyebrow and is involved in frowning, is greatest during the presentation of unpleasant pictures. These distinct facial expressions due to affective stimulation may be considered as the motor components of an emotional experience (Ekman, 1994; Scherer, 2004).

Similarly, the *startle response* also depends on the stimulus valence. The reflexive blink to the startle probe is smallest during pleasant pictures and greatest during unpleasant pictures. The response is part of an evolutionary inherited organismic defense cascade to protect the organism from any outside harm and might therefore be regarded as representing the behavior preparation component of an emotional experience (Lang, 1995).

The *cortical activity* in response to the picture and the probe onset are again associated with the subjective arousal of the picture stimuli. The late positive potential (LPP) and positive slow wave (PSW), both consecutive event-related components of a positive deflection in the EEG after picture onset, are greatest for emotional pictures rated high in subjective arousal, irrespective of their valence (see, Schupp, Flaisch, Stockburger & Junghöfer, 2006, for a review). Both components are considered to reflect sustained attentional and mnemonic processes (Donchin & Coles, 1988; Schupp et al., 2006). The startle P3, a positive deflection following the startle probe, is smallest for emotional pictures rated high in subjective arousal, irrespective of their valence. The P3 is suspected to reflect the amount of attentional resources that is still available for the processing of the secondary probe, while already being cognitively engaged by the picture processing (Schupp, Cuthbert, Bradley & Birbaumer, 1997). These event-related potentials (ERPs) may reflect the component of cognitive engagement in an emotional experience.

Altogether, the physiological response patterns associated with the IAPS pictures have been numerously and consistently replicated in the past (e.g., Bradley et al., 2001; Dichter, Tomarken & Baucom, 2002; Lang et al., 1993, Sabatinelli, Bradley & Lang, 2001). It has been further found that these picture and probe effects are greatest for stimuli that are associated with great subjective arousal and personal relevance (Cuthbert, Bradley & Lang, 1996). In particular, Bradley et al. (2001) stressed the relevance of evolutionary significance in picture content by demonstrating that pleasant pictures depicting erotica as well as unpleasant pictures depicting threat, mutilation, and violence elicited significantly greater effects than pictures of similar subjective valence. At the same time, these evolutionary salient pictures were steadily associated with greater subjective arousal than any picture category of similar valence ratings (e.g., babies, food, and adventure). This supports the assumption that the subjective arousal mirrors the intensity of activation of the two motivational systems. Additionally, it supports the functionality of arousal to serve as an amplification factor for the physiological components of an emotional experience.

In sum, the physiological findings for the IAPS pictures may be prototypical of a utilitarian emotion as outlined by Scherer (2004): Utilitarian emotions are described as being high intensity reactions, which is indicated by large changes in autonomic arousal. Moreover, they feature a very high level of organismic synchronization, as shown by the interplay of different physiological subsystems. Utilitarian emotions, so Scherer, further involve a very high behavioral impact or state of organismic preparedness, which is demonstrated by the modulation of the startle response. At last, utilitarian emotions are associated with very high levels of cognitive engagement, which is reflected in different higher order cortical potentials.

5.3 Shortcomings of the experimental paradigm

Art reception and appreciation is not limited to a general psychological perspective but rather involves differential aspects as well (see point 2.3, *other aspects*). As the model of aesthetic appreciation and aesthetic judgments by Leder et al. (2004) points out, there are distinctive individual features that essentially influence how the artwork is evaluated (Figure 1). Prior experience, art expertise, and taste may influence the different stages of the processing cascade which in turn may affect the emotional outcome. Silvia (2007, 2010) further emphasized that an aesthetic emotion is primarily dependent upon specific individual cognitive appraisal structures. Moreover, demographic and personality variables are additional influencing factors in art appreciation (e.g., Chamorro-Premuzic et al., 2009; Furnham & Walker, 2001a, 2001b). Especially individuals scoring high on openness of experience differ from individuals with lower scores in their preferences for art in general and specific art styles in particular, as well as in their engagement in art-related activities. Altogether, it may therefore be of particular interest whether these individual differences in art reception and appreciation may be reflected in individual differences in the physiological correlates of an aesthetic emotion.

We propose that the paradigm of emotional picture presentation (Lang et al., 1990) might be a valuable experimental approach to assess the physiological correlates of an emotional episode (Scherer, 2004). As useful as it may be, it bears a limitation for the investigation of individual differences. In the majority of the studies, the startle response is quantified as the standardized peak amplitude of the EMG activity of the orbicularis oculi.[2] The rationale for the standardization procedure is to eliminate a large variation in EMG amplitude between participants, which is unrelated to the experimental manipulation (Blumenthal et al., 2005). Presumably, the variance is due to anatomical differences in the fatty tissue and the skin composure over the orbicularis oculi muscle, or the density and structure in the relevant musculature. Either way, it may be regarded as error variance. The standardized data still provide information about the valence modulation of the startle response and about between-group interactions in the valence modulation. However, conclusions about between-group differences in general affective *reactivity* are not possible anymore. Consequently, the standardized startle amplitude is an adequate indicator for the relative differences in affective responding, yet an unqualified measure for the investigation of individual differences in absolute affective reactivity towards emotional stimuli.

[2] z-transformation or T-transformation of the peak amplitude for each participant and trial

Besides the peak amplitude, there are other parameters of the startle response that do not show such large individual variation and do therefore not need to be standardized. In the following study, we investigated whether latency measures might be valid and reliable parameters in the investigation of emotional processing.

6 Latency measures of a startle response (manuscript 2)

Davidson (1998) proposed that individual differences in emotional reactivity can be decomposed into elementary components of affective chronometry, such as the threshold for reactivity or the rise time to the peak of the response. In particular, these latency parameters might be valuable in the investigation of individual differences in the dynamics of affective responding and the understanding of the functional activity of emotion-related neural processes.

In the present study, we investigated whether unstandardized latency measures of the startle response are valid and reliable indicators of emotional processing. The onset latency of the startle response[3] has only been studied by a small number of studies and their findings are largely inconsistent (Bradley, Cuthbert & Lang, 1990; Corr, Wilson, Fotiadou & Kumari, 1995; Cuthbert et al., 1996; Larson, Ruffalo, Nietert & Davidson, 2000). This may, however, be due to methodological inconsistencies rather than to the unfitness of the measure (Hager, Hagemann, Schankin & Danner, submitted). The rise time latency of the startle response[4] had never been studied before and therefore its investigation was primarily exploratory.

We used the paradigm of emotional picture presentation (Lang et al., 1990) and assessed, among other variables, the onset and the rise time latency of the startle response to an unexpected probe. The findings support the use of latency measures in future research of emotional processing. The valence exerted a large effect on the latency measures of the startle response. In particular, an increase in picture valence was associated with an increase in onset latency and a decrease in rise time latency of the startle response. The valence effect sizes were of comparable size for the onset latency, the rise time latency, and the peak amplitude ($\omega^2 \geq .13$). Therefore, the latency parameters appear to be equally informative about the affective impact of an emotional stimulus as the peak amplitude of the startle response.

Our results further showed that the onset and rise time latency can be as reliably measured as the peak amplitude of the startle response ($r_{tt} \geq .77$). A marginally greater reliability estimate for the peak amplitude may be associated with its less confounded scoring procedure. The peak amplitude can be easily detected as the maximum of the EMG within a predefined time window. The scoring of the latency measures, on the other hand, requires the individual setting of a response onset threshold on each trial. The onset threshold is defined as

[3] the time between the startle probe onset and the exceeding of a pre-defined threshold of EMG activity, indicative of a startle response

[4] the time between the response onset and the peak of the response

a significant exceedance in amplitude of the baseline EMG activity just before the probe onset. Any unrelated muscle movement prior to the probe may therefore change the trial's response threshold and accordingly the scoring of the latency measures. As a consequence, the latency measures inherently possess an increased error variance and hence lower reliability estimates. Furthermore, our results advocate that the latency measures validly illustrate the affective valence modulation of the startle response. Both the onset latency and the rise time latency correlated significantly with the peak amplitude in the expected direction ($r < -.64$ and $r > .66$; respectively). At last, the latency measures showed less habituation across the experiment than the peak amplitude, which may be regarded as an advantage in their usefulness. The latter decreased significantly when the pictures were presented for a second time, whereas the latency measures were largely unaffected by the repetition.

Altogether, it can be concluded that the onset and rise time latency reliably, validly, and practically measure the affective modulation of the startle response and may therefore be useful, especially in the investigation of individual differences in the organism's reactivity towards emotional stimuli.

In a secondary aim of the present study, we investigated the necessity of high intensity startle probes for a reliable valence modulation of the startle response. A preponderance of studies uses probe intensities of 95 dB and higher, which has evolved to be paradigmatic in this line of research without being justified by any official recommendations (Amrhein, Mühlberger, Pauli & Wiedemann, 2004; Bradley et al., 2001; Dichter et al., 2002; Gard & Kring, 2007; Lang et al., 1990; Miller, Patrick & Levenston, 2002; Sabatinelli et al., 2001; Temple & Cook; 2007; Vrana, 1995). Blumenthal and Goode (1991) demonstrated that the startle response is not exclusively a high intensity phenomenon. In a series of experiments, they found that probe intensities as low as 50 dB reliably elicited a startle response. The only differences between high and low intensity probes were that the latter were associated with smaller response amplitudes, slower onset latencies, and marginally decreased response probability rates. Cuthbert, Bradley, and Lang (1996) further demonstrated that probe intensities of as low as 80 dB used in the IAPS paradigm were equally useful for the valence modulation of the startle response as probes of greater intensities (≥ 95 db). In addition, the lesser the intensity of the probes, the lesser their perceived aversiveness as rated by the participants. This may be due to the non-linear relationship between decibel and the perceived volume: An increase of only 10 dB results in a doubling of perceived volume, irrespective of the base level (e.g., 90 dB is perceived as double the volume of 80 dB).

In the present study, we investigated the valence modulation of the different startle response parameter within four groups of increasing probe intensities (65 dB, 75 dB, 85 dB, and 95 dB). So far, the results substantiate the sufficiency of startle probes of lesser intensity than the customary probes of 95 dB used in most of the studies. Consistent with previous findings, an increase in probe intensity was associated with greater response amplitudes ($\omega^2 = .27$), faster response onsets ($\omega^2 = .43$), longer rise times ($\omega^2 = .14$), and higher detection rates (cf., Blumenthal et al., 2005; Blumenthal & Goode, 1991; Cuthbert et al., 1996). Nevertheless, the valence modulation of the startle response parameters was present at every intensity level ($\omega^2 \geq .21$).[5] Consequently, we tentatively recommend the use of probe intensities of 85 dB for the following reasons. Firstly, the effect sizes of the valence modulation regarding all three startle response parameters were great and of comparable size for the 85 dB and 95 dB stimulation. It can therefore be concluded that a large amount of the data's variance at the 85 dB level can be explained by the experimental manipulation. Secondly, the reliability estimates were sufficiently great for the peak amplitude, the onset latency, and the rise time latency ($r_{tt} \geq .79$). At last, the scoring of the peak amplitude and the latency measures was of comparable ease at the 85 dB and 95 dB level, but got increasingly difficult at the lower intensity levels. Lower probe intensities were associated with smaller startle response amplitudes. At the same time, the background noise was of steady amplitude across all intensity levels. Thus, there was a worse response/noise ratio for the lower intensities, which made the scoring more difficult. As a consequence, the detection rates of the startle response parameters were smaller at the low intensity levels than at the 85 and 95 dB level.

In sum, the findings promote the use of startle latency measures in the affective picture paradigm (Lang et al., 1990) and may be helpful in the investigation of individual differences in general startle reactivity during emotional processing. In the following, we therefore integrated these measures in the analyses of psychophysiological responses during the emotional processing of aesthetic stimuli.

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[5] except for the onset and rise time latency at the 75 dB level ($\omega2 = .05$).

In art, there is only one criterion: the goose bumps. You either have it or you do not!

Kurt Tucholsky

7 The psychophysiology of aesthetic emotions

The absence of utilitarian aspects in aesthetic emotions does not necessarily imply that they are completely disembodied. To date, plenty of evidence demonstrated that music and other forms of art are able to induce changes in autonomic systems and to trigger specific body sensations, such as aesthetic chills (e.g., Bartlett, 1996; Kuchinke et al., 2009; Tschacher et al., 2012). However, there have been no attempts so far to compare the physiological signature of aesthetic emotions to the physiological findings of utilitarian emotions. For this purpose, the affective picture paradigm may be an ideal experimental design to examine the various physiological components of an emotional experience (Scherer, 1984, 2000). In particular, such findings may help to empirically substantiate Scherer's (2004) conception of an aesthetic emotion and its distinction from utilitarian emotions.

7.1 Physiological Correlates of the Processing of Aesthetic Stimuli (manuscript 3)

The aim of our third study was, first, to investigate the physiological correlates of an aesthetic emotion and, second, to – possibly – delineate these from the physiological correlates of a utilitarian emotion. We used the experimental procedure of the IAPS paradigma to assess the five components of an emotional experience by Scherer (2004), namely the subjective feeling component (SAM ratings), physiological arousal (SCR), behavior preparation (startle response), motor expression (facial EMG), and cognitive processes (ERPs).

At first, we compared the responses to a set of general art pictures – differing in style, artist, and epoch – with a set of control pictures. The control stimuli (i.e., non-art) were manipulated versions of the art pictures, in such a way that the pixel array was randomized but the color spectrum and luminance remained the same. Second, we compared a selection of pleasant and unpleasant art pictures with a selection of pleasant and unpleasant IAPS pictures, because emotional IAPS pictures elicit responses that may be considered prototypical for utilitarian emotions. In order to compare the emotional art and IAPS pictures, they were matched regarding content. Since the largest effects are obtained for IAPS pictures depicting evolutionary salient images (i.e., erotica, threat, and violence), the art pictures were specifically selected to depict similar sceneries.

For the comparison of general art with non-art pictures, we found significant differences for the subjective feeling component (i.e., SAM ratings). The general art pictures were rated as being more pleasant ($\omega^2 = .65$) and more arousing than the non-art pictures ($\omega^2 = .54$). None of the autonomic correlates, such as the SCR (representing physiological arousal), the corrugator and zygomaticus activity (representing the facial expression), or the latency and magnitude parameters of startle response (representing the organismic preparedness) were influenced by the aesthetic stimulation. However, the general art pictures were associated with a greater cognitive engagement compared to the non-art pictures. The positive slow wave was of greater amplitude for the general art pictures, indicating an elaborate stimulus processing ($\omega^2 = .03$). The probe P3 was of lesser amplitude for the general art pictures, indicating a stronger binding of attentional resources by the general art pictures compared to the non-art pictures ($\omega^2 = .18$). Altogether, it may be concluded that an aesthetic emotion foremost involves changes in the subjective feeling component and the cognitive engagement component.

For the comparison of emotional art with emotional IAPS pictures, the findings suggest a differentiation between aesthetic and utilitarian emotions, which corresponds to the theoretical considerations of the design-feature approach to emotions (Scherer, 2004). In particular, differences were found with respect to the physiological arousal component (SCR) and the behavior preparation component (startle response).

In general, the SCR is considered to index the organism's physiological arousal and it has been found to be independent of the valence of the eliciting stimulus or event. So far, it had been a consistent finding that IAPS pictures with great subjective arousal ratings are associated with large changes in the SCR (Lang et al., 1993). However, emotional art pictures did not evoke any autonomic changes, although they were rated as being of great subjective arousal. In general, the startle response is considered to be part of an ancient defense system, which is primarily activated in high arousal situations and involves a basic behavioral spectrum, such as withdrawal, attack, or escape (Bradley et al., 2001). Therefore, the startle response may index the organism's state of behavioral preparedness. Similar to the SCR, emotional art pictures had no effect on the startle response, whereas the expected valence modulation was present for the IAPS pictures.

It may be concluded that the autonomic responses to an emotional stimulus are foremost sensitive to realistic displays of emotional sceneries and not to aesthetic illustrations of such. Presumably, the IAPS pictures inherently possess a greater psychological relevance, since they depict photographic, real life settings. Especially, this may be true for the evolutionary significant IAPS pictures, which are thought to particularly activate the appetitive and defensive motivational system and any subsequent organismic response patterns. In particular, these utilitarian response patterns are in the service of the behavioral adaptation and adjustment to situations involving important consequences for the organism's well being. Art pictures, in opposition, may be instantly recognized as such and categorized as lacking personal and direct relevance for the organismic well-being, despite of their matching evolutionary content (Bradley et al., 2001; Scherer, 2004). Considering that the function of the motivational systems is foremost to optimally prepare the organism for any event promoting survival, it is - of course - uneconomical (and even dangerous) for the organism to overly and unspecifically react to events of no immanent threat.

Furthermore, it may be concluded that the perception of *subjective* arousal (as indicated by great SAM ratings) may not be a necessary condition for the elicitation of *autonomic* reactivity. Whereas the IAPS pictures may engage the primitive motivational systems which initiate a state of heightened physiological arousal, the art pictures may presumably rather engage an elaborate higher-order cognitive processing (see point 2.1, *cognitive aspects*). Although this may translate to a similar perception of subjective arousal, it is rather a 'cognitive arousal' than a physiological arousal.

So far, this finding speaks against the initial hypothesis of Ramachandran and Hirstein (1999), which expected similar autonomic responses to art and any other emotionally evocative cue (see point 4, *aesthetic emotions vs. utilitarian emotions*). Instead, the findings rather fit the conceptualization of an aesthetic emotion and its distinction to utilitarian emotions as outlined by Scherer (2004). While utilitarian emotions may be characterized as being "high-intensity emergency situations, often involving a synchronization of many organismic subsystems" (p. 241), aesthetic emotions, so Scherer, feature an only low or moderate intensity, involve a lesser behavioral impact and a lesser organismic synchronization of physiological subsystems compared to utilitarian emotions (Table 2).

The most remarkable finding of the present study was that emotional art pictures evoked similar cortical responses as well-validated emotional IAPS photographs. The positive slow wave, which is supposed to indicate sustained elaborated cognitive processes, did not differ between emotional art and IAPS pictures. Additionally, the startle P3, which is supposed to indicate the extent of available attentional resources paralleling picture processing, did also not differ between emotional art and IAPS pictures. Therefore, emotional art and IAPS pictures initiate a similar cognitive engagement in the recipients, regardless of their utilitarian or aesthetic nature.

Again, these findings support Scherer's (2004) definition of aesthetic and utilitarian emotions. Both are described as being very high in cognitive processing. Whereas, utilitarian emotions involve the processing of relevant bodily needs, personal goals, and coping strategies (*transactional appraisals*), aesthetic emotions are rather associated with the elaboration of the artwork's inherent aesthetic qualities (*intrinsic appraisals*; Table 2). Moreover, utilitarian and aesthetic emotions are characterized as featuring high event foci, which may explain the increased attentional binding by the respective emotional stimuli as indicated by the startle P3.

The findings of this study suggest that aesthetic emotions are less embodied than utilitarian emotions with respect to the autonomic responses that reflect an engagement of the appetitive and defensive motivational systems (SCR, startle response). Utilitarian emotions serve a strategic function within the context of the preservation of the organism's well being – a quality that is not immanent in aesthetic emotions. However, aesthetic emotions and utilitarian emotions both engage elaborated higher order cognitive processes, which presumably mirror different appraisal contexts. Taken together, these findings may empirically validate Scherer's (2004) conceptualization of an aesthetic emotion as being of low intensity, lesser bodily synchronized and embodied, provoking little organismic preparedness and behavioral output, but involving elaborated cognitive evaluations and appraisals about the intrinsic qualities of the artwork.

7.2 Analyses of individual differences

To date, many findings suggest that both the reception and appreciation of artworks depend on individual differences variables (Augustin & Leder, 2006; Furnham & Walker, 2001a; Furnham & Walker, 2001b; Leder et al., 2012). Foremost, openness to experience (Costa & McCrae, 2009) has been found to be a strong predictor for preferences for specific art styles and the engagement in art-related activities (Chamorro-Premuzic et al., 2009). The present analyses investigated the association between openness to experience and the electrophysiological measures that were found to be modulated by the presentation of artworks (PSW, P300).

Electrophysiological data of interest is oftentimes superimposed by occasion-specific fluctuations. From the perspective of classical test theory, the increase in error variance is usually mirrored by small to moderate reliability estimates for these measures (Hagemann, Naumann, Thayer & Bartussek, 2002). In turn, correlations with other variables may thus be underestimated. Latent state-trait models may be used to separate the trait variance from the state occasion-specific variance and, furthermore, may help to estimate the true covariance between the trait variances of different variables. Necessary to that end, the variable has to be measured with at least two indicators on at least two occasions. Therefore, we repeated the previous experiment with the same sample eight weeks later. The data were split into an odd and an even trial set. The model parameters were estimated with the generalized least squares algorithm implemented in Amos 18 (Arbuckle, 2006). First, we investigated the latent-state-trait measurements for the PSW, the P300, the NEO-PI-R factor openness to experience, and its sub-facets openness to fantasy, aesthetics, and feelings (Costa & McCrae, 2008). Second, we investigated the correlation between the latent trait variables.

Table 2

Correlations between the positive slow wave and openness to experience.

factor/sub-facets[1]	*r*
openness to experience	.00
O1 openness to fantasy[1]	.12
O2 openness to aesthetics[1]	.24
O3 openness to feelings[1]	.03

Note. Correlations are person correlations. Electrophysiological data are from ArtGen only.

Only the measurement models for the PSW of the general art pictures could be well fitted. Neither the models for the PSW of the pleasant and unpleasant art pictures, nor the models for the P300 had an adequate fit. Furthermore, none of the correlations between the latent trait factor of the PSW and of the latent trait personality factors reached significance (see Table 2). These findings therefore suggest that the neuro-cognitive processing of aesthetic stimuli does not systematically vary with the recipients' open personality.

8 Summary and Conclusion

In the present work, we were interested in the features of an aesthetic experience in general, and in the psychophysiological components of an aesthetic emotion in particular.

Speaking of the latter, we found that emotional responses to artwork provoke different emotional pattern as so-called utilitarian emotions. Our results advocate a distinction between physiological measures that are affected by aesthetic stimulation and other that are left unaffected. To the first category belong the facial expressive muscle activity and the cortical EEG components indicative of emotional processing. The latter category, on the other hand, comprises autonomic measures such as the skin conductance response and the startle response. Interestingly, all measures of the first category were similar between the art and IAPS picture stimulation, whereas the measures of the second category were exclusively modulated by the IAPS pictures. The SCR and the startle response have been considered to be effective outputs of the neurophysiological circuits belonging to the appetitive and defensive motivational system (Lang, 1995). In particular, the amygdala and the hypothalamus have been identified to be among the key structures, with their efferent connections mediating the autonomic emotional responses and modulating the startle circuit, respectively (Davis & Whalen, 2001; Hariri, Tessitore, Mattay, Fera & Weinberger, 2002; see Lang, Bradley & Cuthbert, 1998, for an illustrative model of the neural structures of the defensive motivational system). Only stimuli with a great motivational significance for the organism (i.e., a strategic, evolutionary salient relevance) are capable of activating these structures. Art pictures, however, are devoid of any activation potential, even when depicting motivationally significant content. Apparently, the organism instantly attributed no immanent utilitarian importance, presumably by the virtue of their artistic (i.e., irrelevant and unrealistic) depictions.

Most remarkably, art processing involved an elaborate and sustained cognitive engagement, which was furthermore of similar magnitude compared to the IAPS pictures. These findings underline the highly emphasized importance of cognitive operations within the context of art processing, which involve complex associations, interpretations, and appraisal processes (e.g., Hagtvedt et al., 2008; Leder et al., 2004; Silvia 2005a). In accordance, the Art Reception Survey (ARS) – as the subjective evaluation of the aesthetic experience – highlights and concretizes these intrinsic operations. With the ARS, we may comprehensively assess diversified aspects of an intellectual, cognitive engagement, such as a profound curiosity about the artwork (*cognitive stimulation*), self-referential and art-historical analyses (*self-reference* and *expertise*, respectively), and judgments about the artistical and aesthetic value of the artwork (*artistic quality* and *positive attraction*, respectively). Scherer (2004) condensed these cognitive evaluations into one of the main features of an aesthetic emotion (intrinsic appraisals; see Table 1).

Altogether, our findings substantiate the distinction between aesthetic and utilitarian emotions (Scherer, 2004). Whereas the latter involves changes in all components of an emotional experience (Scherer, 1984; 2000), including physiological arousal and a state of organismic preparedness, aesthetic emotions foremost comprise subjective feelings, facial expression, and higher-order appraisal processes.

These findings further strengthen the position that art is indeed able to induce emotional responses in its recipients, which go beyond mere subjective ratings and are physiologically measureable. However, they form a separate category from the functionally adaptive, utilitarian emotions that oftentimes dominate our perspective on *the* emotions, per se. Or as Immanuel Kant (1790) put it – they are but disinterested pleasure.

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Appendix A1 – Manuscript 1

Assessing aesthetic appreciation of visual artworks – The construction of the Art Reception Survey (ARS)

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Abstract

A growing body of research investigates how people respond to art, how art preferences are related to personality traits, or what specific brain structures are involved in the appreciation of artworks. However, most of this research measures the aesthetic experience with a single item (e.g., "the artwork is pleasant"). The aim of the present work was to use a multidimensional approach to (I) analyze the factor structure of an aesthetic experience and (II) to construct the Art Reception Survey (ARS) to validly measure these factors. In study 1, 193 participants rated different art paintings of various styles and artists with a set of 76 items describing various components of an aesthetic experience. Principal component analysis revealed a six-factor structure including the recipient's cognitive involvement, his or her positive and negative affective appraisal, self-referential aspects, judgments about the artistic quality and creativity, as well as information about the knowledge and comprehension the recipient has about the artwork. Furthermore, we examined the specificity of the ARS scales for art stimuli by comparing the questionnaire between art and non-art stimuli (study 2). The results of both studies indicate adequate reliability and validity of the instrument. In future research, the ARS and its specification of relevant facets of an aesthetic experience may help to gain a better understanding of the complex relationships with personality traits or even psychophysiological correlates.

Keywords: aesthetic experience, aesthetic processing, instrument development

Assessing Aesthetic Appreciation of Visual Artworks – The Construction of the Art Reception Survey (ARS)

Art has always been an essential part of the cultural life of mankind. Today we have evidence of people's artistic skills and their need to express themselves in various forms dating back over 80.000 years, may it be in the early form of ritualistic body decoration, ornaments, and beadwork, or in the form of cave paintings and artistic bone carvings, progressing to complex compositions of classical music, paintings of various styles and content, and many more. The word art comes from the Latin word ars, which literally means 'craft' or 'skill'. Not only have people always been artistically talented, even larger numbers of people are fascinated by art and enjoy being exposed to it – whether it be attending a classical concert or visiting art galleries and museums. An impressive illustration of this fascination comes from attendance numbers for museums worldwide in 2010: Taken together, the five most popular art museums in the world alone attracted almost 30 million visitors, with the highest attendance at the Louvre in Paris (8.5 million visitors; "Exhibition and museum attendance figures 2010," 2011). But why exactly are so many of us intrigued by a Da Vinci, a Tizian, or a Picasso? Why do people stand in line, often travel great distances to view paintings of various content and style, painted by people whom they do not know?

In order to understand visual art's remarkable attraction upon people and our intrinsic motivation to expose ourselves to artworks, it is important to gain a thorough insight into what happens when people are exposed to art. Only then we might hypothesize about the reasons why so many of us engage in something which serves no obvious utilitarian function (Chatterjee, 2004). In an attempt to identify emotional states that can be induced by music, Scherer (2004) distinguished between utilitarian emotions and what he called aesthetic emotions. The distinctive feature of the former is their functionality in the adaptation and adjustment of an individual to important environmental challenges, often involving synchronized psychophysiological changes. To a great extent they are based on and influenced by the individual's appraisal of the situation, existing goal relevance, and his or her coping potential within the context (Hagemann, Waldstein & Thayer, 2003). Aesthetic emotions are quite different. They are less concerned with personal needs or goals, specific action tendencies, or coping strategies. Rather, they are triggered by evaluations of aesthetic stimuli and are influenced by a positive reception of its "intrinsic qualities" (Scherer, 2004, p. 244). It is beyond question that a major motive to expose ourselves to art is such an appreciation of intrinsic qualities, which is often referred to as judgments of pleasure, likability, or beauty. Yet, above such a concise judgment, recent findings in aesthetic research suggest that an aesthetic judgment is much more complex. In particular, various affective and cognitive aspects play a central role in the perception, evaluation, and appraisal of visual art.

A model of aesthetic experience. A promising theoretical framework by Leder, Belke, Oeberst, and Augustin (2004) provides first answers to what processes may take place between the moment of exposure to an artwork and the formation of an aesthetic judgment. They outlined a model of aesthetic experience, which proposes a sequential cascade of five information processing stages that are bidirectionally connected via feedback loops. The specific levels integrate basal bottom-up analyses as well as higher-order interpretative processes, which may lead to an aesthetic judgment. During the first stage, perceptual analyses, structural features such as complexity, contrast, symmetry, and grouping are extracted and analyzed, which is then followed by the second stage of implicit memory integration. According to Leder et al. (2004), art specific mechanisms (e.g., familiarity) due to prior experiences of the recipient might be effective on this stage, however they need not to become conscious to the recipient in order to show effects. A deliberate and conscious involvement with the artwork becomes possible on the next stage, explicit classification. The recipient begins to process information of style and content of the artwork, drawing on personal characteristics such as expertise and declarative art knowledge, as well as personal interest and taste. During the fourth stage, cognitive mastering, meaning is extracted from the artwork involving higher-order interpretations. Lay persons are presumed to draw on self-related interpretations like personal experience, everyday knowledge, and feelings, while experts are believed to rely more on art-specific concepts (e.g., style; Augustin & Leder, 2006). Finally, all this information then enters the evaluation stage, where the recipient appraises the success of the preceding processes and accordingly frames an aesthetic judgment. A successful interpretation of the artwork will evoke a positive aesthetic judgment, while an unsuccessful interpretation will cause a more negative and poor aesthetic judgment. The idea of an association between successful cognitive operations concerning a particular artwork and a positive attitude towards it has also been proposed by Reber, Schwarz, and Winkielman (2004). In their concept of processing fluency they proclaimed that artworks are rated more beautiful the easier they are cognitively processed. Parallel to the sequence of cognitive processes, there is a continuous stream of an affective evaluation of the artwork. It builds up on the recipient's initial emotional state and is dynamically influenced by the interim results from each individual stage of information processing. An unsuccessful processing at one stage may cause a decline in the affective evaluation, whereas a successful operation may result in an increase in the positive attitude towards the artwork. The final outcome of the affective evaluation stream is an elaborated aesthetic emotion towards the artwork, which parallels the aesthetic judgment.

While aspects of the model of aesthetic experience might still be under debate, it constitutes a valuable description of factors that are essential to the cognitive and emotional evaluation of artwork, underlining the considerable importance of a successful extraction of meaning. Moreover, it takes recent findings into account by highlighting the interaction between the various stages of cognitive processing and recipient characteristics, such as personality, taste, and interest in art as well as previous experiences and expertise (e.g., Chamorro-Premuzic, Furnham & Reimers, 2007).

Assessment of aesthetic experience. To date, there still lacks a valid instrument for the assessment of cognitive-affective reactions to aesthetic stimuli and their concomitants as proposed by the model by Leder et al. (2004). A first approach to assess the concept of aesthetic experience comes from Rowold (2008). The factor analytically derived Survey for the Assessment of Aesthetic Perception (SAAP) contains 16 items, which load on three factors labeled emotion, cognition, and self-congruence. However, the SAAP has a few limitations. For example, the items of the emotion and cognition scales in the SAAP do not sufficiently cover the range of aesthetic emotions and cognitive processes, as proposed by the existing literature regarding aesthetic perception (e.g., Leder, Belke, Oeberst & Augustin, 2004; Silvia & Brown, 2007; Zentner, Grandjean & Scherer, 2008). In particular, the SAAP does not include the most evident dimensions of an aesthetic judgment, like beautiful-not beautiful, pleasant-unpleasant, like-dislike, which are the most common self-report items in studies concerning empirical aesthetics. The items that load on the SAAP emotion scale all have a positive valence, neglecting that there are also other emotional states in response to art. Silvia and colleagues (2007, 2009) extended the range of aesthetic emotions by including knowledge-based emotions (e.g., interest, confusion, and surprise), hostile emotions (e.g., anger, disgust, and contempt), and self-conscious emotions (e.g., pride, shame, and embarrassment) as possible affective reactions towards art. Furthermore, the conceptual range of the items of the cognition scale is somewhat restricted as well. Some of the items are semantically very similar (e.g., ‘have to think about artwork for a long time’, ‘the content of the artwork occupied my mind’, ‘makes me think’) and they only partially assess the range of cognitive processes as outlined by the Leder et al. (2004). A rather methodical point of criticism is that Rowold used only one painting in the construction process of the questionnaire. The participants viewed a picture called ‘The Most Wanted Painting for Germany’ by Komar and Melamid, which was presumed to be an ideal prototype of an artwork, subsuming the findings on average national art preference. However, it might be doubted that this artificially constructed painting is a true representative of art as it is traditionally classified by the participants. Furthermore, the use of only one painting limits the generalisability of the SAAP with respect to different artworks varying in artist, style, and content.

Another recent scale construction to measure perception and evaluation of visual art comes from Hagtvedt, Hagtvedt, and Patrick (2008). The authors used a combined rational and factor-analytical approach, which exclusively focused on cognitive and affective aspects. Findings identified two dimensions, namely valence and arousal, which constitute four factors describing the emotional reaction to an artwork (negative high arousal, negative low arousal, positive high arousal, and positive low arousal). Additionally, four cognitive factors were identified to describe the perceived attributes of the artwork (creativity, aesthetic appeal, formal execution, and curiosity appeal). This scale provides certain advantages over the SAAP. First, it broadens the range of perceived emotions including more negative or melancholic emotions like agitation, anxiety, loneliness, or sadness. Second, the scale refers to specific attributes of the artwork like being original, inventive, rhythmic, or balanced, and also it refers to attributes of distinct aesthetic appeal of the artwork like being beautiful or attractive. One major limitation of the scale, however, is that the categorization of negative and positive emotions low on arousal contradicts all research findings on emotional reactions to visual stimuli. In order to describe emotions in general, Lang and his research group (Lang, Bradley & Cuthbert, 1999) outlined an affective space, with the intersecting dimensions valence and arousal. It has been well established that only visual stimuli with great positive or negative valence elicit an increased psychophysiological arousal, whereas visual stimuli that are close to a neutral valence are at the same time also low on arousal. Thus, while in traditional, non-aesthetic emotion research there is no such thing like stimuli that elicit great positive or negative emotions of low arousal, this has not yet been empirically examined or confirmed for aesthetic stimuli. An additional conceptual limitation is that Hagtvedt et al. (2008) focused on cognitive and affective aspects only, excluding all self-references a recipient might make towards the artwork and neglecting individual differences in taste, interest, and expertise. Finally, recipients have to first identify the stimulus in question as an artwork, a process which Leder et al. (2004) call the pre-classification of the object as an aesthetic stimulus. Only then, the cognitive-affective cascade of an aesthetic experience can proceed. Accordingly, judgments on artistic quality and skill need to be assessed in addition. Altogether, the inclusion of these decisive factors in the assessment of an aesthetic experience might provide a more thorough insight into the processes and outcomes of an aesthetic experience.

Objective of the present study. The limitations of the SAAP and the instrument by Hagtvedt et al. (2008) suggest the construction of a new questionnaire. Ideally, a new instrument should take all aforementioned aspects into account to comprehensively measure an aesthetic experience of visual art. The value of such a revised instrument would be great, considering the expansion of research in the field of empirical aesthetics in the recent years, such as studies on personality and individual differences, or neuroaesthetics (e.g., Chamorro-Premuzic, Reimers, Hsu & Ahmetoglu, 2009; Jacobsen & Höfel, 2003; McCrae, 2007; Nadal, Munar, Capó, Rosselló & Cela-Conde, 2008). It could be used to evaluate whether high scorers on certain personality traits (e.g., openness to experience), which have already been associated with specific art preferences, aesthetic activities, and attitudes (e.g., Chamorro-Premuzic et al., 2007; Feist & Brady, 2004; McManus & Furnham, 2006), have differentiated patterns of aesthetic evaluation or emotional processing compared to low scorers. Or specifically how novices with little or no art training and experience appraise art in comparison to persons with great art expertise. A more recently evolved field of empirical aesthetics is the study of neuroaesthetics, which is concerned with the investigation of neural correlates of an aesthetic experience. These studies focus on the identification and localization of brain areas that are associated with the formation of an aesthetic judgment (see, Nadal et al., 2008, for a review) using brain imaging and electrophysiological methods. Typically, the aesthetic judgment was assessed with a singular rating on preference, beauty, or aesthetic appeal. A more elaborate questionnaire that specifies explicit cognitive processes might allow a more differentiated insight into aesthetic brain correlates. The objective of the present study was therefore to develop a comprehensive, multi-scaled instrument for the measurement of an aesthetic experience including the most relevant antecedents and concomitants.

The empirical enterprise was conducted in two stages. The aim of the first study was the construction of the Art Reception Survey (ARS). A large sample completed a preliminary version of the questionnaire, and the data was analyzed with principal component analysis (PCA) to identify the underlying structure and scales. An item parameter analysis helped to further refine the questionnaire. In study 2, we tried to validate the ARS by examining its specificity to art pictures in comparison with non-art pictures.

We are well aware that an aesthetic experience is not limited to paintings only, but is in fact a quite common phenomenon in many fields (Dietrich, 2006; Hargreaves & North, 2010; Miele & Murdoch, 2002; Silvia & Berg, 2011). It should be noted, however, that the focus of this paper is limited to visual art in the form of paintings. Moreover, the questionnaire was constructed in German language but an English translation is provided in the Appendix.

Item Generation. The initial step towards a new questionnaire was to generate a list of items that may indicate all relevant aspects of an aesthetic experience. An extensive body of literature was used for the selection of suitable items. These items were either derived from the various elaborate descriptions and definitions of an aesthetic experience or else were borrowed from empirical studies that have used these particular items to assess an aesthetic experience for their own purpose. These items can roughly be subsumed under several categories. First, a subset of the items described affective reactions towards a piece of art (Frijda, 1986; Hagtvedt et al., 2008; Rowold, 2008; Silvia, 2009; Zentner et al., 2008). Other items might be assignable to important cognitive aspects as for example outlined by the model of aesthetic experience (Leder et al., 2004). Here, we chose items that emphasized the interpretation of the artwork and the successful extraction of meaning and understanding. Moreover, we also focused on items grasping an aesthetic judgment, such as items referring to beauty, liking, preference, and "being aesthetic". Picture-specific characteristics were limited to the description of creativity and skillfulness (Kozbelt, 2004; Hagtvedt et al., 2008). Additionally, we took into account that there are specific person-related variables that on the one hand are not directly expressing aspects of an aesthetic experience per se, but on the other hand have an immediate influence on the reception of the evaluated artwork and therefore have an indirect influence on the outcome of the aesthetic experience (e.g., Augustin & Leder, 2006; Belke, Leder & Augustin, 2006). These items can generally be assigned to the concept of art expertise or expert knowledge, describing whether the recipient recognized the particular painting or artist, possesses knowledge about its style, its art historical context, underlying meaning, or artistic relevance. At last, several items described a self-referential association between the recipient and an artwork as suggested by Rowold (2008). In summary, we compiled a preliminary questionnaire including 76 items to a PCA to gain insight into the underlying factor structure.

Study 1

Factorial Validation. The aim of the study was to test the questionnaire with a large sample of participants and to further refine the selection of items. We performed a combination of PCA and item analysis, which resulted in a final version of our questionnaire, the Art Reception Survey.

Method

Participants

We recruited 147 psychology students of the University of Heidelberg and additionally 47 participants through an advertisement in a local newspaper (155 females).[1] The average age was M = 29 years (SD = 17 years, range = 18 – 88 years). One participant had to be excluded due to too many missings in the questionnaires (total N = 193).

Material

Six paintings were selected, painted by different artists and representing different art styles throughout art history.[2] Three of the paintings were representational (i.e., depicting objective content in a rather realistic and recognizable fashion), for example romanticism or impressionism. The three other paintings were all non-representational (i.e., depicting either non-objective forms or content in a rather abstract fashion), for example cubism or constructivism. We chose different paintings to maximize variability and to ensure that our findings would not be restricted to one specific artwork but rather be generalizable. For each item, the participants were asked to rate their endorsement on a five-point rating scale, ranging from 1 = completely disagree, 2 = rather disagree, 3 = neither nor, 4 = partly agree, 5 = completely agree.

Procedure

There were three painting sets each consisting of one representational and one non-representational painting. Each participant rated one painting set during one of five sessions. Due to difficulties in participant recruiting, the group sizes greatly differed between sessions ranging from nine to 81 participants. Therefore, we presented the same picture sets during several sessions in order to increase the number of ratings for these particular pictures. The number of ratings for each picture ranged between 46 and 81 (M = 64.3, SD = 17.6).[2] The presentation of the paintings took place in an auditorium, where the paintings were projected onto a large screen. The lighting was adjusted to assure that the painting and its color were perceived in their best condition. Participants were told to relax and to take in each painting in silence. Smith and Smith (2001) estimated the average amount of time spent on a painting by visitors of the Metropolitan Museum of Art at 27 seconds. In order to always provide the participants with enough time, we chose to present the paintings for one minute before asking to fill out the questionnaire. The paintings remained projected onto the screen during the completion of the questionnaire, yet the lights were turned on again. At the end of the session, we further assessed art activity, art attitude, and art knowledge with a general questionnaire.

The questionnaire was a modified version of a questionnaire used by Augustin and Leder (2006).[3] Findings will not be reported here.

Statistical Analysis

All participants viewed one representational and one non-representational painting and therefore completed the questionnaire twice. Because we were interested in the reactions to art in general rather than to specific art styles, we computed averages for each item across both picture presentations, separately for each participant.[4] Eleven of the 76 items had small negative correlations between the rating of the first and the second picture (M = -.05, SD = .04). Table 1 presents the item correlations between picture 1 and 2 for the items of the ARS. The remaining item correlations were all positive (M = .21, SD = .13). Due to the large majority of positive and only few small negative correlations, we initially kept all items for the subsequent analyses to maintain a large item pool.

Then, we conducted a PCA to explore the data's underlying factor structure.[5] The data met the Kaiser-Meyer-Olkin's sample adequacy criteria (0.90, minimum acceptable level 0.60). The percentage of item correlations greater than r = 0.30 was 20.16%. Altogether, this confirmed the appropriateness of using factorial models. The number of factors that may be extracted was determined by an inspection of the eigenvalues (scree plot) as well as by rational grounds. The factors were rotated with the oblique rotation procedure (direct oblimin). The factor correlation matrix revealed substantial correlations between the individual factors. All items with primary target factor loadings of at least .40 and cross loadings less than .30 were retained. The only exceptions to these criteria were items with low values of the item difficulty parameter (p < .40) since they have a great potential to differentiate between participants at the upper end of the attribute dimension.

The items that were retained after the first item selection were submitted to a second PCA. The aim was to further establish the factor structure and to refine the item selection process. In addition, item parameters such as item difficulty (computed as the percentage of the maximally achievable item score) and item-test correlation (part-whole corrected) were assessed. The subsequent item selection was performed in a two-step fashion. First, items were again scanned for their primary target factor and cross loadings and accordingly retained or eliminated. In a second step, a selection index (S_{el}; Amelang & Schmidt-Atzert, 2006) was calculated for each remaining item and used as a means for selection. The S_{el} is a function of the item-test correlation and the item difficulty.[6] It accounts for both goals that the selection process intends to realize: (a) Items with great item-test correlation should be retained and items with low item-test correlation should be discarded, because only the former optimally represent the factor in question. (b) Items with extreme difficulty (i.e., great or low difficulty) should be retained, because they guarantee a good differentiation of participants across the whole range of the attribute dimension. The selection index is defined in such a way that it increases with increasing item-test correlation (yet steady difficulties) and therefore favors representative items. On the other hand, S_{el} increases with high or low item difficulties. Therefore, such items with extreme difficulties have better chances to be selected on the basis of the S_{el} than items with intermediate item difficulties (Amelang & Schmidt-Atzert, 2006). Altogether, we retained items with a selection index of $S_{el} \geq .70$.

Out of the pool of remaining items, we chose the final list of items on the grounds of item content in order to facilitate the face validity of the scales. Out of all items assigned to a particular factor, the items that heterogeneously outlined the theoretical concept of the factor were selected. In the end, the ARS was composed of exactly these items. The reliability of each factor was estimated with Cronbach's alpha. Finally, a last PCA was run over the finalized selection of items to check if the factor structure remained stable. High primary factor loadings and low cross loadings were expected.

Results

In total, 13 factors had initial eigenvalues greater than one explaining 71% of the total variance. The eigenvalue of the first factor was 22.64, explaining alone almost 30% of the data's variance. The scree plot pointed towards a structure with four to six factors. Because the six factor structure fitted better with the theoretical considerations than the other factor solutions, it was chosen. Together, the six factors explained almost 60% of the data's variance. See Figure 1 for the scree plot of the eigenvalues.

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Please insert Figure 1 about here

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Out of the initial item selection, 21 items did not meet the selection criteria of a minimum target factor loading of .40 and a maximal cross factor loading on other factors of less than .30. All but one of these items were discarded. This particular item (item 59, "I feel repulsed by this painting", see Appendix) was kept due to its rather great difficulty of .38. This item had a target factor loading of .59 and a cross factor loading of .35. The rest of the items that fit the loading criteria had a mean item difficulty of p = .56 (SD = .12, range = .30 – .77). Sixteen items were related to factor 1, with "This painting is pleasant" as its marker item (factor loading = .78). We labeled this factor *positive attraction*. Eleven items were related to factor 2, with "This painting makes me sad" as its marker item (factor loading = .80). We labeled this factor *negative emotionality*. Nine items were related to factor 3, with "I can relate this painting to its art historical context" (factor loading = .84). We labeled this factor *expertise*. Nine items were related to factor 4, with "This painting is unique" as its marker item (factor loading = .79). We labeled this factor *artistic quality*. Six items were related to factor 5, with "This painting makes me curious" as its marker item (factor loading = .74). We labeled this factor *cognitive stimulation*. Four items were related to the last factor 6, with "This painting makes me think about my own life history" (factor loading = .88). We labeled this factor *self-reference*.[7]

The reduced item set (56 items) entered a second PCA to review the factor structure and refine the item selection for the final version of the questionnaire. Overall, the factor structure remained stable. For the item selection, we examined the factor loadings and the selection index (S_{el}). Only two items failed to meet the criteria concerning target factor and cross factor loading (items 35 and 59). Thirty-eight items had a selection index of .70 and greater, including all marker items (items 8, 13, 17, 36, 69, 75): Nine items were related to factor 1 (*positive attraction*), 5 items were related to factor 2 (*negative emotionality*), 7 items were related to factor 3 (*expertise*), 9 items were related to factor 4 (*artistic quality*), 6 items were related to factor 5 (*cognitive stimulation*), and only 2 items were related to factor 6 (*self-reference*). In order to obtain more items assigned to self-reference, we included the other two items (items 28, 64) representing factor 6, irrespective of their selection index (S_{el} = .55 and .62, respectively). Additionally, four items were retained in spite of their inadequate factor loading (item 59) or their low selection index (items 4, 26, 29, 59) due to their rather extreme item difficulty of below p = .40 (p = 33, 34, 30, 38, respectively).

Altogether, this left us with an item pool of 44 items from which to compile the final version of the ARS. Since all remaining items were adequate in terms of item parameters, the decision of which items to select was based on theoretical grounds only. It was important that the final items covered a broad range of the theoretical construct of the particular factor and that they did not overlap in their content. In the process, we chose five items per factor, except for factor 6 (only 4 suitable items left), resulting in a total of 29 items.

Table 1 shows the item parameter of all 29 ARS items after a final PCA was run over the finalized list of items. Please note that the factor structure remained intact, however the order of the six factors did change. The factor pooling most of the variance was now *cognitive stimulation*, instead of *positive attraction*. The factor 2 and 3 (*negative emotionality* and *expertise*, respectively) remained in the same order. The fourth factor was now *self-reference*, instead of *artistic quality*. The fifth factor was now *artistic quality*, instead of *cognitive* *stimulation*. At last, the sixth factor was now *positive attraction*, instead of *self-reference*. Cronbach's alpha was adequate for all 6 subscales of the ARS, ranging between α = .83 and α = .90.

Please note, that two items of the final ARS questionnaire were items with negative correlations between the ratings of picture 1 (representational) and picture 2 (non-representational). Both these items belong to the factor *positive attraction* (item 8 and item 40; see Table 1). However, we kept these two items for several reasons. First, there were no psychometric reasons to eliminate these two items. Both of the items had satisfying item difficulties [p = .55 (item 8) and p = .57 (item 40)] and item-test correlations [r_{it} = .64 (item 8) and r_{it} = .68 (item 40)]. Moreover, the internal consistency of the entire factor *positive attraction* was adequate (Cronbach's α = .83). Second, the items made theoretical sense. Item 8 ("This painting is pleasant") is a very fitting and relevant example of an overall positive aesthetic judgment. In addition, it was even the marker item for the entire factor *positive attraction* with the highest factor loading (.71). Item 40 ("This painting thrills me") describes a kind of vivid enthusiasm or fascination with the painting that none of the factor items grasped.

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Please insert Table 1 about here

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The correlation matrix of the six ARS factors revealed substantial correlations between some of the extracted factors (see Table 2). *Artistic quality* positively correlated with both *cognitive stimulation* (.41) and *positive attraction* (.35). And *cognitive stimulation* positively correlated with *positive attraction* (.30). All other factor correlations were below .30.[8]

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Please insert Table 2 about here

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Discussion

Altogether, a pool of 76 items entered the analysis. The component analysis pointed towards a six factor solution, explaining almost 60% of the data's variance. The compilation of the ARS was done on psychometric and rational grounds. Besides the loading of each item to a factor, the items were selected according to their item difficulty and item-test-correlation. From the remaining set of psychometrically adequate items, we selected those items that broadly delineated each corresponding factor. This left us with a final set of 29 items for the ARS.

The factor that explained most of the variance was *cognitive stimulation*, which describes an intellectual engagement of the viewer with an artwork. Individuals that score high on this factor are intellectually intrigued by the painting. They enjoy thinking about the artwork (irrespective of the particular content) and are curious to learn more about artist and background. The second factor, *negative emotionality*, describes the arousal of unpleasant affective responses towards the artwork. Some of the items express a rather melancholic and gloomy feeling ('feel troubled', 'sad', or 'lonesome'). The third factor, *expertise*, assesses the extent of explicit knowledge the person has about artist and painting, as well as a sense of understanding of the artist's intention or idea that was meant to be expressed. This factor provides information beyond a mere cognitive involvement, and describes the relative success of these operations that are performed during stimulus processing. It therefore captures the output of the cognitive mastering stage of the model by Leder et al. (2004). The fourth factor, *self-reference*, describes whether the recipient is feeling a personal connection to the painting, evoking past memories or emotions. This factor shows close resemblance to Rowold's self-congruence from the SAAP (2008). The fifth factor, *artistic quality*, outlines the level of creativity and artistic skillfulness that is attributed to the painting and painter. The last factor, *positive attraction*, subsumes items describing a positive reception of the artwork. It combines items which have been frequently used in other aesthetic studies (beauty, pleasantness) with items referring to a much more profound emotional engagement, such as being inspired or thrilled.

Study 2

Validation of the ARS. In a second study, we tested the specificity of the ARS for aesthetic stimuli. Therefore, we compared the ARS in response to art stimuli to the ARS in response to non-art stimuli, expecting greater scores on all ARS scales for the art pictures than for the non-art stimuli.

Method

Participants

We recruited 30 students from the University of Heidelberg (23 females). The average age was $M = 21$ years ($SD = 1$ year, range = 19 - 25 years).

Material

We presented a set of 12 stimuli to the participants, consisting of six reproductions of art paintings and six pictures of the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2008).[9] The IAPS is a set of normative, emotional evocative color photographs that cover a broad range of semantic categories. They are traditionally used in emotion research to investigate the many facets (e.g., psychophysiological correlates) of an emotional response. Again, we carefully selected the art stimuli to be of different art styles and content. The IAPS pictures were selected to that effect that they depicted partly similar scenes, like an interior decoration, a still life, and a scene with people. The participants viewed all 12 stimuli intermixed in one of two pseudo-randomized orders. Half of the participants viewed order 1, and the other half of the participants viewed order 2.

Procedure

All 12 pictures (6 art, 6 IAPS) were presented in an auditorium, where they were projected onto a large screen. The lighting was adjusted to assure that all stimuli were perceived in their best condition. Each picture was presented for 60 seconds. After each picture, the students were asked to fill out the ARS questionnaire (final version, 29 questions). This resulted in a total of 12 ARS questionnaires per person. The paintings remained projected onto the screen during the completion of the questionnaire, yet the lights were turned on again. At the end of the session, we further assessed art activity, art attitude, and art knowledge with questions of a general art questionnaire (Augustin & Leder, 2006). Items regarding art activity assessed if a participant for example enjoys going to museums, reads art literature, has had art education at school, or paints as a hobby. Items regarding art attitudes assessed if a participant for example considers art to be merely decorative, considers modern art to be trivial, thinks that art is mostly about an exact portrayal of the surrounding world (positive answers would indicate a negative art attitude, resulting in a low score). Items regarding art knowledge assessed a participant's knowledge about different artists and their associated painting styles (e.g., Salvador Dalí and surrealism, respectively).

Statistical Analysis

Across the six ARS questionnaires referring to the art pictures, the scores for each of the six ARS subscale were averaged per participant. And across the six ARS questionnaire referring to the IAPS pictures, the scores for each of the six ARS subscales were averaged per participant. We then computed a repeated measures analysis of variance (ANOVA) with the within factors STIMULUS (art pictures, IAPS pictures) and ARS FACTOR (cognitive stimulation, negative emotionality, expertise, self-reference, artistic quality, positive attraction). For post-hoc comparisons, we computed *t*-tests (one-sided, corrected for multiple comparisons). Furthermore, we correlated the scale scores for each factor with the results of our general art questionnaire, assessing art activity, art attitude, and art knowledge. Higher scores on each scale indicated more frequent art activities, a more positive and artistic art attitude, and a better and more profound art knowledge, respectively.

We expected that the ARS scores of the art pictures would be generally greater than the ARS scores of the IAPS pictures. Furthermore, we expected that the scores for art attitude, activity, and knowledge would only correlate with the ARS scores of the art pictures but not with the ARS scores of the IAPS pictures. Further hypotheses may be derived from the model of aesthetic appreciation and aesthetic judgments by Leder et al. (2004). It describes a close relationship between declarative knowledge (i.e., expertise) and the stage of cognitive mastering. Oftentimes, art experts tend to engage in art-related interpretations whereas lay persons tend to engage in rather self-related interpretations. The authors presume that "with expertise, the artwork, its historical importance, or the knowledge about the artist also become the content of the aesthetic object" (Leder et al., 2004, p. 497). Lay persons, on the other hand, oftentimes "associate the content of an artwork with their situation and their own emotional states (Parsons, 1987)" (Leder et al., 2004, p. 499). Consequently, we expected art knowledge to correlate positively with expertise and negatively with self-reference. In general, we also expected a positive art attitude to correlate positively with cognitive stimulation and positive attraction, since a more open and artistic mindset might promote a more positive cognitive and affective reception of an artwork.

Results

There was a significant main effect of STIMULUS, $F(1,28) = 120.76$, $p < .001$, $\omega^2 = .67$. On average, the scale scores for the art stimuli were higher than the scale scores for the non-art stimuli. There was a significant main effect of FACTOR, $F(5,140) = 82.45$, $p < .001$, $\omega^2 = .69$. In addition, there was a significant interaction between STIMULUS and FACTOR, $F(5,140) = 36.90$, $p < .001$, $\omega^2 = .33$. See Table 3 for the descriptive results. Post-hoc comparisons revealed that not all ARS scales differed between the art and the non-art stimuli. The scale score for *cognitive stimulation* was higher for the art stimuli than for the non-art stimuli, $t(29) = 7.91$, $p < .001$. The scale score for *positive attraction* was higher for the art stimuli than for the non-art stimuli, $t(29) = 8.26$, $p < .001$. The scale score for *expertise* was higher for the art stimuli than for the non-art stimuli, $t(29) = 6.91$, $p < .001$. The scale score for *artistic quality* was higher for the art stimuli than for the non-art stimuli, $t(29) = 15.53$, $p < .001$. The scale score for *negative emotionality* did not differ between the art stimuli and the non-art stimuli, $t(29) < 1$, $p = .321$. The scale score for *self-reference* did not differ between the art stimuli and the non-art stimuli, $t(29) < 1$, $p = .396$.

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For the art stimuli, art activity correlated positively with *self-reference* (r = .49, p = .007), with *positive attraction* (r = .48, p = .008), and with *expertise* (r = .60, p = .001). The more active participants were regarding art-related activities, the more they could personally relate to the art stimuli, the more attracted they were to the art stimuli, and the more they knew about the art stimuli. As expected, art knowledge correlated positively with *expertise* (r = .59, p = .001). The more a participant knew about art in general, the more he or she knew could cognitively relate to the presented art picture. This confirms our initial hypothesis that art experts go beyond the depicted content of the artwork and have a generally more thorough understanding about the artist, the works significance, and its meaning. However, art knowledge did not correlate with *self-reference*, speaking against our initial presumption of a relationship between lesser art knowledge and a possibly higher importance of self-referential associations with the artwork. The hypotheses about art attitude were only partly confirmed. While a more positive art attitude was associated with higher scores on the cognitive stimulation scale (r = -.32, p = .086) there was no relationship between art attitude and positive attraction.[10] As expected, art activity, attitude, and knowledge did not correlate with any of the ARS scale scores in response to IAPS pictures.

Discussion

We were interested in the validity of the ARS to assess specifically the aesthetic experience in response to art paintings. We therefore compared the ARS in response to art stimuli with the ARS in response to non-art stimuli (here, IAPS pictures). As expected, the participants rated the art paintings differently on the ARS than the non-art stimuli. However, not on all factor levels were the average scores significantly greater for the art paintings than for the non-art pictures. Only the ARS scales *cognitive stimulation*, *positive attraction*, *expertise*, and *artistic quality* showed greater scores, while there was no difference for the scales *negative emotionality* and *self-reference*. Both latter factors can be subsumed under the common higher-order factor *emotional self-reference*, which describes the recipients connection to the artwork in form of personal memories and emotions. One reason for the indistinctness of *negative emotionality* and *self-reference* for the art stimuli might be the age of the participants. On average, the participants were rather young and it might therefore be possible that they could have had difficulties to relate to the paintings. Although, little is known about art and age-related empathy, it might be possible that older recipients have a greater ability to relate to an artwork, may it be due to a generally higher art preference (Chamorro-Premuzic et al., 2009) or a greater experience with artworks in general. With respect to the current sample, the level of involvement in art-related activities was in particular associated with the *self-*

reference scale. Only participants engaging in art-related activities (such as visits to an art museums and galleries, or pursuing painting as a hobby, etc.), showed greater self-reference scores for art stimuli than non-art stimuli. This difference was not found for participants with little or no engagement in art-related activities. It may be further noted that the item difficulties for the factors *negative emotionality* and *self-reference* have been rather low with respect to the other scales (see study 1). Correlations between the ARS scales in response to art pictures – and not IAPS pictures – with general artistic facets like activity, attitude, and knowledge point towards a convergent validity of the ARS scales.

Altogether, it can be concluded that the ARS assesses specifically cognitions and emotions that are formed in response to art paintings. However, this distinctiveness was not found for the factor *negative emotionality.*

General Discussion

Interested in the underlying factor structure of art experience, we constructed an art reception questionnaire based on the complex processes that are involved in the formation of an aesthetic judgment and an aesthetic emotion as proposed by Leder et al. (2004). Their model suggested that an aesthetic experience to a visual artwork is the result of a complex and dynamic evaluation process that integrates both basal perceptual analyses, higher order cognitive operations, as well as a continuously updated affective appraisal of the artwork. According to the model however, an aesthetic experience does not merely depend on cognitive and affective appraisals alone. In particular, specific person-related characteristics influence how the artwork is perceived. Classification and evaluation processes are modulated by top down influences of art expertise, declarative knowledge, personal interest, and taste. Therefore, the focus on these aspects was of particular importance for the construction of the ARS. Our main focus was not on singular features of the artwork itself. A considerable amount of research in the field of empirical aesthetics has already investigated which perceptual properties are perceived as more beautiful than others (e.g., Berlyne, 1974; Jacobsen & Höfel, 2003; Ramachandran & Hirstein, 1999). However, we wanted the questionnaire to be independent of the explicit content and thus, it should be generalizable to a large variety of art paintings.

The factor structure mirrored to a great extent the a priori assumptions we made. The extraction of the factors was based on empirical and rational grounds. The factor that explained most of the variance was *cognitive stimulation*. The importance of an intellectual engagement in the reception of art is not new. It corresponds well to Berlyne's concept of curiosity, describing the search for knowledge and meaning, which again is closely related to interest as a dimension of an aesthetic response (Berlyne, 1949; Cupchik & Gebotys, 1990). In the same vein, Martindale proposes in his theory of cognitive hedonics a “hedonic calculus”, which relates the pleasure derived from an aesthetic stimulus to the cognitive processes involved in the striving for meaning (Cupchik & Gebotys, 1990; Martindale, 1984). Moreover, Leder et al. (2004) have explicitly emphasized the essence of cognitive operations in the processing of artworks and its self-rewarding experience. The second factor, *negative emotionality*, describes the arousal of unpleasant emotions elicited by an artwork and therefore validates recent considerations about the existence of other aesthetic emotions beyond the mere positive responses towards art (Scherer, 2004; Silvia, 2009). The undertone of most of the items is rather melancholic or anxious. Melancholy has often been suspected to exert an influence on art itself. Many artists are believed to have had a melancholic or depressive disposition, which is sometimes claimed as the aesthetic driving force behind their creativity (Brady & Haapala, 2003; Clair, 2005). It is conceivable that a melancholic undertone of a painting is sometimes picked up by an empathetic recipient and thus mirrored in his or her affective response towards the painting. By all means, *negative emotionality* is well in accordance with literature on the arousal of unpleasant emotions in an aesthetic experience. Foremost, Silvia (Silvia, 2009; Silvia & Brown, 2007) has propagated that art is not merely capable of eliciting pleasure and preference but also is able to induce unpleasant, even hostile emotions, such as anger, disgust, sadness, or anxiety. It is of importance to also pay attention to such rather “unusual aesthetic emotions” since they might help to understand people’s diverse reactions towards art, including also confusion, surprise, or sometimes even rejection (Silvia & Brown, 2007). The results of our study do also correspond to the findings of Hagtvedt et al. (2008) who identified positive as well as negative emotions as underlying dimensions of an aesthetic response. The third factor, *expertise*, subsumes both the viewers’ background knowledge about painting and artist and the level of understanding they have about the painting’s meaning and the painter’s intentions. In spite of the fact that *expertise* is not a feature inherent to an aesthetic experience, it may still offer additional information concerning the aesthetic process. It has been repeatedly stressed in the literature on aesthetics that the successful mastery, i.e. the extraction of meaning and the understanding of a piece of art, has an essential influence on its overall reception, presumably through its self-rewarding character (Augustin & Leder, 2006; Belke et al., 2006; Belke, Leder, Strobach & Carbon, 2010; Russell, 2003; Winston & Cupchik, 1992). This appears to be all the more important when it comes to modern art of the 20th century, where “recognition and understanding of individual style have become essential for aesthetic experiences” (Leder et al., 2004, p. 479).

Moreover, the success in cognitive mastering might in general be “an important element in solving the question why people search for an aesthetic experience” (Leder et al., 2004, p. 499). The fourth factor, self-reference, describes the viewer’s perceived emotional and biographic connection with an artwork. Leder et al. (2004) have also conceptualized these self-related semantic and memory associations as being a direct reflection of the understanding of the artwork. In fact, this strategy of self-related interpretation is mostly common for naïve art perceivers who – in lack of art specific information – draw on the artworks content and associate it “with their situation and their own emotional states (Parsons, 1987)” (Leder et al., 2001, p. 499). Self-reference and expertise therefore capture different aspects of the cognitive mastering stage, presumably depending on individual differences in art expertise. The fifth factor, *artistic quality*, describes evaluations of the painting’s artistry, creativity, and skillfulness. The importance of the latter is in accordance with the findings reported by Kozbelt (2004). In his study, participants rated a set of drawings with respect to technical skill, the level of creativity, and quality. The latter was operationalized with the evaluation of the paintings’ overall quality and their aesthetic value. The items relating to skill and creativity loaded on the overall quality dimension and jointly accounted for 90% of its variance. Therefore, it can be presumed that the level of artistry of the painting has a significant influence on the overall appreciation of the artwork. This aspect has not been explicitly considered in the model by Leder et al. (2004). Possibly, general judgments on skill and creativity are – at least in part – incorporated in the output of the explicit classification and cognitive mastering stages, which is indicated by the shared variance of *cognitive stimulation* and *expertise* with *artistic quality* (r = .41 and .26, respectively). The last factor of the ARS, *positive attraction*, covers the most intuitive and validated aspect of an aesthetic experience. It assesses the positive attitude towards a painting describing it as beautiful, pleasant, and valuable. These items in particular come closest to the concept of an aesthetic experience as it is assessed in many studies, using scales of preference, likability, or beauty (e.g., Furnham & Walker, 2001; Jacobsen & Höfel, 2003; Johnson, Muday & Schirillo, 2010; Ramachandran & Hirstein, 1999; Russell, 2003). Indeed, the conception of an aesthetic experience as being pleasing and pleasurable is inherent in most approaches to aesthetics and its assessment (Berlyne, Ogilvie & Parham, 1968; Cupchik & Gebotys, 1990; Hagtvedt et al., 2008; Leder et al., 2004; Martindale & Moore, 1988; Russell & George, 1990). Berlyne identified pleasingness as one of the two major dimension of an aesthetic experience besides interestingness, which rather corresponds with *cognitive stimulation* (Berlyne et al., 1968; Cupchik & Gebotys, 1990). These findings are not restricted to visual artworks alone. Rather, the experience of pleasure is a commonality of the reception of a wide range of aesthetic stimuli, may it be musical excerpts or photographs (Axelsson, 2007; Zentner, Grandjean & Scherer, 2008). In addition, the factor *positive attraction* further grasps a vivid excitement and feeling of inspiration resulting from the personal engagement of the viewer with the artwork. These aspects reveal a more profound relationship with the artwork, maybe even bridging the gap between the cognitive and affective evaluation of the artwork. An association of this factor with the factor of *cognitive stimulation* at least points towards such a conceptualization. This finding is in accordance with Leder et al. (2004). In their model of aesthetic appreciation and judgments, the authors describe the cognitive output and the affective output to be dependent, at least for art naïves. In general, a successful cognitive involvement with an artwork is a self-rewarding process, resulting in a positive aesthetic emotion. Art experts on the other hand may be able to form a negative aesthetic judgment (e.g., judging the painting as a poor work of art), yet still have a positive aesthetic emotion due to the successful classification of the artwork. This dissociation is oftentimes not possible for art naïves. In the same vein, it is not surprising that *expertise* correlated positively with *positive attraction*. The more recipients know about the artist or painting in question, the greater the chance that they will be forming a successful aesthetic judgment and accordingly the greater the chance that they will develop a positive aesthetic emotion towards the painting. This fits well with the idea of the hedonic effects of greater processing fluency of artworks, according to which recipients judge an artwork as more pleasant and beautiful when it is easy to process (Belke et al., 2010; Reber et al., 2004). This involves an “ease of mental operations concerned with stimulus meaning and its relation to semantic knowledge structures” (Winkielman, Schwarz, Fazendeiro & Reber, 2003, p. 366). *Cognitive stimulation* and *positive attraction* are both positively correlated with *artistic quality.* The higher the level of artistry and creativity of the artwork, the more positive is the cognitive and affective evaluation of it. Thus, there seems to be an underlying quality dimension that recipients use in making aesthetic judgments.

In an additional study, we tested the validity of the ARS by comparing the experience to art vs. non-art stimuli. As expected, participants showed greater ARS scores after the presentation of art stimuli compared to non-art stimuli. In general, art paintings elicited a stronger positive appeal, were more cognitively stimulating, and were of greater artistic quality. On the level of expertise, participants had a better sense of understanding, insight, and explicit knowledge with respect to the art paintings than to the non-art pictures. However, the scores of the factors *negative emotionality* and *self-reference* did not differ between the art and the non-art stimuli. The indistinctness of these two scale scores might be attributed to characteristics of the sample or the selection of the artworks. It appeared that only participants who engage in art-related activities had a sense of personal connection to the artworks. Furthermore, it might be possible that the artworks presented were altogether not suitable to elicit any negative emotions. In general, negative emotions are foremost elicited by paintings that are perceived as offensive or controversial by the participants (Silvia & Brown, 2007). In sum, the specificity of the greater ARS scores for most of the ARS factors for art paintings suggests the validity of the instrument.

The ARS might be a valuable and versatile tool for future research in the field of empirical aesthetics. It is the first instrument that differentially assesses an aesthetic experience towards an artwork with respect to affective and cognitive factors, as well as to concomitant factors known for their relevance in the process of an aesthetic experience. Many studies so far have assessed an aesthetic reaction with a single item, namely inquiring if the painting is beautiful, pleasant, or liked. Although these items might be a good overall indicator for aesthetic preference, an aesthetic experience is multi-layered. If an artwork is rated with the ARS, a researcher finds out not only about the personal preference of a recipient, but also about other aspects of his or her subjective appreciation of the artwork. To date, it is well established that art preference and a generally more positive aesthetic attitude are strongly correlated with the personality dimension openness to experience (Chamorro-Premuzic et al., 2009; McManus & Furnham, 2006). Overall, individuals with high scores on the openness scale prefer modern art styles, while individuals with lower scores are foremost drawn to representational paintings. Moreover, individuals with higher openness scores have a greater interest in art, a more positive aesthetic attitude, and occupy and identify themselves more with art than low scorers. Considering that aspects of art interest, art taste, and self-reference were deliberately included in the construction of the ARS, it might be possible that significant differences between high and low scorers on the openness scale emerge with the ARS. Moreover, the NEO-PI-R personality questionnaire (Costa & McCrae, 2008) assesses openness to experience as a broad construct that contains six different facets of openness (e.g., openness to aesthetics, to feelings). It might be hypothesized that especially persons scoring high on openness to aesthetics might have a greater overall score on the ARS, compared to persons scoring rather low. In a similar vein, persons scoring high on openness to emotions might score higher on the ARS factors negative emotionality and self-reference. Altogether, the use of the ARS might be a convenient tool to assess the complex process of an aesthetic experience, and it may further help to elucidate how open recipients differ in this complex process. Furthermore, the ARS can be used in brain imaging studies. Researchers could get a more detailed picture of how art is subjectively perceived and this might allow a more valid and differentiated analysis of the identification of brain structures that are involved.

One disadvantage of the ARS is its limitation to paintings. It can therefore not be used to assess an aesthetic experience to other artworks, like for example, sculptures or installations. It still remains to be clarified whether the factors that are relevant in an aesthetic experience to art paintings are also relevant in experiencing other classes of art. One further limitation might be that the participant samples of study 1 and study 2 were largely homogenous. Overall, most of the participants were female and university students, being rather young compared to the participants recruited via newspaper advertisement. According to the literature, men and women differ in their specific preference for art styles and general art preference, but not in their interest and attitudes towards art in general. Age seems to exert an equally strong effect on general art preference as openness to experience (Chamorro-Premuzic et al., 2009; McManus & Furnham, 2006; Rawlings, 2003). More research is needed that investigates the replicability of the ARS in different samples.

In sum, the ARS offers a differentiated tool for the assessment of constituents of an aesthetic experience, such as cognitive, affective, and self-referential aspects, which altogether might be beneficial for investigations in the various fields of aesthetic research.

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Footnotes

[1] At first, we attempted to restrict the sample to a non-student population. However, a repeatedly advertised newspaper call attracted not enough participants for the intended analyses. Therefore, the other participants were recruited at the University of Heidelberg, all being psychology students of the first and third semester. They participated in the study as part of a class assignment.

[2] *Representational paintings*: Édouard Manet [46], the bar at the Folies-Bergère (1882). Edgar Degas [66], woman bathing in a shallow tub (1886). Caspar David Friedrich [81], the sea of ice (1923-24). *Non-representational paintings*: El Lissitzky [46], Proun 19 D (1922). Georges Braques [66], man with a guitar (1911). Fernand Léger [81], railway crossing (1919). The numbers in square brackets are the numbers of participants who have rated this picture across all sessions.

[3] Requests for the questionnaire may be sent to Helmut Leder (Email: helmut.leder@univie.ac.at)

[4] The rationale behind the averaging procedure was to reduce the number of variables in relation to the number of participants in order to facilitate a PCA. Prior to averaging there were 152 variables for each of the 193 participants. This ratio of variables to sample size would have been unfavorable for the PCA. Therefore, we reduced the number of variables by averaging across both picture presentations for each participant.

[5] In the following, we will use the commonly used term ‘factor’ instead of ‘component’ due to popular convention.

[6] Selection index (Amelang & Schmidt-Atzert, 2006): $S_{el} = r_{it} / 2*s_i$. Note: r_{it} = item-test correlation, s_i = item standard deviation.

[7] In order to examine whether the largest subsample (81 participants) in our sample dominated the factor structure in the whole sample, we calculated the congruence coefficient for each of the six ARS factors (Lorenzo-Seva & ten Berge, 2006). The congruence coefficients (φ) were as follows: φ = .90 (cognitive stimulation), φ = .91 (negative emotionality), φ = .90 (self-reference), φ = .92 (expertise). φ = .91 (artistic quality), and φ = .80 (positive attraction). The congruence coefficient for the entire factor structure was φ = .89. All values indicate a sufficient congruence of the factor structures in the largest subsample and in the rest of the sample in study 1 (Lorenzo-Seva & ten Berge, 2006). Therefore, it can be concluded that the largest subsample did not dominate the factor structure in the whole sample.

[8] A second-order component analysis was performed on the factor correlation matrix. While the Kaiser-Guttmann criterion suggested only two factors with an eigenvalue greater than one, the scree plot suggested that three relevant factors may be involved. Accordingly, we checked both the two- and the three-factor solution. A first oblique rotation of the two- and three-factor solution revealed factor correlations smaller than r = .30, which suggested an orthogonal rotation instead. The factors were then rotated with the varimax procedure. The two-factor structure was rather ambiguous. While 4 out of the 6 first-order factors were clearly assigned to one of the two second-order factors, one first-order factor had substantial cross-factor loadings (-.39) and the other had almost identical factor loadings on both second-order factors (.55 and .50). This first-order factor was therefore not unequivocally assignable to one of the two second-order factors. The three-factor structure was finally chosen over the two-factor structure. There were no substantial cross loadings and factors were clearly assigned to one of the three second-order factors. The first second-order factor was composed of *cognitive stimulation*, *artistic quality*, and *positive attraction*, and may best be described as *admiration.* All of these first-order factors describe one or another form of pronounced appreciation for the artwork, may it be intellectually, emotionally, or artistically. The second second-order factor was composed of *negative emotionality* and *self-reference*, and may be best described as *emotional self-reference*. Both first-order factors relate to an influence that the artwork is exerting on the recipient, may it be emotions or personal memories. The third second-order factor was composed of *expertise* only and therefore may keep its initial labeling. Cronbach's alpha for the first second-order factor was α = .91, for the second second-order factor α = .83, and for the third second-order factor α = .85. The item-test correlations of the items contributing to the first second-order factor ranged between r_{it} = .42 and r_{it} = .73. The item-test correlations of the items contributing to the second second-order factor ranged between r_{it} = .40 and r_{it} = .61. The item-test correlations of the items contributing to the third second-order factor ranged between r_{it} = .50 and r_{it} = .76.

[9] *Art paintings*: William Turner, The burning of the houses of parliament (1835), Eduard Gaertner, picture of a room (1849), Claude Monet, Madame Monet and her son (1875), Paul Cezanne, still life with apples and oranges (1895-1900), Wassily Kandinsky, Moscow 1 (1916), Jackson Pollock, Number 1 (1949). *IAPS pictures*: 5001, 5390, 5875, 7175, 7217, 7710.

[10] Note that lower scores indicated a more positive attitude and greater scores a less positive art attitude.

Figure 1. Scree plot of the first PCA with all 76 items. Only the factors with an eigenvalue greater than one are displayed.

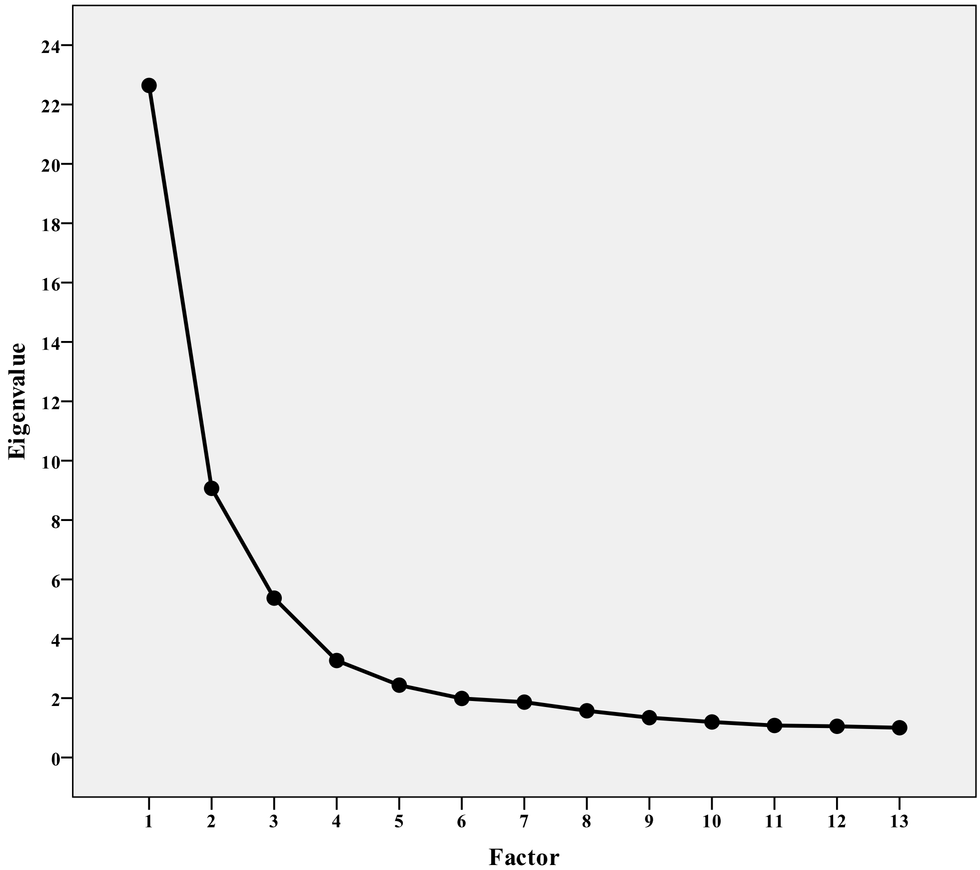

Table 1

Item parameters of the final item selection, separately for each factor. Cronbach's α is reported for each of the six factors.

factor	α	item	loading	*M* (*SD*)	*p*	r_{it}	r_{xy}
1. cognitive stimulation	.90	*This painting makes me curious*	.87	3.46 (.92)	.69	.79	.18
		This painting is thought-provoking	.86	3.60 (.86)	.72	.74	.28
		It is exciting to think about this painting	.82	3.59 (.88)	.72	.80	.36
		It is fun to deal with this painting	.78	3.37 (.89)	.68	.77	.32
		I would like to learn more about the background of this painting	.67	3.75 (.97)	.75	.65	.27
2. negative emotionality	.85	*This painting makes me feel afraid*	.82	1.80 (.84)	.36	.74	.37
		This painting makes me sad	.79	2.31 (.90)	.46	.71	.35
		This painting makes me feel troubled	.76	2.45 (.99)	.49	.70	.37
		This painting makes me feel lonesome	.74	2.25 (.98)	.45	.64	.30
		This painting disgusts me	.71	1.47 (.67)	.29	.50	.19
3. expertise	.85	*I can relate this painting to its art historical context*	.85	2.47 (1.21)	.49	.75	.52
		I can relate this painting to a particular artist	.83	2.00 (1.20)	.40	.76	.48
		I know this painting	.81	1.70 (1.08)	.34	.69	.30
		I have an idea what the artist is trying to convey with this painting	.66	3.13 (.88)	.63	.62	.24
		With regard to its content this painting remains inaccessible to me	.60	3.18 (.86)	.64	.50	.11
4. self-reference	.85	*This painting makes me think about my own life history*	-.92	1.79 (.86)	.36	.80	.29
		I can associate this painting with my own personal biography	-.90	1.96 (.90)	.39	.80	.23
		Personal memories of mine are linked to this painting	-.76	1.95 (.92)	.40	.61	.16
		This painting mirrors my own personal emotional state	-.53	2.07 (.87)	.42	.54	.23
5. artistic quality	.85	*This painting is unique*	.82	3.53 (.94)	.71	.64	.32
		This painting features a high level of creativity	.76	3.44 (.79)	.69	.67	.12
		The composition of this painting is of high quality	.74	3.82 (.69)	.77	.66	.23
		The artists manner of painting is fascinating	.72	3.42 (.86)	.69	.67	.10
		This painting is very innovative	.71	3.54 (.80)	.71	.68	.15

6. positive attraction	.83	*This painting is pleasant*	.71	2.75 (.80)	.55	.64	-.05
		This painting is beautiful	.69	2.98 (.88)	.60	.72	.08
		I would consider to invest a large sum of money to buy this piece of art	.64	1.66 (.70)	.33	.46	.07
		This painting thrills me	.57	2.65 (.79)	.53	.68	-.07
		I feel inspired by this painting	.42	2.69 (.90)	.54	.63	.14

Note. Items in italic are marker items. α = Cronbach's alpha; M = mean, SD = standard deviation, p = item difficulty, r_{it}.= item-test correlation, part-whole corrected, r_{xy}.= correlation between picture 1 and picture 2 (study 1).

Table 2

Correlations between the six factors of the ARS questionnaire.

factor	1	2	3	4	5
1. cognitive stimulation		-	-	-	-
2. negative emotionality	.07		-	-	-
3. expertise	.11	-.16		-	-
4. self-reference	.26	.20	.12		-
5. artistic quality	.41	-.11	.26	.15	
6. positive attraction	.30	-.13	.24	.20	.35

Table 3

Means and standard deviations for each subscale of the ARS, separate for art and IAPS pictures.

factor	art		IAPS	
	M	*SD*	*M*	*SD*
1. cognitive stimulation	3.46	.48	2.82	.54
2. negative emotionality	1.67	.44	1.65	.45
3. expertise	2.63	.46	1.98	.38
4. self-reference	2.36	.61	2.33	.61
5. artistic quality	3.63	.41	2.39	.41
6. positive attraction	3.32	.42	2.61	.34

Note. Separate for each ARS subscale, the scores are averages across all art pictures and all IAPS pictures.

Appendix

Preliminary selection of items to enter the analysis. Items in bold are the items from the final version of the ARS. Corresponding factors are in brackets.

1.	This painting is meaningless	
2.	Viewing this painting annoys me	
3.	This painting evokes many associations in me	
4.	**I would consider to invest a large sum of money to buy this piece of art**	**(PA)**
5.	**This painting is beautiful**	**(PA)**
6.	This painting makes me feel revolted	
7.	I feel attracted to this painting	
8.	**This painting is pleasant**	**(PA)**
9.	The artist's manner of painting is fascinating	
10.	Viewing this painting makes me feel insecure	
11.	This painting is attractive	
12.	**With regards to its content, this painting remains inaccessible to me**	**(EX)**
13.	**This painting makes me feel afraid**	**(NE)**
14.	Dealing with this painting is a challenge to me	
15.	I can sort the painting's content in its historical context	
16.	This painting does not appeal to me	
17.	**I can relate the painting to its art historical context**	**(EX)**
18.	**The composition of the painting is of high quality**	**(AQ)**
19.	**This painting is very innovative**	**(AQ)**
20.	This painting is positive	
21.	**This painting makes me feel troubled**	**(NE)**
22.	The meaning of the painting is evident to me.	
23.	This painting is endearing.	
24.	I can recognize a personal connection between this painting and myself.	
25.	This painting makes me feel relaxed	
26.	**I know this painting**	**(EX)**
27.	I like this painting	
28.	**This painting mirrors my own personal emotional state**	**(SR)**
29.	**This painting disgusts me**	**(NE)**
30.	This painting was done very skilful	
31.	**I have an idea what the artist is trying to convey with this painting**	**(EX)**
32.	This picture is calming	
33.	I can understand what the artist is trying to communicate	
34.	**This painting features a high level of creativity**	**(AQ)**
35.	This painting makes me feel good	
36.	**This painting is unique**	**(AQ)**
37.	This painting is touching	
38.	This painting makes me impatient	
39.	This painting is special	
40.	**This painting thrills me**	**(PA)**
41.	This painting is admirable	
42.	**I feel inspired by this painting**	**(PA)**
43.	**It is exciting to think about this painting**	**(CS)**
44.	**I would like to learn more about the background of this painting**	**(CS)**
45.	This painting makes me feel unhappy	
46.	This painting fascinates me	

47. **It is fun to deal with this painting** **(CS)**
48. This painting impresses me
49. This painting is appealing to me
50. **This painting makes me sad** **(NE)**
51. The content of this painting is interesting
52. I can relate this painting to a particular art movement
53. This painting surprises me
54. **This painting makes me feel lonesome** **(NE)**
55. This painting makes me feel affectionate
56. **I can relate this painting to a particular artist** **(EX)**
57. This painting bores me
58. **I can associate this painting with my own personal biography** **(SR)**
59. I feel repulsed by this painting
60. With regard to its content, I think this painting is interesting
61. This painting is outstanding due to its wealth of ideas
62. I would like to learn more about the artist
63. **The artist's manner of painting is fascinating** **(AQ)**
64. **Personal memories of mine are linked to this painting** **(SR)**
65. This painting is a riddle to me
66. I think this painting is good
67. I would display this painting at my home
68. **This painting is thought-provoking** **(CS)**
69. **This painting makes me curious** **(CS)**
70. This painting stimulates me
71. This painting makes me feel content
72. This painting makes me feel joyous
73. This painting makes me feel distressed
74. This painting makes me angry
75. **This painting makes me think about my own life history** **(SR)**
76. I am certain that this painting is on display in a renowned museum

Note: (CS) = cognitive stimulation, (NE) = negative emotionality, (EX) = expertise, (SR) = self-reference, (AQ) = artistic quality, (PA) = positive attraction. Answer format: recipients were asked to rate their endorsement to each statement on a five-point rating scale, ranging from 1 = completely disagree, 2 = rather disagree, 3 = neither nor, 4 = partly agree, to 5 = completely agree.

Appendix A2 – Manuscript 2

Emotional modulation of startle response parameters after variation of probe intensity

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Abstract

Most studies that investigate the affective modulation of the startle response use probe intensities of at least 95 dB and the startle response peak amplitudes as the dependent measure. The current study examined if less intense startle probes are sufficient to reliably elicit the typical response pattern of startle inhibition during pleasant picture presentation and startle potentiation during unpleasant picture presentation. Furthermore, we examined if time domain measures, such as response onset latency and rise time latency of the startle response are also affected by the valence manipulation.

Participants were startled with different probe intensities (95 dB, 85 dB, 75 dB, 65 dB) while they were viewing pleasant, neutral, and unpleasant IAPS pictures. For all probe intensities, peak amplitudes were larger, onsets shorter, and rise times longer during unpleasant compared to pleasant pictures presentation. Altogether, our findings promote the usefulness of latency measures for future research and indicate the sufficiency of less intense probes for the affective startle paradigm.

Keywords: startle probe intensity; valence modulation; latency measures; individual differences.

Emotional modulation of startle response parameters after variation of probe intensity

In the past, there has been an enormous effort in investigating how the organism responds to emotional stimulation. Findings are that both the autonomic and central nervous system react with specific physiological patterns to emotionally pleasant and unpleasant stimuli. Among variation in event-related potentials of the electroencephalogram, cardiac response, skin conductance, and facial electromyographic activity, the valence modulated startle response has been most rigorously studied (e.g., Bradley, Codispoti, Cuthbert & Lang, 2001; Cuthbert, Bradley & Lang, 1996; Lang, Bradley & Cuthbert, 1990; Vrana, Spence & Lang, 1988). The presentation of a short blast of white noise (startle probe) while being exposed to an affective foreground stimulus elicits activity in the orbicularis oculi muscle which surrounds the eye: the person shows a blink reflex. The valence of the foreground stimulus modulates the magnitude of the blink reflex. Lang and colleagues (1990) have proposed a theory that outlines a model implicating two motivational systems: an appetitive system that is activated in any context promoting survival (e.g., nurturance and reproduction), and a defensive system that is engaged when the organism faces threat or danger. Any compatible cue, like a picture depicting a pleasant or unpleasant scene, can activate the respective system. Once a system is activated, the physiological responsiveness towards subsequent stimuli of the same valence (pleasant or unpleasant) is enhanced, and the responsiveness towards subsequent stimuli of the opposite valence is attenuated. The basic principle of the model's framework is therefore that the magnitude of the startle response depends on a match or mismatch between the probe and a concurrent emotional stimulus. The confrontation with an unpleasant picture stimulus matches the aversive nature of the startle probe, while a pleasant picture stimulus constitutes a mismatch. Accordingly, the startle response is potentiated when the startle occurs while the organism is already in an aversive motivational state (e.g., viewing a picture of a mutilated body). Yet, a startle probe presented while the appetitive system has been activated (e.g., viewing an erotic picture) leads to an attenuated startle response, because of the incompatibility of state and stimulus (Bradley et al., 2001; Lang, Bradley & Cuthbert, 1992).

In addition thereto, the subjective arousal of the picture stimulus also has an impact on the startle response. The difference between startle responses during pleasant and unpleasant picture presentation is most evident when these pictures are also highly arousing (e.g., Cuthbert et al., 1996). Bradley et al. (2001) found that unpleasant pictures high in subjective arousal (foremost pictures of mutilations and threat) increased the startle response to a greater extent relative to unpleasant contents low in arousal (e.g., contamination). Vice versa, high arousing pleasant pictures (foremost erotic scenes) inhibited the startle response to a greater extent compared to pleasant pictures low in arousal (e.g., adventure scenes). At the same time, pleasant and unpleasant pictures both low in arousal did not differ in startle response magnitude.

The magnitude of the startle response is typically quantified as the peak amplitude of the electromyogram (EMG). This measure is usually standardized (*z*-transformation or *T*-transformation) because of large differences in amplitude between participants that are not related to the experimental manipulation. These differences may perhaps be due to anatomical differences between participants such as fatty tissue and skin composure over the orbicularis oculi muscle, or density and structure in the relevant musculature. Although, the precise cause of these individual differences in magnitude are to date largely unknown they are presumably "unrelated to the experimental phenomena of interest" (Blumenthal et al., 2005, p. 11) and might therefore be regarded as error variance.

Many studies therefore remove the individual variation in the startle response by standardizing the startle peak amplitude for each participant with the mean and standard deviation of the average startle peak amplitude across all trials of the participant. This entails that all participants receive the same mean value and the same standard deviation across all trials (0 and 1 in the case of a *z*-transformation, and 50 and 10 in the case of a *T*-transformation, respectively) and therefore they do not differ any more in their average startle reactivity. Despite the equalization of the *average* startle response between participants, the information about *relative* differences in the startle response between the individual valence categories is unaffected. Consequently, the standardized data still provide the information to draw conclusions about the valence modulation on the one hand, and about between-group interactions in the valence modulation on the other hand. Conclusions about between-group differences in general affective startle reactivity are however not possible anymore (due to a common mean of all participants). Accordingly, the majority of studies that are interested in individual differences in the startle response does not focus on the latter but rather investigates associations between, for example, aspects of personality or clinical syndromes and differences in the valence modulation of the startle response (e.g., Allen, Trinder & Brennen, 1999; Cook, Davis, Hawk & Spence, 1992; de Jong, Arntz & Merckelbach, 1993; Vaidyanathan, Patrick & Bernat, 2009). Nevertheless, comparisons of the *absolute* reactivity between these subject groups might still offer valuable information beyond the comparisons of the *relative* affective reactivity of these groups. For example, there may be individual differences in the reactivity of the neural systems that mediate the startle response. Some studies have used the unstandardized startle response for these between-group comparisons of absolute reactivity (e.g., Medina, Mejia, Schell, Dawson & Margolin, 2001; Melzig, Weike, Zimmermann & Hamm, 2007; Stritzke, Patrick & Lang, 1995). But its usefulness is limited because of the measure's increased error variance due to its large individual variation that is not attributable to the experimental manipulation. Therefore, a measure that (a) does not need to be standardized and (b) is a valid and reliable indicator of the affective startle response may be useful for between-group comparisons.

One such measure may be the onset latency of the startle response. This time domain measure has been used in fewer studies and the findings are inconsistent. While some studies were able to find shorter onsets for the startle response during the presentation of unpleasant pictures compared to pleasant pictures (e.g., Bradley, Cuthbert & Lang, 1990; Larson, Ruffalo, Nietert & Davidson, 2000), others failed to detect any valence effect at all (e.g., Corr, Wilson, Fotiadou & Kumari, 1995; Cuthbert et al., 1996). There are indications, however, that variation in onset latency – similar to the peak amplitude – also depends on the subjective arousal of the pictures. Bradley, Codispoti, and Lang (2006) found that only high arousing unpleasant pictures prompted a significantly faster onset than high arousing pleasant pictures, whereas unpleasant and pleasant pictures low in arousal did not differ in onset latency. This presumption is further supported by Cook et al. (1992), where high fear and low fear participants viewed neutral and aversive pictures. Only the high fear group had significantly faster response onsets for aversive pictures compared to neutral pictures, whereas the low fear group had similar onset latencies for both aversive and neutral pictures.

A good indicator of the level of arousal of a stimulus is the skin conductance response (SCR). Independent of valence, the SCR consistently shows a positive relation to arousal (e.g., Lang, Bradley & Cuthbert, 1998). Emotional (pleasant and unpleasant) pictures high in arousal elicit larger SCRs than (neutral) pictures low in arousal. While ensuring high arousal of emotional pictures by means of great SCRs, we predict that onset latencies for unpleasant pictures are substantially faster than onset latencies for pleasant pictures.

Another time domain measure is the rise time latency of the startle response (the time from the onset of the startle response to its peak amplitude). Davidson (1998) framed the concept of affective chronometry as the temporal dynamics of affective responding. He proposed that emotional reactivity could be divided into more elementary components, such as the threshold for reactivity, the peak amplitude, and the rise time latency to the peak of the response. He further proposed that time domain measures may be particularly relevant for the understanding of individual differences that may be associated with a vulnerability to psychopathology. For example, affective or anxiety disorders may be related to either an abnormally early onset of a response and/or to a failure to turn off an emotional response with adequate speed due to an insufficiency of regulatory mechanisms (Davidson, 2003). The rise time latency of the startle response has to our knowledge never been investigated before in the context of valence modulation of the startle response, and therefore we included it in the present study in a rather exploratory fashion. Altogether, one aim of the present study was to clarify if the time domain measures are valid and reliable indicators of affective states and hence may serve as additional supplements in the description of the startle response.

Another goal of the experiment was to explore the effect of startle probe intensity on the valence modulation of the startle response. A preponderance of studies investigating the affective startle modulation uses probe intensities of typically 95 dB (e.g., Bradley, Codispoti, Cuthbert & Lang, 2001; Lang et al., 1990; Miller, Patrick & Levenston, 2002), with some studies increasing intensities up to even 100 dB and higher (e.g., Amrhein, Mühlberger, Pauli & Wiedemann, 2004; Dichter, Tomarken & Baucom, 2002; Gard & Kring, 2007; Sabatinelli, Bradley & Lang, 2001; Temple & Cook, 2007; Vrana, 1995). However, Blumenthal and Goode (1991) were able to demonstrate that startle probes of lower intensities (50 dB, 60 dB, 70 dB) are just as useful for the elicitation of the startle response. Although lower intensities were generally associated with smaller response amplitudes, slower response onset latencies, and more diminished response probability rates, the results substantiated the claim that even startle probes of low intensities are reliable in eliciting and modifying the startle response. Therefore, Blumenthal and Goode (1991, p. 296) concluded that “the startle response is more sensitive than previously thought and that the elicitation of startle by low intensity stimuli argues against the limitation of the startle reflex as a high intensity phenomenon.”

Cuthbert and colleagues (1996) investigated whether lower intensities are also as sufficient as intensities of 95 dB and higher to evoke the affective modulatory response pattern. They varied probe intensity levels (80 dB, 95 dB, 105 dB) while the participants viewed emotional and neutral pictures. Again, the increase in intensity was associated with an increase in startle response amplitude but had no effect on the modulation of the startle response. However, participants rated greater intensities as being more aversive than lower intensities. As a matter of fact, there is no linear relationship between decibel and the subjective perception of volume. Rather, an increase of 10 dB results in a twofold increase in perceived volume.

Altogether, in can be tentatively concluded that an increase in intensity results in a greater aversiveness for the participants but does not change the basic modulatory pattern for the startle response amplitude. Although these findings indicate the sufficiency of probes as low as 80 dB for an affective modulation of the startle response, there is still a primacy for greater intensities because of a lacking recommendation as to which startle intensity suffices for the experimental setup of the valence modulated startle response.

In summary, the experimental focus in the present study was twofold: (1) resolving existing inconsistencies in the startle onset literature, and investigating the usefulness of the rise time latency for the measurement of the startle modulation; (2) evaluation of the effect of probe intensity on all startle response parameters in order to – ideally – provide a recommendation for startle intensity that serves the experimental purpose yet spares the exposure to unnecessarily aversive startle probes.

Method

Participants

The participants were 44 female students of the University of Heidelberg. All participants were between 19 und 35 years of age (*M* = 23, *SD* = 2.9). Some participants had to be excluded from the analyses of some physiological parameters due to an insufficient number of artifact-free trials. Final *N*s were as follows: SCR = 44, startle response amplitude = 38, latency measures = 33.

The restriction to an all female sample was based on pragmatic reasons. At the department of Psychology the majority of the students are female. Accordingly, we generated only one set of IAPS slides for female participants that included some pictures of male nudes, which have proven to be highly arousing in both sexes. Although there are differences in the relative magnitude of the startle response amplitude between men and women, they do not affect the valence modulation pattern per se when high arousing IAPS pictures are presented (Bradley, Codispoti, Sabatinelli & Lang, 2001).

Materials and Design

Thirty-six pictures were chosen from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2008), showing 12 pleasant, 12 unpleasant, and 12 neutral scenes. The selection of pictures was similar to Bradley et al. (2001) and restricted to high arousing emotional pictures and low arousing neutral pictures: unpleasant pictures showed mutilations, human attack, and animal attack; pleasant pictures showed erotic couples and male nudes; neutral pictures showed household objects and mushrooms.[1] The picture set included two blocks of 18 pictures each, with 6 pictures of each valence category in each block. Six orders of picture presentation were constructed so that each block was presented first and second with equal frequency and that each picture within each block was presented in the first, the second, and the third part of each block with equal frequency. After a short break, all pictures were presented for a second time, but in a different order. The acoustic startle probe (50 ms of white noise, nearly instantaneous rise time) was presented binaurally over loudspeakers and differed in intensity between four groups. Intensity levels were 65 dB, 75 dB, 85 dB, and 95 dB.

Procedure

After the attachment of electrodes, participants were familiarized with the procedure, informed that unpleasant pictures were to be expected, and that any brief loud noises during the experiment should be ignored. After a 5-minute resting period and a practice set of six additional pictures (excluded from analyses), the pictures were presented for the first time. Each picture was presented for 6 seconds, and startle probes were randomly delivered at either 2.500 ms or 3.500 ms after picture onset. Not more than two pictures of the same valence category and not more than three startle probe trials were presented in a row. Intertrial intervals (ITI) lasted randomly between 19 to 25 seconds. Eight startle probes were presented at each of the three valence categories, plus eight startle probes during the ITIs to decrease predictability. After picture offset, the pictures were rated on valence and arousal using the Self Assessment Manikin (SAM; Bradley & Lang, 1994).

After a short break during which the participants filled out a questionnaire unrelated to the experiment, pictures were presented for a second time, yet in different order and with a different selection of pictures during which the startle probes were delivered.

Physiological Recording and Quantification

All signals were digitized with a 2500 Hz sampling rate using a DC Brainamp amplifier (Brain products, Munich). The impedances at all electrodes were kept below 5 kΩ.

Activity of the orbicularis oculi muscle was recorded from under the left eye with a band-pass filter of 10 to 1000 Hz, filtered offline with a band-pass of 28-500 Hz, and subsequently rectified. Then, a low-pass filter of 40 Hz was applied to smooth the data. The peak amplitude of the startle response was defined as the largest peak within a time window of 20 to 200 ms following the startle probe. Trials without a detectable response or trials with excessive noise during the baseline (-100 – 0 ms) were excluded from the analyses. The average response rate was 98 % in the 95dB group (*SD* = 3.9 %) 94 % in the 85dB group (*SD* = 13 %), 85 % in the 75dB group (*SD* = 11 %), and 59 % in the 65dB group (*SD* = 31 %). Due to the large variability of response rates in the 65 dB group, we restricted the analysis to participants that had response rates of at least 50 %. As a result, 4 participants from the 65-dB group were excluded from all further analyses, leaving a total *N* = 38 participants.[2] For each participant on each trial, the startle response amplitude was *z*-standardized with the mean and standard deviation of the average peak amplitude of the ITI startle response of that respective participant. Afterwards, the data was transformed to *T* scores [(*z* * 10) + 50]. Subsequent analyses included both unstandardized (μV) and standardized (*T* scores) peak amplitudes.

The startle response onset was defined as the point where the signal exceeds four times the standard deviation of the baseline activity (Van Boxtel, Geraats, Van den Berg-Lenssen & Brunia, 1993). The onset latency was defined as the time between the startle probe and response onset. Only trials with a detectable onset within 20 – 100 ms after the probe were included, in order to exclude non-reflexive responses. Trials with excessive noise during the baseline and during the first 20 ms after the startle probe were omitted from the analysis.

The rise time latency was defined as the duration from the preliminary determined onset point to the maximum peak of the response. The groups differed with respect to the number of trials that were included in the latency analysis. In the 95-dB group, onset and rise time latency could be scored in 85 % of all trials (*SD* = 11 %). In the 85-dB group, latency measures could be scored in 83 % of all trials (*SD* = 9 %). In the 75-dB group, latency measures could be scored in 67 % of all trials (*SD* = 21 %). In the 65-dB group, latency measures could be scored in 64 % of all trials (*SD* = 23 %). Again, we restricted the analyses to participants that showed detectable response onsets and response peaks in at least 50 % of all trials. This resulted in a final *N* = 33 for the latency measures.[3]

The SCR was recorded from the left hand with a band-pass filter of DC to 1000 Hz and filtered offline with an 8.5 Hz low pass filter. The average change within the first 4 seconds of picture presentation relative to a one-second baseline was scored as the dependent measure. Only those trials, which did not involve a startle probe presentation, were considered for the SCR analysis to avoid a confounding of the SCR to the picture stimuli with the reactivity to the startle probe. Amplitudes were log-transformed [log (SCR + 1)] in order to normalize their distribution.

Data Analysis

Startle parameters were analyzed with an analysis of variance (ANOVA) with PRESENTATION (first, second time) and VALENCE (pleasant, neutral, unpleasant) as within-subject factors. For SCR we used the factor AROUSAL (high, low), grouping pleasant and unpleasant pictures together as highly arousing and neutral pictures as low arousing. Startle INTENSITY (95 dB, 85 dB, 75 dB, 65 dB) was added as a between-subject factor for the analysis of the startle measures. For the analysis of valence effects on the peak amplitude we used the standardized startle response (*T* scores), and for the analysis of intensity effects on the peak amplitude we used the unstandardized startle response (µV). Greenhouse-Geisser corrections of degrees of freedom were applied when necessary. Effect sizes of all effects are reported. Significant effects were followed up with planned contrasts and post-hoc comparisons. Bonferroni-Holm corrections were applied in case of multiple comparisons.

The odd-even split-half method was used to estimate the reliability of the startle measures, employing the Spearman-Brown formula. We computed correlations between peak amplitude and latency measures of the startle response in order to investigate the convergence of these measures. Only correlations above $r = .50$ will be reported. The level of significance was set at $\alpha = .05$.

Results

Valence and Arousal Ratings

There was a significant main effect of VALENCE on the valence SAM ratings, $F(2,84) = 406.58$, $p < .001$, $\varepsilon = .87$, $\omega^2 = .86$. Pleasant pictures were rated as more pleasant than neutral pictures, $t(43) = 4.12$, $p < .001$, and neutral pictures were rated as more pleasant than unpleasant pictures, $t(43) = 28.67$, $p < .001$. There was also a significant main effect of VALENCE on the arousal SAM rating, $F(2,84) = 309.69$, $p < .001$, $\varepsilon = .69$, $\omega^2 = .82$. Pleasant and unpleasant pictures both were rated as more arousing than neutral pictures, $t(43) = 12.57$, $p < .001$, and $t(43) = 24.67$, $p < .001$, whereas unpleasant pictures were also rated more arousing than pleasant pictures, $t(43) = 14.10$, $p < .001$. The descriptive statistics are presented in Table 1.

Modulation of SCR

There was a significant main effect of AROUSAL on the SCR, $F(1,43) = 5.33$, $p = .024$, $\omega^2 = .05$. High arousing emotional stimuli triggered a larger SCR than low arousing (neutral) stimuli. There was a significant main effect of PRESENTATION, $F(1,43) = 11.21$, $p = .002$, $\omega^2 =$ .10. The first picture presentation elicited greater responses ($M = .017$, $SD = .007$) than the second picture presentation (*M* = .002, *SD* = .007), which suggests a habituation of the SCR. There was no interaction between AROUSAL and PRESENTATION, $F < 1$.

Modulation of the startle response

Standardized Peak Amplitude (*T* scores). There was a significant main effect of VALENCE, $F(2,74) = 46.17$, $p < .001$, $\omega^2 = .44$. Startle responses during pleasant pictures showed smaller amplitudes than during neutral pictures, $t(37) = 3.49$, $p < .001$. Startle responses during neutral pictures were smaller in amplitude than during unpleasant pictures, $t(37) = 5.50$, $p < .001$. PRESENTATION had a significant effect on the response amplitude, $F(1,36) = 28.19$, $p < .001$, $\omega^2 = .27$. Response amplitudes were greater when the pictures were presented for the first time (*M* = 51.43, *SD* = 1.79) than for to the second time (*M* = 48.37, *SD* = 1.79). There was no significant interaction between VALENCE and PRESENTATION (p = .107).

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Latency Measures. There was a significant VALENCE effect on the startle onset latency, $F(2,64) = 10.29$, $p < .001$, $\omega^2 = .16$. Onset latencies during pleasant pictures were longer than during neutral pictures, $t(32) = 2.65$, $p = .006$, and onset latencies during neutral pictures were marginally longer than latencies during unpleasant pictures, $t(32) = 1.60$, p = .060. There was no main effect for PRESENTATION and no interaction between VALENCE and PRESENTATION, (ps > .171).

There was a significant VALENCE effect on the rise time latency, $F(2,64) = 21.89$, $p < .001$, $\varepsilon = .80$, $\omega^2 = .30$. Rise time latencies during pleasant pictures were shorter than during neutral pictures, $t(32) = 4.14$, $p < .001$, and rise time latencies during neutral pictures were shorter than during unpleasant pictures, $t(32) = 2.45$, $p = .010$. There was a marginally significant main effect for PRESENTATION, $F(1, 28) = 3.50$, $p = .072$, $\omega^2 = .04$. Rise time latencies tended to be longer during the first presentation (*M* = 19.40, *SD* = 2.36) than during the second presentation (*M* = 16.87, *SD* = 3.60). There was no significant interaction between VALENCE and PRESENTATION, $F < 1$.

Probe Intensity

Unstandardized Peak Amplitude (µV). There was a significant INTENSITY effect on the peak amplitude, $F(3,34) = 5.72$, $p = .003$, $\omega^2 = .27$. Greater intensities were associated with greater peak amplitudes (see Figure 1). Specifically, peak amplitudes at 95 dB were greater than amplitudes at 85 dB, $t(20) = 1.95$, $p = .033$, and amplitudes at 85 dB were greater than amplitudes at 75 dB, $t(19) = 1.92$, $p = .036$. Amplitudes at 75 dB did not differ from amplitudes at 65 dB, $t < 1$.

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There was a significant interaction between VALENCE and INTENSITY, $F(6,68)= 2.71$, $p = .020$, $\omega^2 = .08$, indicating that the valence modulation of the peak amplitude differed between intensity levels. In particular, the VALENCE effect was significant at 95 dB, $F(2,20) = 19.71$, $p < .001$, $\omega^2 = .53$. Specifically, the peak amplitudes were smaller during pleasant compared to neutral pictures, $t(10) = 3.85$, $p = .002$, and smaller during neutral pictures compared to unpleasant pictures, $t(10) = .18$, $p = .027$. The VALENCE effect was significant at 85 dB, $F(2,20) = 16.61$, $p < .001$, $\omega^2 = .49$. Peak amplitudes during pleasant pictures did not differ from neutral pictures, $t < 1$. However, peak amplitudes during both neutral and pleasant pictures were smaller compared to unpleasant pictures, $t(10) = 3.93$, $p = .002$ and $t(10) = 8.40$, $p < .001$, respectively. The VALENCE effect was significant at 75 dB, $F(2,18) = 10.04$, $p = .001$, $\omega^2 = .39$. Peak amplitudes during pleasant pictures did not differ from neutral pictures, $t < 1$, but both peak amplitudes during neutral and during pleasant pictures were smaller compared to unpleasant pictures, $t(9) = 2.92$, $p = .009$, and $t(10)= 4.63$, $p < .001$, respectively. The VALENCE effect was significant at 65 dB, $F(2,10) = 5.73$, $p = .022$, $\omega^2 = .34$. Peak amplitudes during pleasant pictures were marginally smaller compared to neutral pictures, $t(5) = 1.74$, $p = .072$, and marginally smaller during neutral compared to unpleasant pictures, $t(5) = 1.72$, $p = .072$. However, peak amplitudes during pleasant pictures were significantly smaller compared to unpleasant pictures, $t(5) = 3.26$, $p = .011$.

Latency Measures. There was a significant INTENSITY effect on the onset latency, $F(3,29) = 9.27$, $p < .001$, $\omega^2 = .43$. Greater intensity was associated with shorter onset latencies. Post-hoc comparisons revealed that the onset latency at 95 dB was shorter than the onset latency at 85 dB, $t(19) = 2.28$, $p = .017$. The onset latency at 85 dB was shorter than the latency at 75 dB, $t(16) = 3.00$, $p = .005$. There was no difference in onset latency between the 75 and 65 dB group, $t < 1$. There was no significant interaction between VALENCE and INTENSITY, $F(6,58) = 1.87$, $p = .102$.

There was a significant INTENSITY effect on the rise time latency, $F(3,29) = 2.80$, $p = .058$, $\omega^2= .14$. Greater intensity was associated with longer rise time latencies. Post-hoc comparisons revealed that the rise time latency at 95 dB was longer than at 85 dB, $t(19) = 1.77$, $p = .047$. There were no significant differences between the rise time latency at 85 dB and 75 dB, and between 75 dB and 65 dB, *t*s < 1. The interaction between VALENCE and INTENSITY was marginally significant, $F(6,58) = 2.29$, $p = .065$, $\varepsilon = .78$, $\omega^2 = .07$. In particular, the VALENCE effect was significant at 95 dB, $F(2,20) = 11.97$, $\omega^2 = .40$. Specifically, the rise time was faster during pleasant compared to neutral pictures, $t(10) = 3.71$, $p = .002$, whereas the rise time during neutral pictures did not differ from the rise time during unpleasant pictures, $t < 1$. The rise time during pleasant pictures was faster compared to unpleasant pictures, $t(10) = 3.63$, $p = .003$. The VALENCE effect was significant at 85 dB, $F(2,18) = 12.67$, $\omega^2 = .44$. Rise times during pleasant pictures were no faster compared to neutral pictures, $t(9) = 1.10$, $p = .002$, whereas both the rise times during neutral and pleasant pictures were faster compared to unpleasant pictures, $t(9) = 5.00$, $p < .001$ and $t(9) = 4.88$, $p < .001$, respectively. At 75 dB, there was no VALENCE effect on the rise time latency, $F(2,14) = 1.62$, $p = .233$. The VALENCE effect was significant at 65 dB, $F(2,6) = 20.74$, $\omega^2 = .77$. Rise times during pleasant pictures were faster compared to neutral pictures, $t(3) = 3.16$, $p = .026$, and rise times during neutral pictures were faster compared to unpleasant pictures, $t(3) = 3.80$, $p = .016$. The descriptive statistics for the startle response parameters are presented in Table 2, separately for each intensity level.

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Please insert Table 2 about here

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Correlation Analysis

Across the four intensity groups, the reliability estimates for the peak amplitude of the startle response were $r_{tt} = .97$ for both the pleasant and neutral, and $r_{tt} = .94$ for the unpleasant picture category. The reliability estimates for the onset latency were $r_{tt} = .80$ for the pleasant, $r_{tt} = .88$ for the neutral, and $r_{tt} = .90$ for the unpleasant picture category. The reliability estimates for the rise time latency were $r_{tt} = .77$ for the unpleasant, $r_{tt} = .92$ for the neutral, and $r_{tt} = .89$ for the unpleasant picture category. See Table 2 for the reliability estimates in each category separately for each intensity group.

The correlations were negative between the onset latency and the unstandardized peak amplitude of the startle response. Across all intensity levels, both measures correlated with $r = -.64$ for the pleasant, $r = -.79$ for the neutral, and $r = -.74$ for the unpleasant picture category (*p*s < .001).

The correlations were positive between the rise time latency and the unstandardized peak amplitude of the startle response. Across all intensity levels, both measures correlated with $r = .67$ for the pleasant, $r = .66$ for the neutral, and $r = .77$ for the unpleasant picture category (ps < .001).

The correlations were negative between the onset and the rise time latency of the startle response. Across all intensity levels, both measures correlated with $r = -.45$ for the pleasant, $r = -.76$ for the neutral, and $r = -.72$ for the unpleasant picture category (ps ≤ .005). See Table 3 for the correlations between the three startle response measures at each intensity level and valence category.

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Please insert Table 3 about here

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Discussion

The IAPS pictures from the current study differed both in subjective valence and arousal. As expected, pleasant pictures had the highest and unpleasant pictures the lowest valence ratings. Pleasant and unpleasant pictures were also rated as more arousing than neutral pictures. The SCR to emotional pictures were larger than to neutral pictures, replicating previous findings (e.g., Lang, Greenwald, Bradley & Hamm, 1993). This suggests that both pleasant and unpleasant pictures had a substantially greater arousal potential than neutral pictures. This was a necessary precondition for further analyses of the startle response parameters because previous research indicated that the valence modulation of the startle response was most evident for stimuli with a great arousal potential (Bradley et al., 2006; Cuthbert et al., 1996).

Latency measures. Replicating previous findings, the magnitude of the startle response amplitude decreased as a function of picture valence (Bradley et al., 2001; Lang, 1995). The response amplitudes were smallest during the presentation of pleasant pictures and largest during unpleasant pictures. Beyond replication of the peak amplitude modulation, the present study aimed at clarifying the inconsistent findings on the onset latency of the startle response. We found that the onset latency was also modulated by the picture valence. In particular, an increase in picture valence was associated with an increase in onset latency of the startle response. In addition, the rise time latency of the startle response was also affected by the valence of the IAPS pictures. Startle responses during unpleasant picture presentation had the longest, startle responses during neutral picture presentation the intermediate, and startle responses during pleasant picture presentation had the shortest rise time latency.

Altogether, this considerably helps to complete the picture of the startle response as an index for emotional processing. A startle response during unpleasant picture presentation can be characterized by having a greater peak amplitude, a faster response onset, and a prolonged duration till the response reaches its maximum peak compared to startle responses during pleasant picture presentation. As indicated by the large effect sizes, a substantial amount of the variation of the three measures can be attributed to the influence of picture valence. Overall, the effect sizes were large for the standardized peak amplitude ($\omega^2 = .44$), the onset latency ($\omega^2 = .16$), and the rise time ($\omega^2 = .30$). Despite the larger effect size for the peak amplitude, it may not be concluded that the valence manipulation had a larger impact on the peak amplitude. Effect sizes quantify the proportion of variance that can be attributed to the experimental manipulation. For this purpose, it relates the variance within conditions (i.e., the variance between participants within one condition, often referred to as statistical error variance) to the variance between conditions (often referred to as systematic variance). With the standardization of the peak amplitude the variance within the conditions decreases and in turn the proportion of systematic variance increases, thus resulting in a larger effect size. Therefore, the effect size of the unstandardized peak amplitude has to be used for a comparison of the effect of the valence modulation on the startle response parameters. In the current study, the effect size of the unstandardized peak amplitude was $\omega^2 = .19$ [$F(2, 74) = 14.46$, $p < .001$, $\varepsilon = .78$] and therefore of similar size as the onset latency and even smaller than the effect size for the rise time latency. Therefore, latency parameters appear to be equally informative about the valence impact on the startle response as the strength of the response (i.e., peak amplitude).

In many respects, latency measures might be useful parameters for the research of the affective startle modulation. First of all, we found that the onset and rise time latency can be reliably measured ($r_{tt} \geq .77$). The reliability estimates were somewhat higher for the peak amplitude of the startle response, than for its latency measures. This might be attributable to increased difficulties in the accurate scoring of the latency measures. Trials with movement artifacts during the baseline prior to the probe presentation had to be excluded from the latency analyses since the baseline activity was used in the determination of the onset threshold. The peak amplitude, however, was unaffected by any baseline activity and was therefore scored with a greater ease. Peak amplitudes were scored on an average of 90 % of all trials whereas latency measures were scored only on an average of 81 % of all trials (of the participants included in the analyses). Presumably, there may have been more error variance in the latency measures than for the peak amplitude, resulting in somewhat lower reliability coefficients.

Onset and rise time latency showed great convergence with the peak amplitude. Great negative correlations between the peak amplitude and the onset latency, as well as great positive correlations between the peak amplitude and the rise time latency show that the respective measures share a considerable amount of common variance, which indicates congruent validity of these measures. Startle responses with greater amplitudes were associated with faster response onsets and longer rise times, and vice versa. Therefore, findings are that the latency measures are capable of validly assessing the valence modulations of a startle response.

A practical advantage of the latency measures is that they showed less habituation across the experimental procedure. Whereas the peak amplitude decreased significantly during the repeated picture presentation, the onset and the rise time latency were largely unaffected by the repetition of the pictures.

A further, important advantage is that the latency measures do not need to be standardized. The peak amplitude is preferably standardized to avoid unwanted variance in the startle data that is unrelated to the experimental manipulation. However, the standardization may also remove individual differences that may be of interest, for example, individual differences in general affective reactivity towards a startle probe, which may indicate differences in the neural systems that mediate the startle response. Such differences may again be linked to aspects of personality or clinical disorders. However, they cannot be studied with standardized response amplitudes. Altogether, the latency measures may be useful in various fields of individual research.

Probe intensity. Our results replicate previous findings that probe intensity has an influence on the startle response. An increase in probe intensity was associated with increased peak amplitudes, faster response onset latency, and prolonged rise time latency (cf. Blumenthal et al., 2005; Blumenthal & Goode, 1991).

For all intensity levels, we found large effect sizes for the valence modulation of the peak amplitude and the latency measures (an exception was the rise time latency at 75 dB). This is remarkable insofar as only four and six participants entered the latency and peak amplitude analyses, respectively, for the 65 dB group.

A recommendation for a particular intensity level remains difficult and should be considered with caution. However, a tentative proposal for the 85 dB stimulation is emerging from the current findings. Compared to the 95 dB startle probe, we found comparable large valence effects for the peak amplitude ($\omega^2 = .53$ and.49, respectively) and for the rise time latency ($\omega^2 = .40$ and .44, respectively) for 85 dB probes. Moreover, the reliabilities of all startle response parameters were generally greater for probes of 95 dB and 85 dB than probes of less intensity.

Additionally, we found that the startle parameters could be scored with a greater ease for the 85 dB probes than for the less intense probes. The peak amplitude could be easily scored on almost all trials for the 95 dB and the 85 dB startle probes (98 % and 94 %, respectively), whereas the scoring was much more difficult for the less intense probes. Peak detection even dropped below 60 % for the 65 dB stimulation, which made the response identification less convenient. Interestingly, the probability rates for the 75 dB (85 %) and 65 dB (59 %) stimulation matched the results from Blumenthal and Goode (1991), who found probability rates of approximately 70 % – 80 % for 70 dB stimulation and of approximately 50 % for 60 dB stimulation. A similar picture was found for the onset latency measures. The onset and the rise time latencies were easily scored on the majority of trials for the 95 and 85 dB probes (85 % and 83 %, respectively), whereas scoring becomes more difficult for the 75 dB and 65 dB probes (67 % and 64 %, respectively).

Altogether, our findings suggest that the startle response can be reliably and conveniently measured with startle probes of 85 dB. In particular, the use of 85 dB startle probes was in no way inferior to the commonly used startle probes of 95 dB. Bearing in mind that an increase of only 10 dB in probe intensity doubles the perceived volume of the stimulus and that greater intensities are associated with greater aversiveness for the participants (Bradley, Cuthbert & Lang, 1999), we tentatively recommend a startle intensity of 85 dB for future research. With our and previous findings in mind (Blumenthal et al., 2005, Cuthbert et al., 1996), we suggest to value the comfort of the participants by choosing startle probes of less intensities.

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Footnotes

[1] IAPS picture number: pleasant: 4460, 4470, 4490, 4510, 4520, 4531, 4650, 4660, 4680, 4687, 4690, 4689. neutral: 5500, 5510, 5520, 5530, 5532, 5533, 7009; 7010, 7030, 7040, 7080. unpleasant: 1050, 1120, 1300, 1930; 3080, 3110, 3130, 3530, 3060, 6260, 6350, 6510.

[2] Final *N*s for the analysis of the peak amplitude of the startle response in the four groups: 95 dB = 11, 85 dB = 11, 75 dB = 10, 65 dB = 6.

[3] Final *N*s for the analyses of rise time and onset latency in the four groups: 95 dB = 11, 85 dB = 10, 75 dB = 8, 65 dB = 4.

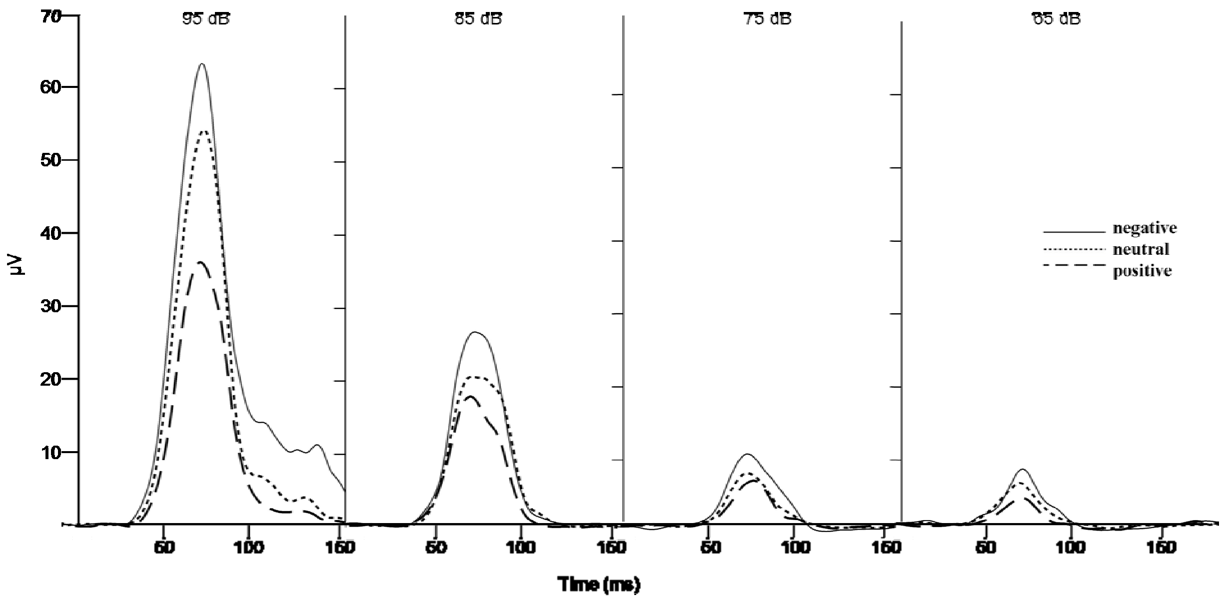

Figure 1. Valence modulated pattern for the unstandardized startle amplitude (in μV) for four startle probe intensities.

Table 1

Mean ratings of pleasure, arousal, skin conductance response, and the standardized peak amplitude, onset and rise time latency of the startle response.

Dependent variable	pleasant		neutral		unpleasant	
	M	*SD*	*M*	*SD*	*M*	*SD*
Pleasure ratings (1-9)	6.1	0.9	5.4	0.8	2.4	0.5
Arousal ratings (1-9)	4.5	1.6	1.9	0.9	6.1	1.3
Skin Conductance Δ (log µS +1)	.015	.042	.002	.023	.015	.031
Startle amplitude (T score)	47.13	2.10	49.48	2.64	53.30	2.18
Startle onset latency (ms)	52.03	6.69	49.44	7.90	48.34	7.89
Startle rise time latency (ms)	20.22	6.476.7	24.39	9.92	25.94	9.07

Table 2

Unstandardized peak amplitude (µV), onset latency, and rise time latency (both in ms) of the startle response, separately for each intensity level. All reliability coefficients are listed.

intensity	picture category	peak amplitude (µV)			onset latency (ms)			rise time latency (ms)		
		M	*SD*	r_{tt}	*M*	*SD*	r_{tt}	*M*	*SD*	r_{tt}
95dB	pleasant	54.14	44.87	.94	47.60	5.39	.84	23.27	6.46	.94
	neutral	79.30	62.92	.97	42.88	7.92	.96	31.19	12.00	.92
	unpleasant	87.42	71.29	.97	41.53	6.30	.93	31.34	11.31	.95
	average	73.62	58.60	.96	44.00	6.13	.92	28.60	9.57	.94
85dB	pleasant	27.31	19.28	.89	50.72	6.39	.94	20.78	5.91	.90
	neutral	34.63	41.45	.84	50.95	5.37	.64	21.47	7.64	.87
	unpleasant	41.36	35.86	.86	47.74	5.83	.62	25.21	6.43	.73
	average	34.43	31.82	.86	49.80	5.45	.79	22.25	6.42	.85
75dB	pleasant	11.98	6.60	.97	57.39	4.39	.20	18.83	6.98	.57
	neutral	12.86	7.00	.94	54.54	4.58	.31	21.65	7.26	.90
	unpleasant	19.02	10.56	.80	56.21	3.31	.70	21.60	7.80	.92
	average	14.62	7.63	.93	56.04	2.44	.43	20.70	6.75	.84
65dB	pleasant	10.16	5.09	.75	56.76	5.36	.57	14.94	3.54	N/A*
	neutral	14.91	10.39	.97	53.50	8.10	.89	18.49	3.06	N/A*
	unpleasant	18.43	9.95	.80	52.85	6.33	.57	21.63	1.51	N/A*
	average	14.50	8.21	.88	54.37	6.13	.72	18.35	2.57	N/A*

Note. r_{tt}=reliability estimate. N/A=not available. *Due to the low number of participants included in the rise time analysis (*N*=4) we did not compute the correlations for this measure.

Table 3

Correlations between the peak amplitude (unstandardized), the onset latency, and the rise time latency of the startle response.

intensity	picture category	peak amplitude – onset latency	peak amplitude – rise time latency	onset latency – rise time latency
95dB	pleasant	-.72 *	.84 **	-.57 *
	neutral	-.60 *	.68 *	-.79 *
	unpleasant	-.45	.44	-.71 *
85dB	pleasant	-.43	.55 *	-.62 *
	neutral	-.71 *	.60 *	-.90 **
	unpleasant	-.49	.72 *	-.64 *
75dB	pleasant	-.26	.45	-.17
	neutral	-.05	.14	-.60
	unpleasant	-.16	.62	-.65 *
65dB	pleasant	.20	.80	.40
	neutral	-.80	.40	.20
	unpleasant	-.60	.40	.40

Note. * = correlation significant on the 0.05 level (one-tailed). ** = correlation is significant on the 0.01 level (one-tailed).

Appendix A3 – Manuscript 3

Art and emotion: Physiological correlates of the processing of aesthetic stimuli

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Abstract

An aesthetic experience may involve a wide spectrum of affective responses, ranging from mere experiences of preference and beauty to highly diversified emotions such as joy and happiness, but also rather unpleasant feelings of e.g., melancholy, agitation, or anxiety. So far, findings on aesthetic emotions are primarily based on subjective ratings only. To date, little is known about the affective psychophysiology of emotional responses to aesthetic stimuli in the form of art paintings.

We investigated the effect of artworks on somatic, autonomic, and cortical indicators of emotions. We recorded facial electromyographic activity, changes in skin conductance (SCR), the startle response, and cortical activity of 50 participants while looking at various artworks and pictures from the International Affective Picture System (IAPS). There was no art effect on autonomic measures, such as the SCR and the startle response. However, the cortical activity was significantly modulated by the art stimuli, showing a similar pattern as for the emotional IAPS pictures. The picture-related positive slow wave and the probe-related P300 were significantly affected when art pictures were presented compared to non-art control stimuli. Both components have been associated with a sustained stimulus evaluation, pointing towards an elaborate cognitive processing in the perception of artworks.

keywords: aesthetics, aesthetic emotion, utilitarian emotion, psychophysiology of emotion

Physiological Responses to Aesthetic Stimuli

Art is an essential element of our cultural identity. Since the evolution of modern man, people have always engaged in various forms of artistic activities, from archaic cave paintings to Michelangelo's Sistine Chapel, from primitive melodies to Beethoven's symphonies. This remarkable commitment is, however, not limited to active forms of art production. A large number of people worldwide enjoy being exposed to art, whether it may be going to a museum in their free time or attending a classical concert. Attendance figures from museums document the attraction of (visual) art upon people. The ten most popular art museums worldwide alone attracted almost 47 million visitors in 2010 ("Exhibition and museum attendance figures 2009," 2010).

Visual art and emotion. In recent years, there has been an increasing interest in the field of aesthetics with researchers trying to find out more about the appeal of art upon people. Some studies examined which perceptual features of a painting are particularly appealing to a recipient (e.g., Berlyne, 1974; Jacobsen & Höfel, 2003; Ramachandran & Hirstein, 1999), how art taste and preference are related to personality and demographic variables (Chamorro-Premuzic, Furnham & Reimers, 2007; Chamorro-Premuzic, Reimers, Hsu & Ahmetoglu, 2009; Furnham & Bunyan, 1988), or which neural structures in the brain are involved in the perception of beauty and aesthetics (see, Nadal, Munar, Capó, Rosselló & Cela-Conde, 2008, for an overview). Focusing on the domain of visual art, Leder, Belke, Oeberst, and Augustin (2004) have developed a theoretical framework, which describes the distinctive processes involved in the perception of paintings. They propose a combination of multilevel cognitive operations and affective evaluations that in the end result in an aesthetic judgement and an aesthetic emotion. The range of emotions that are suspected to be elicited by artworks is diverse, including feelings of pleasure, joy, melancholy, sadness, surprise, and anxiety, to just name a few (Hagtvedt, Hagtvedt & Patrick, 2008; Silvia, 2009). To date, most studies have used self-reports to assess the emotional impact of aesthetic stimuli.

In music research, a distinction is made between *perceived* emotions and *felt* emotions (Gabrielsson & Juslin, 2003; Scherer, 2004). The cognitivist's position proposes that emotions are not really induced by music but that listeners simply recognize the emotions represented by the music. The emotivist's position, on the other hand, proposes that music is able to induce emotions that are truly felt by the listeners (Kivy, 1989). There is increasing consensus that emotions need to be conceptualized as multicomponential phenomena (Scherer, 2000; Scherer & Zentner, 2001). Especially, the involvement of physiological changes in autonomic and somatic systems is considered a necessary criterion for an emotional response. From this perspective, a multitude of findings so far speak in favour of the emotivist's position that music is capable of inducing emotions that are felt rather than perceived. Pleasant and unpleasant excerpts of music elicit different psychophysiological changes in parameters of the somatic and autonomic nervous system, which are indicative of an emotional engagement (e.g., Krumhansl, 1997; Lundquist, Carlsson, Hilmersson & Juslin, 2009; Roy, Mailhot, Gosselin, Paquette & Peretz, 2009).

With respect to visual art, the question of perceived versus felt emotions may arise as well. To date, there are little findings that unambiguously answer the question whether visual artworks only represent emotions that are then perceived by the recipients and reported as being their own experience, or if art is indeed able to induce emotional states that are physiologically measureable. In this context, the validity and sufficiency of verbal reports of subjective feelings elicited by artworks has been questioned (Ramachandran & Hirstein, 1999; Scherer & Zentner, 2001). In particular, Ramachandran and Hirstein (1999) have suggested that there are better measures for the assessment of an emotion in response to aesthetic stimulation than simply asking art recipients how they feel while looking at an artwork. They argue that a subjective rating is always prone to being filtered, edited, and even censored by the recipient, may it be consciously or unconsciously. Therefore, Ramachandran and Hirstein (1999) suggested in particular the skin conductance response (SCR) to be a more valid measure for an emotion elicited by an artwork. The subjective emotional significance of any emotional stimulus, they argue, is evaluated by limbic structures, which is then further relayed to the autonomic nervous system causing activity in the sweat glands. In particular, the authors propose that the autonomic response to an artwork should be similar to any kind of emotionally evocative stimulus. This hypothesis has to date not been empirically tested.

Another view on emotions associated with aesthetic stimulation was introduced by Scherer (2004). In contrast to Ramachandran and Hirstein (1999) who proposed a similarity between the emotions elicited by art and by other emotional stimuli, Scherer made a theoretical distinction between *aesthetic emotions* and *utilitarian emotions* (e.g., anger, fear, joy), the latter having been subject majority of emotion of research in the past. The distinctive feature of utilitarian emotions is their evolutionary inherited functionality in the adaptation and adjustment of an individual to important environmental challenges, which often involves synchronized psychophysiological changes (Bradley, Codispoti, Cuthbert & Lang, 2001). To a great extent they are influenced by the appraisal of the situation regarding goal relevance and coping potential within the context (Hagemann, Waldstein & Thayer, 2003). Aesthetic emotions, Scherer argues, are quite different. They are less concerned with personal needs or goals, specific action tendencies, or coping strategies. Moreover, they are generally less organismically synchronized, of less intensity, and have a lower behavioral impact compared to utilitarian emotions. Rather, aesthetic emotions entail an increased cognitive involvement with the stimulus and are foremost triggered by positive evaluations of their “intrinsic qualities” (Scherer, 2004, p. 244).

Moreover, Scherer (1984, 2000, 2004) specifies five components to describe an emotion episode, irrespective of its utilitarian or aesthetic nature, namely subjective feeling, physiological arousal, behavior preparations, motor expression, as well as cognitive processes. However, it is an open question whether these components are similar or differ between aesthetic and utilitarian emotions in the context of visual art processing. If aesthetic emotions indeed form a separate affective category besides utilitarian emotions, there should be measurable differences in – at least some of the – specific emotion components.

Psychophysiology of utilitarian emotion. Traditional emotion research uses autonomic and central nervous system indicators to investigate the induction of emotional states. In the last two decades, Peter Lang and his research group have established a valid and reliable paradigm for the investigation of objective manifestations of emotional states that correspond to each of the five emotion components as proposed by Scherer (Lang, Bradley & Cuthbert, 1990; Scherer, 2004). They suggest that emotions are organized biphasically, as either appetitive or defensive. Two corresponding motivational systems promote appropriate behavioral responses that favor either approach, or defense and escape, respectively. These action tendencies manifest themselves in measurable bodily symptoms, such as changes in skin conductance, increased activity in the muscles of facial expressions, or a modulation of the blink response to a secondary startle probe (Lang, Greenwald, Bradley & Hamm, 1993). Foremost, these symptoms co-vary either with the valence or the arousal of an emotion eliciting stimulus or event. Usually, participants are asked to indicate the perceived valence of the emotional stimulus and the degree of arousal that has been elicited with a self-assessment manikin (Bradley & Lang, 1994). These dimensional ratings might be regarded as operationalisations of the subjective feeling component. The ratings of valence and arousal are highly correlated. Consistently, judgements of pleasure and displeasure are both positively correlated with ratings of greater arousal. This suggests that arousal ratings might generally index the level of activation in a motivational system, not differing between pleasure (appetitive system) and displeasure (defensive system; Cuthbert, Schupp, Bradley, Birbaumer & Lang, 2000; Lang, Bradley & Cuthbert, 1997). For example, the SCR is based on the sympathetic nervous system and it is sensitive to stimulation and physiological arousal of an organism. Therefore, the SCR validly and reliably reflects the intensity with which a motivational system is activated and thus may represent the physiological arousal component of an emotion. Another measure is the magnitude of a blink response to a loud and unexpected secondary startle probe, which is associated with reports of pleasure or displeasure due to a primary emotional stimulus. In the case of a pleasant foreground stimulus, the blink response is inhibited relative to a neutral stimulus, whereas in the case of an unpleasant foreground stimulus, the blink response is potentiated relative to a neutral stimulus. The startle probe is experienced as highly aversive. The subsequent startle response, as being part of a defensive response system, intends to protect the organism against this potential threat. This measure might therefore be indicative of the component of the behavioral preparation of the organism. Further measures are derived from the electromyogram (EMG) of facial muscles and assess the mimic activity inherent to an emotional response. The corrugator supercilii muscle, which is placed right at the medial end of the eyebrow and is involved in frowning, is again indicative of unpleasant emotional states. It is therefore activated during the presentation of stimuli of negative valence. The zygomaticus major muscle on the contrary, which extends from the cheekbone to the corners of the mouth and is involved in smiling, is activated during the presentation of stimuli of positive valence. These facial expressions are generally regarded as principal motor components of an emotion. For the investigation of these and other physiological modulations, researchers most commonly use the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2008), a set of normative color photographs that cover a broad range of semantic categories.

In recent years, a number of different studies have also focused on brain correlates of the processing of emotional stimuli, which may represent the cognitive processes component of an emotion (see, Olofsson, Nordin, Sequeira & Polich, 2008; Schupp, Flaisch, Stockburger & Junghöfer, 2006, for reviews). A distinction can be drawn between event-related potentials (ERPs) locked to the onset of an emotional stimulus and ERPs locked to the onset of a secondary startle probe, which is presented during the presentation of an emotional stimulus. For the ERP locked to the onset of a picture, there are consistent findings of greater positivity for emotionally intense pictures than for neutral pictures. The late positive potential (LPP) is maximal over centro-parietal sites, develops around 300 ms, and is most apparent between 400 to 700 ms after picture onset. It is then followed by an extended positive slow wave (PSW), which may last up to several seconds afterwards (Cuthbert, et al., 2000). Regarding its functionality, the LPP amplitude is suspected to generally reflect the stimulus representation in the working memory (Donchin & Coles, 1988; Schupp, et al., 2006) and the PSW amplitude has been suggested to reflect sustained motivated attention to visual emotional stimuli and is further associated with enhanced encoding processes (Olofsson, et al., 2008; Schupp, et al., 2006). Another component that is sensitive to emotionally intense pictures is the startle probe P3. ERPs show a positive deflection around 300 ms following a secondary startle probe, which is larger during the presentation of low arousing neutral stimuli pictures than during the presentation of high arousing emotional pictures (Schupp, Cuthbert, Bradley & Birbaumer, 1997). The magnitude of the P3 is presumed to be proportional to the extent of attentional resources available to the probe stimulus. Emotional pictures, as opposed to neutral pictures, automatically allocate sustained attentional resources due to their motivational significance and therefore only small attentional resources are left over for the cortical processing of a subsequent startle probe. All three ERP components have in common that their magnitude is associated with the arousal of the stimulus. The amplitude of the LPP and the PSW are greatest and the amplitude for the probe P3 is smallest for emotional pictures that elicit great subjective arousal, as indicated by self-reports of the participants and a great SCR (Cuthbert, et al., 2000; Schupp, et al., 1997; Schupp et al., 2004). Moreover, the arousal ratings, the averaged LPP amplitude, and the skin conductance response have great loadings on one common factor and therefore share a great deal of common variance (Cuthbert, et al., 2000). In particular pleasant and unpleasant pictures of great evolutionary and motivational relevance, such as erotic scenes and scenes depicting threat or mutilations, have been found to be associated with an enlarged LPP even compared to pictures of the same valence but less reported arousal. Evolutionary salient pictures inherently engage attentional resources and are therefore considered to strongly activate the appetitive or defensive motivational system and corresponding behavioral patterns (Cuthbert, et al., 2000; Lang, et al., 1997).

The current study. We addressed the empirical question whether aesthetic stimuli in the form of art paintings are able to induce a full scale emotional response with respect to the five emotion components of Scherer (2004). In particular, we were interested in similarities or dissimilarities in the affective responses to art vs. non-art on the one hand and to emotional art vs. emotional IAPS pictures on the other hand. The latter, in particular, may help to clarify whether an aesthetic emotion is distinguishable from utilitarian emotions (Scherer, 2004) or whether it shows close resemblance to them (Ramachandran & Hirstein, 1999).

In the past, the self-report of subjective feelings elicited by art has been the most frequently used approach. Due to its possible confounding with various artifacts it is debatable whether verbal reports are a reliable and sufficient criterion of a genuine emotional experience (Ramachandran & Hirstein, 1999; Scherer & Zentner, 2001). The component-process model of emotion by Scherer (1984, 2000, 2004) suggests otherwise and it describes an emotion as a multicomponential phenomenon, including physiological and cognitive components. Accordingly, we assessed verbal, autonomic, and central nervous system responses as operationalizations of the five emotion components while our participants were viewing various artworks. In a first set of art stimuli we selected paintings that covered a broad range of artists, styles, and art epochs. In order to generate control stimuli, we randomized the array of the pictures' pixels, leaving them unrecognizable but maintaining their physical properties like color spectrum and luminance.

In addition, we compared the findings for art stimuli with the findings for IAPS stimuli regarding the five emotion components. We examined whether pleasant or unpleasant artworks have comparable physiological effects and subjective feeling ratings as pleasant and unpleasant photographic (i.e., realistic) IAPS pictures. The content categories of the IAPS to have proven most effective for the induction of emotions are erotica for the pleasant category and threat, and mutilations for the unpleasant category (Bradley et al., 2001). Accordingly, we selected a second set of art stimuli that contained paintings to specifically match the IAPS content. In particular, we selected paintings explicitly depicting erotic content (e.g., nudes) and aversive content (e.g., mutilations, body limbs). The experimental procedure was similar to that of studies using the IAPS (see, Bradley, et al., 2001, for an example).

Ramachandran and Hirstein (1999) have argued that an emotional response to artworks should be similar to an emotional response towards other emotional stimuli, including elaborated cognitive processes. Scherer (2004) agreed on the similarity between utilitarian emotions and aesthetic emotions regarding the cognitive processing (intrinsic and transactional appraisals, respectively). Accordingly, it may be hypothesized that art stimuli show similar responses compared to stimuli from the IAPS regarding the cognitive processing component (EKPs). Regarding the SCR (physiological arousal) there is theoretical support for two opposing hypotheses. Ramachandran and Hirstein (1999) argued that emotional art pictures should evoke a similar SCR than other emotional stimuli, whereas Scherer (2004) describes aesthetic emotions as less intense and being lower synchronized across different bodily systems. The latter might suggest a generally lower embodiment of an aesthetic emotion, resulting in a lower SCR.

Method

Participants

Fifty-seven students from the University of Heidelberg participated in the study. The data of 6 students had to be discarded due to technical problems, and one student dropped out voluntarily after the first session. This left us with a final *N* of 50 participants (26 male, 24 female). The average age was *M* = 25.72 years (*SD* = 4.93 years). All participants had normal or corrected-to-normal vision. One participant had to be excluded from the analyses of the startle response amplitude due to an insufficient number of artifact-free trials.

Materials and design

We presented two types of stimuli to the participants. The first stimulus type were pictures taken from the International Affective Picture System (IAPS; Lang, et al., 2008). We presented 45 IAPS pictures that consisted of the following categories: 15 neutral, 15 pleasant, and 15 unpleasant pictures. The neutral pictures depicted inanimate objects (e.g., books, kitchen supplies). The pleasant pictures depicted in equal numbers erotic couples, pictures of female nudes (for the male participants only) or male nudes (for the female participants only), and adventure/sport scenes. The unpleasant pictures depicted in equal numbers scenes of mutilations, human attack, and animal attack.[1] According to the normative ratings, the pleasant pictures were more pleasant than the neutral pictures, and the neutral pictures were more pleasant than the unpleasant pictures (Lang, et al., 2008). Both pleasant and unpleasant pictures were greater in arousal compared to neutral pictures, while unpleasant were also greater in arousal than pleasant pictures.

The second stimulus type were representations of art paintings. We presented 45 art pictures that consisted of the following categories: 15 pictures were general artworks of various artists, art periods, paintings styles, and content (from now on labeled “artGen”).[2] In order to generate control stimuli, we randomly arranged the position of the individual pixels of each art picture in order to make it unrecognizable to the participant but to maintain its physical properties like luminance and color scheme (from now on labeled “artPix”). An additional 15 pictures were artworks that depicted scenes of heightened emotional valence and evolutionary significance, eight of them depicting pleasant content (i.e., erotica; from now on labeled “posArt”) and seven depicting unpleasant pictures (i.e., threat and mutilation; from now on labeled “negArt”). One of the erotic pictures was presented to the male participants or the female participants only (Egon Schiele, s*eated female nude* and *seated male nude*, respectively).[3] All pictures were presented on a PC screen with a black background, at a visual angle of approximately 20 degrees.

The pictures were presented in two blocks, one block containing only IAPS pictures and the other block containing only art pictures. Half of the participants viewed the IAPS pictures first, the other half of the participants viewed the art pictures first. Per block, each participant viewed one of five pseudo-randomized picture orders. Each order was constructed such that no more than two pictures of the same category (*IAPS*: neutral, pleasant, unpleasant; *art*: artGen, artPix, posArt, negArt) were presented in direct succession. Moreover, across all orders, each IAPS and each art picture was presented with equal frequency within the first, second, and third part of the respective block. Each order was presented to approximately one fifth of the participant.

The pictures were presented for 30 s because a study by Smith and Smith (2001) suggests that art recipients spend an average of 27 seconds looking at an artwork in an art museum. During the presentation of nine out of 15 pictures of each category (i.e., 60 %), we presented an acoustic startle probe (85 dB, 50 ms of white noise, nearly instantaneous rise time) that was presented binaurally over two loudspeakers. The onset of the probe was either after 2.500 ms or 3.500 ms after picture onset. No more than two trials with a startle probe were presented consecutively and no more than two trials with the same startle probe onset latency were presented consecutively. In each presentation order, different pictures were selected for the trials with a startle probe. Across all presentation orders, each picture was presented with a startle probe with equal frequency. The intertrial interval (ITI) lasted randomly between 19 and 25 s. Per block, nine additional startle probes were presented during the ITIs to decrease their predictability. Altogether, we presented 36 startle probes per block and 72 startle probes per session.

Procedure

Each participant had two sessions of the identical experiment. Session 1 and Session 2 were approximately 8 weeks apart. The second measurement was intended to facilitate an analysis of the stability of any personality effect if present. In the current paper, we will only report the findings of Session 1. The participants were seated in a sound-attenuated chamber with dimmed lights. After the attachment of the electrodes, participants were informed that unpleasant pictures were to be expected, and that any brief, loud noises during the experiment should be ignored. Each participant viewed the block with the IAPS pictures and the block with the art pictures. The order of presentation was balanced across the participants. Before each IAPS and each art block, a set of six additional pictures (IAPS or art pictures, respectively) were presented to familiarize the participants with the procedure.

After the offset of the IAPS and the art pictures, the participants rated the valence and the arousal of each picture with the Self Assessment Manikin (SAM; Bradley & Lang, 1994). The order of the ratings was randomized for each picture. After the first block of pictures, the participants were free to take a self-paced break before the second block started.

Physiological recording

All signals (SCR, EMG, EEG) were recorded continuously with a sampling rate of 2.500 Hz. All electrode impedances were kept below 5 kΩ.

SCR was recorded from the thenar and the hypothenar eminence of the left hand, with an online band-pass filter of DC to 1000 Hz. The signal was filtered offline with an 8.5 Hz low pass filter.

All EMG signals were measured with Ag-AgCl miniature electrodes from the left side of the face, using standard procedural recommendations (Blumenthal et al., 2005; Fridlund & Cacioppo, 1986). Corrugator supercilii activity and zygomaticus major activity were measured over the eyebrow and the cheek, respectively. The startle response was measured by recording EMG activity of the orbicularis oculi muscle. The EMG signals were recorded with a 1000 Hz low pass filter and a 10 s time constant, filtered offline with a band-pass of 28 to 500 Hz, and subsequently rectified. Then, a low-pass filter of 40 Hz was applied to smooth the data.

The electroencephalogram (EEG) was recorded with Ag-AgCl electrodes (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4, O1, Oz, O2) using a Brain Amp DC amplifier (Brain products, Munich, Germany). The electrodes were positioned according to the international 10-20 system. All electrodes were referenced to Cz and digitally re-referenced offline to linked mastoids (TP9, TP10). The aFz electrode was used as the ground electrode. The horizontal and vertical electrooculogram (EOG) were recorded bipolarly from the outer canthi of the eyes and from above and below the right eye, respectively, to account for ocular artifacts. A 250 Hz high frequency cut-off and a 10 s time constant were used to record the EEG channels. The EEG signals were filtered offline with a band pass filter of 0.1 to 10 Hz.

Data reduction

Picture response. Only the trials that did not include a startle probe were used for the following analyses to avoid a confounding of the physiological response to the picture stimuli with the reaction to the startle probe.

Skin conductance reactivity was quantified as the change score between a 1-sec baseline interval and a 4-sec viewing interval after picture onset. Amplitudes were log-transformed [*log*(SCR+1)] in order to normalize their distribution.

Facial reactivity to picture presentation was quantified as the change score between a 1-sec baseline interval and a 4-sec viewing interval after picture onset.

Event-related potentials (ERPs) were calculated time-locked to the onset of the pictures, with epochs extending from 100 ms before picture onset until 7000 ms afterwards (trials without startle probes only). An eye movement artifacts correction procedure was applied to the EEG recording (Gratton, Coles & Donchin, 1983). Any epoch showing amplitudes exceeding ± 70 µV were discarded as artifacts. Grand average waveforms were calculated separately for each picture category (*IAPS*: neutral, pleasant, unpleasant; *art*: artGen, artPix, artPos, artNeg) and electrode site, and referenced to a 100-ms-baseline. In accordance with previous studies, the LPP was assessed within a time window from 400 to 700 ms and the PSW was assessed within a time window from 1000 to 6000 ms, divided into five 1-s-bins (for reviews, see Olofsson et al., 2008; Schupp et al., 2006).

Startle response. Blink responses to a startle probe were defined as the largest peak within an interval of 20 to 200 ms following the startle probe. Each trial was visually inspected and trials with no detectable blink response or with excessive noise were excluded from the analyses. For each participant, the raw blink response of each trial was *z*-standardized with the mean and standard deviation of the average peak amplitude of the startle response during the intertrial interval of that respective participant. Subsequently, the values of each participant were transformed to *T* scores [(*z**10)+50], which results in $M = 50$ and $SD = 10$.

ERPs were calculated time-locked to the onset of the startle probes, with epochs extending from 100 ms before probe presentation to 600 ms afterwards. Following artifact correction, grand average waveforms for the P3 were calculated separately for each picture category and electrode site, and referenced to a 100-ms-baseline. The P3 wave of the ERP was scored as the average activity within the time window from 250 to 400 ms after probe onset (Schupp et al., 1997; Schupp et al., 2004).

Statistical analysis

Separately for each dependent variable (valence and arousal ratings, SCR, EMG responses, ERPs), we performed the following statistical analyses.

IAPS stimuli. We compared the results of the different valence categories of the IAPS pictures as a manipulation check and as a basis for comparison for the results for the art pictures. Data entered a repeated measures analysis of variance (ANOVA) with the within factor valence category (pleasant, neutral, unpleasant).

General art stimuli. We compared the results of the general art pictures (artGen) with the results of the randomized control pictures (artPix) in order to detect any changes in verbal, autonomic, and central nervous system measures due to general art presentation. Data entered a repeated measures analysis of variance (ANOVA) with the within factor valence category (artGen, artPix). One limitation of this analysis is that it does not allow a direct comparison of physiological changes due to general art and IAPS pictures because of their differing content. The IAPS pictures in the current study show exclusively evolutionary significant content. Therefore, we performed a third analysis for emotional art and IAPS pictures that were matched on content.

Emotional art and IAPS pictures. All measures with a significant valence effect in the first (IAPS) and second analysis (general art) entered this analysis. We compared the results of the pleasant and unpleasant art pictures and the pleasant and unpleasant IAPS pictures, respectively, in order to see whether emotional art pictures elicit comparable changes in verbal, autonomic, and central nervous system measures as emotional IAPS pictures. Data entered a repeated measures analysis of variance (ANOVA) with the within factors valence category (pleasant, unpleasant) and picture type (art, IAPS).

In all three analyses, the factors caudality (frontal, central, parietal) and laterality (left, midline, right) were added for the ERP analyses. Only interactions involving the valence category factor will be reported. Greenhouse-Geisser corrections of degrees of freedom were applied when necessary. Post-hoc comparisons were calculated with simple *t*-tests. The significance level for all analyses was set at $\alpha = .05$, and Bonferroni corrected in the case of multiple comparisons. The power $(1 - \beta)$ of the repeated measures analysis within the IAPS (three level) and the art stimulus category (two level) was .98 and .93 respectively ($\alpha = .05$, $\Phi^2 = .25$). The power for the comparison between IAPS and art stimuli (2 x 2 interaction) was .93 ($\alpha = .05$, $\Phi^2 = .25$).

Results

Valence and arousal ratings

IAPS stimuli. There was a significant main effect of the picture category (pleasant, neutral, unpleasant) on the valence ratings of the IAPS pictures, $F(2,98) = 287.16$, $p < .001$, $\omega^2 = .79$. Pleasant pictures were rated as more pleasant than neutral pictures, $t(49) = 8.85$, and neutral pictures were rated as more pleasant than unpleasant pictures, $t(49) = 16.69$ (all *p*s < .001). There was a significant main effect of the picture category on the arousal ratings of the IAPS pictures, $F(2,98) = 322.12$, $p < .001$, $\varepsilon = .75$, $\omega^2 = .81$. Both pleasant and unpleasant pictures were rated as more arousing than neutral pictures, $t(49) = 16.88$ and $t(49) = 21.10$, respectively. Unpleasant pictures were also rated as more arousing than pleasant pictures, $t(49) = 7.68$ (all *p*s < .001). See Table 1 for the descriptive statistics of the IAPS pictures.

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Please insert Table 1 about here

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General art stimuli. ArtGen pictures were rated as being more positive than artPix pictures, $F(1,49) = 92.54$, $p < .001$, $\omega^2 = .65$. ArtGen pictures were rated as being more arousing than artPix pictures, $F(1,49) = 60.78$, $p < .001$, $\omega^2 = .54$. See Table 2 for the descriptive statistics of the art pictures.

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Please insert Table 2 about here

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Emotional IAPS and art pictures. There was a significant main effect of stimulus type (IAPS, art) on the valence rating, $F(1,49) = 7.73$, $p = .008$, $\omega^2 = .06$. On average, IAPS pictures were rated as more pleasant than art pictures. There was a significant main effect of picture category (pleasant, unpleasant) on the valence ratings, $F(1,49) = 382.53$, $p < .001$, $\omega^2 = .79$. Pleasant pictures were rated as more pleasant than unpleasant pictures. There was also a significant interaction between type and category, $F(1,49) = 66.17$, $p < .001$, $\omega^2 = .25$. Post-hoc comparisons showed that pleasant IAPS pictures elicited greater valence ratings and unpleasant IAPS pictures elicited lower valence ratings that the respective art pictures, *t*s ≥ 3.40, *p*s < .001.

There was no significant main effect of stimulus TYPE on the arousal rating of the picture stimuli, $F < 1$. There was a significant main effect of picture category on the arousal ratings, $F(1,49) = 73.22$, $p < .001$, $\omega^2 = .42$. On average, pleasant pictures were rated as less arousing than unpleasant pictures. There was no significant interaction between type and category, $F(1,49) = 1.34$, $p = .252$. Figure 1 shows the relationship between valence and arousal dimensions for IAPS and art pictures.

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Please insert Figure 1 about here

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SCR and facial EMG

IAPS stimuli. There was a main effect of picture category on the SCR, $F(2,98) = 4.02$, $p = .021$, $\omega^2 = .04$. Pleasant and unpleasant IAPS pictures prompted larger skin conductance changes than neutral IAPS pictures, $t(49) = 2.53$, $p = 008$ and $t(49) = 2.40$, $p = .010$, respectively, whereas the SCR for pleasant pictures did not differ from the SCR for unpleasant pictures, $t(49) < 1$ (all *p*s one-sided).

For the facial EMG, there was a significant main effect of picture category only for the corrugator muscle activity, $F(2,98) = 19.75$, $p < .001$, $\varepsilon = .63$, $\omega^2 = .20$. Corrugator activity was greatest during the presentation of unpleasant pictures and differed from neutral pictures, $t(49) = 4.78$, $p < .001$, whereas neutral pictures elicited greater corrugator activity than pleasant pictures, , $t(49) = 1.99$, $p = .024$. There was no significant main effect of picture category on the zygomaticus muscle activity, $F(2,98) = 2.18$, $p = .119$, $\varepsilon = .64$, $\omega^2 = .02$.

General art stimuli. The SCR in response to picture presentation did not differ between artGen and artPix, $F < 1$.

For the facial EMG, corrugator muscle activity in response to picture presentation did not differ between artGen and artPix, $F < 1$. Also, zygomaticus muscle activity in response to picture presentation did not differ between artGen and artPix, $F < 1$.

Emotional IAPS and art pictures. There was a significant main effect of stimulus type on the SCR, $F(1,49) = 11.58$, $p = .001$, $\omega^2 = .10$. Emotional IAPS pictures elicited greater SCR changes than emotional art pictures. The main effect of picture category as well as the interaction between type and category were insignificant, *F*s < 1.[4]

There was a significant main effect of stimulus type on the corrugator muscle activity, $F(1,49) = 4.21$, $p = .045$, $\omega^2 = .03$. On average, emotional art pictures elicited greater corrugator muscle activity than emotional IAPS pictures. There was a significant main effect of picture category, $F(1,49) = 25.64$, $p < .001$, $\omega^2 = .20$, with unpleasant pictures eliciting greater corrugator muscle activity than pleasant pictures. The interaction between type and category was insignificant, $F(1,49) = 2.69$, $p = .108$, $\omega^2 = .01$. A post-hoc comparison between unpleasant IAPS and artNeg pictures showed no significant differences in EMG activity for the corrugator, $t < 1$.

Startle blink response

IAPS stimuli. There was a significant main effect of the picture category on the startle blink amplitude, $F(2,96) = 25.83$, $p < .001$, $\omega^2 = .25$. The blink response to a startle probe during pleasant IAPS pictures was smaller in amplitude than during neutral IAPS pictures, $t(48) = 4.01$, $p < .001$. And the blink response to a startle probe during neutral pictures was smaller in amplitude than during unpleasant pictures, $t(48) = 3.39$, $p < .001$.

General art stimuli. The startle blink amplitude in response to the startle probe did not differ between artGen and artPix, $F(1,48) = 1.64$, $p = .207$, $\omega^2 = .01$.

Emotional IAPS and art pictures. There was no significant main effect of stimulus type on the startle blink amplitude, $F < 1$. On average, emotional art pictures did not elicit greater startle blink amplitudes than emotional IAPS pictures. There was a significant main effect of picture category, $F(1,49) = 22.76$, $p < .001$, $\omega^2 = .18$, with unpleasant pictures eliciting greater startle blink amplitudes than pleasant pictures. The interaction between type and category was highly significant, $F(1,49) = 28.68$, $p < .001$, $\omega^2 = .22$. Post-hoc tests showed that pleasant IAPS pictures elicited smaller amplitudes than artPos pictures, $t(48) = 2.36$, $p = .022$. Unpleasant IAPS pictures elicited marginally higher amplitudes than artNeg pictures, $t(48) = 1.86$, $p = .069$. See Figure 2 for the startle blink amplitudes of the emotional IAPS and art pictures.

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Please insert Figure 2 about here

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ERPs evoked by pictures

IAPS stimuli. ***LPP***. In a first step, we analyzed the electrophysiological activity within the time window of the LPP (400 to 700 ms). There was a significant main effect of picture category (pleasant, neutral, unpleasant), $F(2,98) = 59.39$, $p < .001$, $\omega^2 = .44$. Both pleasant and unpleasant IAPS pictures prompted a more positive LPP than neutral IAPS pictures, $t(49) = 8.79$ and $t(49) = 9.34$ (*p*s < .001), whereas unpleasant IAPS pictures elicited also a more positive LPP than pleasant IAPS pictures, $t(49) = 3.16$, $p = .003$. See Figure 3 for the LPP in response to IAPS pictures.

There was a significant main effect of laterality (left, midline, right), $F(2,98) = 5.59$, $p = .005$, $\omega^2 = .06$. The LPP was most positive at midline electrodes ($M = 2.94$ µV, $SD = 2.96$ µV) and less positive at right electrodes ($M = 2.25$ µV, $SD = 2.57$ µV) and left electrodes ($M = 2.45$ µV, $SD = 2.61$ µV), $t(49) = 3.49$, $p = .001$ and $t(49) = 2.17$, $p = .035$ (Bonferroni corrected for three comparisons).

There was a significant main effect of caudality (frontal, central, parietal), $F(2,98) = 23.27$, $p < .001$, $\varepsilon = .63$, $\omega^2 = .23$. In general, the potential increased in positivity from anterior to posterior electrodes. At frontal electrodes ($M = .40$ µV, $SD = 3.61$ µV), the LPP was less positive than at central electrodes ($M = 3.14$ µV, $SD = 3.21$ µV), $t(49) = 5.60$, $p < .001$. And at central electrodes, the LPP was less positive than at parietal electrodes ($M = 4.10$ µV, $SD = 3.53$ µV), $t(49) = 2.42$, $p = .019$.

There was a significant interaction between laterality and picture category, $F(4,196) = 4.88$, $p = .001$, $\omega^2 = .03$. Subsequent analyses, however, showed significant quadratic trends at the left, the midline, and the right side electrodes (*F*s ≥ 41.58, *p*s ≤ .001), with emotional pictures eliciting a larger positivity than neutral pictures.

PSW. We analyzed the electrophysiological activity of the PSW over the entire latency of 6000 ms, starting from 1000 ms following picture onset until 7000 ms afterwards. There was a significant main effect of the picture category, $F(2,98) = 11.03$, $p < .001$. On average, there was no difference in the PSW amplitude between pleasant and unpleasant pictures, $t(49) = 1.23$, $p = .225$. However, emotional pictures evoked a more positive PSW than neutral pictures, $t(49) = 4.32$, $p < .001$. See Figure 3 for the PSW in response to IAPS pictures.

There was a significant main effect of laterality, $F(2,98) = 3.71$, $p = .028$, $\omega^2 = .03$. On average, the PSW was more positive in amplitude on the left side of the scalp (*M* = 2.35 μV, *SD* = 3.27 μV) than on the right side of the scalp (*M* = 1.48 μV, *SD* = 3.17 μV), $t(49) = 3.22$, $p = .002$. The PSW at the midline electrodes (*M* = 2.10 μV, *SD* = 3.70 μV), however, did not differ in amplitude from the left or the right side electrodes, $t < 1$ and $t(49) = 1.58$, $p = .120$, respectively.

There was a significant main effect of caudality, $F(2,98) = 81.70$, $p < .001$, $\varepsilon = .64$, $\omega^2 = .52$. The PSW was more positive in amplitude at the frontal electrodes (*M* = 5.19 μV, *SD* = 4.58 μV) than at the central electrodes (*M* = 3.30 μV, *SD* = 3.48 μV), $t(49) = 3.36$, $p = .002$, and it was more positive at the central electrodes than at the parietal electrodes (*M* = -2.57 μV, *SD* = 3.99 μV), $t(49) = 13.42$, $p < .001$.

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Please insert Figure 3 about here

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General art stimuli. ***LPP.*** There was no significant main effect of picture category, $F < 1$.

There was a significant main effect of laterality, $F(2,98) = 3.08$, $p = .050$, $\omega^2 = .06$. However, post-hoc test did not reveal any differences in amplitude between the left (*M* = -.06 μV, *SD* = 3.14 μV), right (*M* = .25 μV, *SD* = 3.15 μV), and midline electrodes (*M* = .26 μV, *SD* = 3.96 μV), *t*s < 1.18, *p*s < .246. See Figure 4 for the LPP in response to art pictures.

There was a significant main effect of caudality, $F(2,98) = 41.99$, $p < .001$, $\varepsilon = .63$, $\omega^2 = .55$. In general, the scalp potential increased in positivity from anterior to posterior electrodes. At frontal electrodes (*M* = -2.46 μV, *SD* = 4.42 μV), the LPP was less positive than at central electrodes (*M* = .607 μV, *SD* = 3.75 μV), $t(49) = 6.34$, $p < .001$. And at central electrodes, the LPP was less positive than at parietal electrodes (*M* = 2.68 μV, *SD* = 3.62 μV), $t(49) = 5.20$, $p < .001$.

There was a significant interaction between caudality and picture category, $F(2,98) = 4.60$, $p = .012$, $\omega^2 = .02$. At frontal, central, and parietal sites artGen elicited greater amplitudes than artPix. However, none of these comparisons were significant, *t*s < 1.76, *p*s < .84.

PSW. Subsequently, we analyzed the PSW between 1000 and 7000 after picture onset. There was a significant main effect of the picture category, $F(1,49) = 4.41$, $p = .041$, $\omega^2 = .06$. Across all electrodes, artPix prompted a less positive PSW than pictures depicting artGen. See Figure 4 for the PSW in response to artGen and artPix pictures.

There was significant main effect of laterality, $F(2,98) = 3.56$, $p = .032$, $\varepsilon = .83$, $\omega^2 = .03$. On average, the PSW was more positive on the left side of the scalp ($M = .88$ µV, $SD = 3.73$ µV) than at the midline electrodes ($M = -.04$ µV, $SD = 4.73$ µV), $t(49) = 3.33$, $p = .002$. The PSW at the midline electrodes, however, did not differ from the right side electrodes ($M = .09$ µV, $SD = 4.39$ µV), $t < 1$.

There was a significant main effect of caudality, $F(2,98) = 33.29$, $p < .001$, $\varepsilon = .61$, $\omega^2 = .45$. On average, the PSW was marginally more positive at the frontal electrodes ($M = 2.60$ µV, $SD = 6.15$ µV) than at the central electrodes ($M = 1.36$ µV, $SD = 4.12$ µV), $t(49) = 1.84$, $p = .072$, and at the central electrodes it was more positive than at the parietal electrodes ($M = -3.03$ µV, $SD = 4.46$ µV), $t(49) = 9.68$, $p < .001$.

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Please insert Figure 4 about here

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Emotional IAPS and art pictures. ***LPP.*** There was a significant main effect of stimulus type on the LPP amplitude, $F(1,49) = 16.89$, $p < .001$, $\omega^2 = .14$. The amplitudes during the emotional IAPS picture presentation were larger than during the emotional art picture presentation. There was no significant main effect for picture category, $F(1,49) = 2.83$, $p = .099$. There was a significant interaction between TYPE and CATEGORY, $F(1,49) = 3.37$, $p < .001$, $\omega^2 = .01$. Unpleasant IAPS pictures prompted a larger LPP amplitude than artNeg, $t(49) = 5.50$, $p < .001$, whereas there was no difference between pleasant IAPS pictures and artPos, $t < 1$.

PSW. There were no significant main effects of stimulus type or picture category, F < 1. The interaction between type and category was also insignificant, $F < 1$. See Figure 5 for the LPP and the PSW in response to emotional IAPS and art pictures.

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Please insert Figure 5 about here

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ERPs evoked by startle probes

IAPS stimuli. There was a significant main effect of picture category, $F(2,98) = 22.84$, $p < .001$, $\omega^2 = .23$. The P3 amplitude was significantly more positive during the presentation of neutral IAPS pictures than during pleasant or unpleasant IAPS pictures, $t(49) = 6.56$ and $t(49) = 4.73$ (ps < .001), while there was no difference in P3 amplitude during pleasant and unpleasant IAPS picture presentation, $t(49) = 1.39$, $p = .172$. See Figure 6 for the P3 in response to the startle probe during IAPS picture presentation.

There was a significant main effect of laterality, $F(2,98) = 42.70$, $p < .001$, $\varepsilon = .89$, $\omega^2 = .36$. The P3 at the midline electrodes ($M = 4.49$ µV, $SD = 2.73$ µV) was larger in amplitude than at the left side ($M = 2.68$ µV, $SD = 1.87$ µV) and at the right side electrodes ($M = 3.09$ µV, $SD = 1.98$ µV), $t(49) = 7.90$ and $t(49) = 6.48$ (ps < .001).

There was a significant main effect of caudality, $F(2,98) = 37.30$, $p < .001$, $\omega^2 = .33$. The P3 at the central and parietal electrodes ($M = 4.67$ µV, $SD = 2.60$ µV and $M = 4.52$ µV, $SD = 2.89$ µV, respectively) was larger in amplitude than at the frontal electrodes ($M = .83$ µV, $SD = 3.45$ µV), $t(49) = 9.71$ and $t(49) = 5.63$ (ps < .001), respectively.

There was a significant interaction between laterality and picture category, $F(4,196) = 2.48$, $p = .045$, $\omega^2 = .01$. Post-hoc comparisons revealed significant main effects of picture category at the left side, the midline, and the right side of the scalp (Fs ≥ 16.28, ps < .001). Overall, there was a more pronounced P3 amplitude during the presentation of neutral IAPS pictures than during pleasant and unpleasant IAPS pictures (ts ≥ 3.77, ps < .001).

There was a significant interaction between caudality and picture category, $F(4,196) = 5.15$, $p < .001$, $\omega^2 = .04$. Post-hoc comparisons revealed significant main effects of picture category at the frontal, the central, and the parietal electrodes of the EEG (Fs ≥ 5.27, ps ≤ .007). At all sites, there was a more pronounced P3 amplitude during the presentation of neutral IAPS pictures than during pleasant and unpleasant IAPS pictures (ts ≥ 3.11, ps ≤ .003).

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Please insert Figure 6 about here

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General art stimuli. There was a significant main effect of picture category, $F(2,98) = 12.29$, $p < .001$, $\omega^2 = .18$. The P3 amplitude was significantly more positive during the presentation of artPix than during artGen. See Figure 6 for the P3 in response to the startle probe during artGen and artPix presentation.

There was a significant main effect of laterality, $F(2,98) = 46.90$, $p < .001$, $\varepsilon = .88$, $\omega^2 = .38$. The P3 amplitude was most positive at the midline electrodes ($M = 5.68$, µV, $SD = 3.40$ µV) than at the left side ($M = 3.49$ µV, $SD = 2.64$ µV) or right side ($M = 3.71$ µV, $SD = 2.49$ µV) electrodes, $t(49) = 8.78$, and $t(49) = 6.90$ (ps < .001).

There was a significant main effect of caudality, $F(2,98) = 51.60$, $p < .001$, $\varepsilon = .67$, $\omega^2 = .40$. The P3 amplitude increased in positivity from frontal to parietal electrodes. The P3 amplitude was larger in amplitude at central electrodes ($M = 5.61$, µV, $SD = 3.09$ µV) than at frontal electrodes ($M = 1.47$, µV, $SD = 3.46$ µV), $t(49) = 9.56$, $p < .001$. The P3 amplitude at central electrodes did not differ from parietal electrodes ($M = 5.80$, µV, $SD = 3.42$ µV), $t < 1$.

Emotional IAPS and art pictures. There was no significant main effect of stimulus type, $F(1,49) = 2.25$, $p = .140$, and no significant main effect of picture CATEGORY, $F < 1$. The interaction between type and category was also insignificant, $F < 1$. See Figure 6 for the P3 in response to the startle probe during emotional IAPS and art picture presentation.

Discussion

In the current study, we pursued the question whether aesthetic stimuli induce measurable psychophysiological changes in the recipients that correspond to the emotion components outlined by Scherer (1984, 2000). Furthermore, we evaluated whether our findings delimit the theoretical conceptualization of aesthetic emotions from utilitarian emotions (Scherer, 2004). The findings for the IAPS pictures were successful replications of previous studies (see, Lang, Bradley & Cuthbert, 1998; Schupp, et al., 2006, for overviews). In the following, we will therefore focus primarily on the findings for the art pictures and only discuss similarities or dissimilarities with the findings for the IAPS pictures.

Valence and arousal ratings. In a first step, we examined if the selected general and emotional art stimuli show the expected variation in the valence and arousal ratings. This was a necessary prerequisite in order to compare the physiological responses between general art and non-art stimuli and to compare the responses of the emotional art and IAPS pictures (i.e., pleasant and unpleasant). Indeed, general art pictures were rated higher in valence and arousal than random control pictures (artPix). The emotional art pictures did not differ in arousal from the emotional IAPS pictures. Only small differences were found for the valence ratings between pleasant art and IAPS pictures and between unpleasant art and IAPS pictures. Altogether, we can conclude that the selection of all pictures was suitable for the subsequent investigation of physiological responses.

Physiological arousal. So far, it has been a consistent finding that emotional pictures that are rated high on the arousal dimension are associated with large changes in skin conductance (Bradley et al., 2001). In particular, Lang et al. (1993) reported a great positive correlation between the SCR and the arousal ratings ($r = .81$). Therefore, the SCR may be regarded as a valid and reliable indicator of the processing of highly arousing pictures. Presumably, the SCR indicates the intensity with which the appetitive or the defensive motivational system is activated (Lang, Bradley & Cuthbert, 1992).

In the present study, the presentation of the general and emotional art pictures had no effect on the skin conductance, whereas the expected SCR pattern was successfully replicated for the IAPS pictures. This finding was remarkable insofar as the pleasant and unpleasant art pictures were of comparable subjective arousal and comparable content to the emotional IAPS pictures. Thus, there was no association between subjective arousal and changes in the SCR for the art pictures.

The presence of subjective arousal seems therefore not to be the sufficient prerequisite for the elicitation of physiological arousal (i.e., changes in the SCR). One explanation may be that the *quality* of the arousal elicited by the art stimuli is different from the arousal that is associated with emotional IAPS pictures. One might argue that the IAPS pictures represent a semantically different stimulus category. They are naturalistic photographs, depicting real life settings and therefore inherently possess a greater psychological relevance. This holds true especially for the pictures showing evolutionary significant content, such as erotica, threat, and mutilations. Bradley et al. (2001) clearly differentiated between stimuli that are related to species survival and such that are related to “higher evolved aesthetic or social sensibilities” (p. 280). Only the former, evolutionary salient stimuli are able to strongly activate the primitive motivational systems, whereas the latter are not. The finding that even art pictures depicting evolutionary salient content did not elicit significant changes in the SCR suggests that the organism is able to quickly distinguish between realistic cues and mere painted versions of them, separating personal relevance from irrelevance, respectively. Moreover, paintings may be evaluated differently simply because they are classified as *art*. In particular, various cognitive operations can be performed on an artwork, ranging from the analysis of its style, color, and content to matters of specific interpretations and evaluations (Augustin & Leder, 2006; Leder, et al., 2004). Perhaps, the level of cognitive engagement that follows the presentation of an artwork translates to a perception of arousal – a kind of ‘cognitive’ arousal as opposed to the physiological arousal that manifests itself in a heightened SCR.

In sum, these findings contradict the hypothesis of Ramachandran and Hirstein (1999) that the emotional impact of artworks may be reflected in autonomic changes in skin conductance similar to any other emotional stimuli. They rather fit the conceptualization of an aesthetic emotion and its distinction to utilitarian emotions as outlined by Scherer (2004). While utilitarian emotions may be characterized as being “high-intensity emergency situations, often involving a synchronization of many organismic subsystems” (p. 241), aesthetic emotions feature only low or moderate intensity and are associated with a lesser embodiment.

Facial expression. In general, unpleasant pictures are associated with greater corrugator activity and pleasant pictures with greater zygomaticus activity (Lang et al., 1998). Facial mimic activity due to emotional stimulation depends on the valence of the stimulus and may be regarded as an index of the motor expression component according to Scherer (2004).

Regarding the *corrugator* activity, we did not find any differences between the general art and the random stimuli. At first, this may appear surprising, since the random pictures were rated as less pleasant than the art pictures. However, it is possible that, besides being less pleasant, they were not truly *un*pleasant to the participants. Previous findings showed that the greatest differences in corrugator activity were between highly pleasant and highly aversive (e.g., dead bodies, wounds) picture contents, whereas only marginal differences were found between pleasant and neutral IAPS categories (Bradley et al., 2001).

The corrugator activity for unpleasant art pictures was comparable to the results for the unpleasant IAPS pictures, which both differed significantly from pleasant art and IAPS pictures, respectively. Artistic interpretations of war scenes, a beheading, or the arrangement of dead body limbs were just as potent in activating facial expressions of discomfort as detailed photographs displaying realistic close-ups of similar sceneries.

Regarding the *zygomaticus* activity, we could not find any modulations of the different picture types (art, IAPS) and categories on the EMG activity of the zygomaticus major. It did not vary as a function of the pleasantness of the pictures. That the zygomaticus muscle does not always show a uniform activity pattern in emotional states has been noted previously. In particular, there are findings that suggest that the specific semantic content of a picture is equally important as its valence. In the study by Bradley et al. (2001), the greatest changes in zygomaticus activity were obtained when viewing happy families, laughing babies, or food. Moreover, the presentation of erotic couples elicited even *less* zygomaticus activity compared to some neutral (e.g., household objects) and even some unpleasant pictures categories (e.g., scenes of contamination, attack). The authors of the study offered a possible explanation for the apparent semantic specificity. Human facial expressions show high individual variation and – unlike somatic or autonomic reflexes – are more responsive to deliberate modulations by the participant. One of the main functions of facial expressions is social communication, i.e. they are tactical responses that are most useful in the interaction with others in different social contexts. Thus, it may be that the zygomaticus activity is less specific to emotional states and therefore not the most valid indicator (Lang et al., 1993).

Startle response. The amplitude of an eye blink to a loud startle probe presented shortly after the onset of a picture varies systematically with the pleasantness of the picture (Lang et al., 1998). The startle response is part of the organism's defensive reflex cascade following an unexpected, potentially harmful stimulus or event. Depending on whether the appetitive or the defensive motivational system is activated, the startle response amplitude is either inhibited or potentiated. Moreover, the arousal of a picture serves as an amplification factor in such a way that reflexes during highly arousing pleasant pictures are stronger inhibited and reflexes during highly arousing unpleasant pictures are stronger potentiated than during pictures of similar valence but less intensity (Bradley et al., 2001; Cuthbert et al., 1996). This modulatory pattern of the blink response is highly stable and replicable for the IAPS pictures (Larson, Ruffalo, Nietert & Davidson, 2000).

For the art pictures, however, we found no valence modulation of the startle response. There was neither an inhibition during pleasant art pictures nor was there a potentiation while viewing unpleasant art pictures. This is remarkable as the pleasant and unpleasant art pictures were both of comparable content, and of similar valence and arousal ratings as the emotional IAPS pictures.

Similar to the SCR, it appears that the valence and arousal ratings are a necessary but not a sufficient precondition for the modulation of the blink reflex. Again, only stimuli that show realistic photographs of evolutionary relevant cues – as in opposition to mere painted illustrations of such – were able to trigger bodily changes. Considering that the activation of the appetitive and defensive motivational systems foremost serves the initiation of appropriate action tendencies to optimally prepare the organism for any event promoting survival, it may, of course, be uneconomical (and even dangerous) for the organism to overly and unspecifically react to events of no immanent threat.

Altogether, the findings of the startle response corresponds to Scherer's (2004) conceptualization of an aesthetic emotion as opposed to a utilitarian emotion. The behavioral impact and the organismic synchronization of physiological subsystems are both considered to be very high for the utilitarian emotions and only moderate for aesthetic emotions. In particular, utilitarian emotions are in the service of the behavioral adaptation and adjustment to situations involving important consequences for the organism's well being, whereas aesthetic emotions are supposed to be lacking direct and personal relevance (Scherer, 2004).

Event-related potentials. In general, the presentation of emotional IAPS pictures elicit a prolonged positive deflection, which is usually analyzed biphasically: the late positive potential (LPP) and a following positive slow wave (PSW) that is present for several seconds. Both have been associated with sustained motivational and attentional processes (Olofsson, et al., 2008; Schupp, et al., 2006). The presentation of a secondary startle probe shortly after picture onset elicits the probe P3, which is less positive in amplitude during high arousing emotional IAPS pictures compared to low arousing neutral pictures (Schupp, et al., 1997). Presumably, the amplitude of the probe P3 reflects the attentional resources that are available for the processing of a secondary startle probe. Similar to the SCR, the ERPs are dependent on the arousal rather than the valence of the stimulus.

In the present study, no difference in the LPP amplitude was found between the general art and random pictures, whereas the emotional art pictures elicited a marginally smaller LPP amplitude than the emotional IAPS pictures. The PSW was more positive for the general art compared to the random pictures, whereas the emotional art and IAPS pictures did not differ. Furthermore, the P3 amplitude was less positive during general art pictures than during random pictures, whereas there was no difference in the P3 between emotional art and IAPS pictures.

The ERPs apparently reflect an emotional quality of the stimulus regardless of features such as evolutionary significance and whether it is a realistic illustration or merely painted. Also the binding of attentional resources appears to be independent of the aesthetic or utilitarian nature of the emotional stimulus. Art pictures are therefore capable of evoking similar cortical responses as well-validated emotional photographs.

These findings correspond with Scherer's (2004) aesthetic emotion and also with the model of aesthetic appreciation and aesthetic judgments by Leder et al. (2004). Both emphasize the cognitive involvement in art appreciation. An aesthetic emotion features a high level of cognitive appraisals about the intrinsic quality of the artwork. Leder et al. (2004) further specified these cognitive operations as including mnemonic processes, analyses of style and content, as well as higher-order interpretative aspects. Utilitarian emotions on the other hand are primarily concerned with the relevance of bodily needs, goals, and coping strategies (i.e., transactional appraisals). These different kinds of cognitive considerations for both aesthetic and utilitarian emotions, however, may well engage equal amounts of cognitive resources and thus evoke similar event-related potentials.

Limitations. Before strong conclusions may be drawn, one limitation of the present study may be noted. Some may argue that the laboratory setting to study aesthetics might have been lacking ecological validity, as oftentimes in emotion research. Undoubtful, the original paintings unfold a different atmosphere when presented in a museum as opposed to the experimental presentation. They differ in size, material and structure, have a frame that may add impact, and are subject to curatorial staging. Moreover, the participants in our study viewed pre-selected pictures as opposed to museum visitors who freely chose which picture to look at. Thus, they might bring a different motivation to get involved in art compared to study subjects that 'simply' participate in a research project. In a recent study, Tschacher et al. (2011) have tried to avoid these limitations by assessing physiological correlates of aesthetic perception in a fine art exhibition. Electronic gloves were able to wirelessly monitor the locomotion, the heart rate, and the skin conductance of voluntary visitors. They found relationships between the heart rate and skin conductance variability during art perception and the subjective aesthetic-emotional experience, for example ratings on aesthetic quality. The SCR was neither associated with the art on display nor with any of the predictors of an aesthetic-emotional experience. In spite of its ecological validity, this study has limitations with respect to experimental control. For example, the sample was restricted to voluntary museum visitors, which raises the question of a self-selection of the participants. Moreover, there was no inclusion of adequate control stimuli, such as neutral non-art pictures or other emotional visual material to contrast the findings. Finally, the social impact of the situation – with the presence of other museum visitors – was not controlled either. These limitations were avoided in the present study.

Conclusion. Our findings speak in favor of a differentiated physiological processing of aesthetic and utilitarian stimuli. Pictures of artworks failed to evoke autonomic and somatic responses (SCR, startle response), whereas emotional IAPS pictures elicited significant changes in the respective physiological systems. In terms of the component process approach, the emotional processing of aesthetic stimuli involved less physiological arousal and less behavioral preparation tendencies compared to utilitarian stimuli. The SCR and the startle response have both been suspected to be indices of the activation of the appetitive and defensive motivational systems (Lang et al., 1992). Our and previous findings suggest that these systems are primarily activated by realistic, evolutionary salient stimuli (Bradley et al, 2001). Art and IAPS stimuli, however, did not differ with respect to the corrugator activity as well as the ERPs. Consequently, the emotional processing of aesthetic and utilitarian stimuli involved similar facial expressions and similar cognitive processes.

Altogether, these findings may validate the concept of an aesthetic emotion as outlined by Scherer (2004). Aesthetic emotions are delimited from utilitarian emotions by being of lesser intensity and organismic synchronization, having a lower behavioral impact, but featuring an equally high event focus as well as elaborated intrinsic appraisal processes. This may fit with Immanuel Kant's idea of aesthetic appreciation being 'disinterested pleasure' – an appreciation without obvious functionality or purpose (Kant, 1790). Our findings are further in accordance with theoretical considerations highlighting the cognitive involvement in affective art appreciation. Leder et al. (2004) described an aesthetic emotion to be dynamically affected by the outcomes of various cognitive analyses about the artwork.

In sum, our results may offer a first insight into the affective and cognitive perception of artworks. Additionally, our findings may help to empirically validate the theoretical concept of aesthetic emotions in contrast to utilitarian emotions (Scherer, 2004).

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Footnotes

[1] IAPS slides. *Neutral*: 5740, 7000, 7004, 7006, 7010, 7020, 7031, 7080, 7090, 7110, 7150, 7175, 7217, 7491, 7950. *Pleasant*: 4659, 4664, 4670, 4681, 4800 (erotic couples). 4180, 4210, 4232, 4290, 4300 (female nudes). 4470, 4490, 4520, 4531, 4550 (male nudes). 8030, 8080, 8185, 8370, 8490 (adventure/sports). *Unpleasant*: 3010, 3060, 3080, 3130, 3266 (mutilations). 3530, 6230, 6313, 6510, 6550 (human attack). 1050, 1120, 1300, 1301, 1931 (animal attack).

[2] General art pictures (artGen): Jan van Eyck, *The Arnolfini Portrait* (1434), Sandro Botticelli, *The Birth of Venus* (1486), Jan Vermeer, *Girl with a Pearl Earring* (1665), Jaques-Louis David, *The Death of Marat* (1793), William Turner, *Rain, Steam, and Speed* (1844), Édouard Manet, *A Bar at the Folies-Bergère* (1882), Vincent van Gogh, *Bedroom in Arles* (1888), Edvard Munch, *The Scream* (1893), Pablo Picasso, *Les Demoiselles d'Avignon* (1907), Gustav Klimt, *Adele Bloch-Bauer I* (1907), Wassily Kandinsky*, Improvisation 26* (1912), Ernst Ludwig Kirchner, *Berlin Street Scene* (1913), Salvador Dalí, *Dream Caused by the Flight of a Bee Around a Pomegranate a Second Before Awakening* (1944), Jackson Pollock, *No. 1* (1949), Andy Warhol, *Marilyn Monroe* (1962).

[3] Pleasant (artPos): School of Fontainebleau, *Gabrielle d'Estrées and One of Her Sisters* (1594), Gustave Courbet, *The Origin of the World* (1866), Egon Schiele, *seated female nude* (1914), and *seated male nude* (1910), Amedeo Modigliani, *Red Nude* (1917), Tamara De Lempicka, *La Belle Rafaela* (1927), Christian Schad, *Two Girls* (1928), Salvador Dalí, *Young Virgin Auto-Sodomized by the Horns of Her Own Chastity* (1954), Tom Wesselmann, *Great American Nude #92* (1967). Unpleasant (artNeg): Caravaggio, *Judith Beheading Holofernes* (1598/99), Peter Paul Rubens, *Head of Medusa* (1618), Théodore Géricault, *Severed Heads* (1818), and *Study of Severed Arms and Legs* (1818/19), Francisco Goya, *Saturn Devouring His Son* (1819-23), Otto Dix, (middle piece of the triptych) *The War* (1932), Francis Bacon, *1946* (1946).

[4] It may be noted that these findings are due to the fact that the SCR was not modulated by the art pictures at all. In particular, there was no detectable SCR for artPos and artNeg.

Figure Captions

Figure 1. Affective space spanning the dimensions valence and arousal for the selection of IAPS pictures (left) and art pictures (right) of the current study.

Figure 2. Standardized blink amplitudes (T values) for the IAPS picture categories (left) and for the general art (artGen) and random pictures (artPix; middle). The right figure shows the comparison of both emotional IAPS and art pictures. Standard errors are depicted as error bars.

Figure 3. Grand average waveforms of the LPP and PSW component locked to IAPS picture onset for Fz (top), Cz (mid), and Pz electrode (bottom).

Figure 4. Grand average waveforms of the LPP and PSW component locked to the onset of artGen and artPix for Fz (top), Cz (mid), and Pz electrode (bottom).

Figure 5. Grand average waveforms of the LPP and PSW component locked to the onset of emotional IAPS and art pictures for Fz (top), Cz (mid), and Pz electrode (bottom).

Figure 6. Grand average waveforms of the P3 component at Pz, locked to the startle probe onset for IAPS pictures (left), general art and random pictures (middle), and emotional IAPS and art pictures (right).

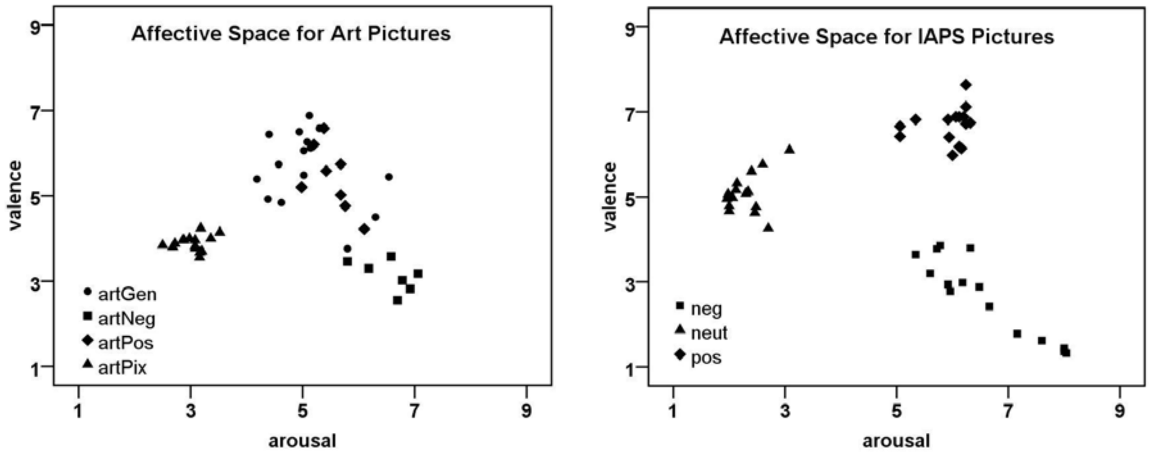

Affective Space for Art Pictures
valence
arousal
artGen
artNeg
artPos
artPix
1
3
5
7
9
Affective Space for IAPS Pictures
neg
neut
pos

Figure 1.

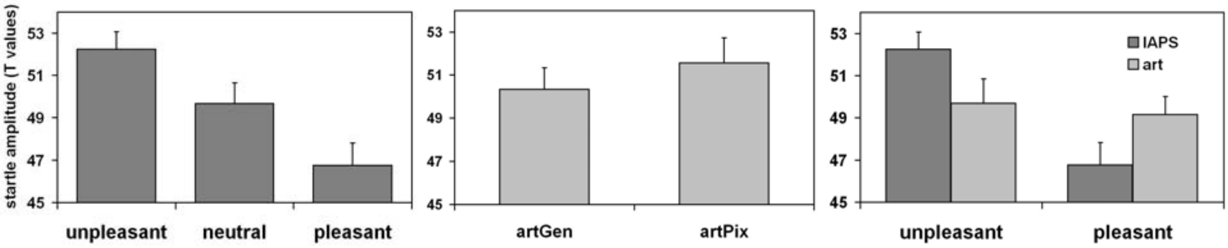
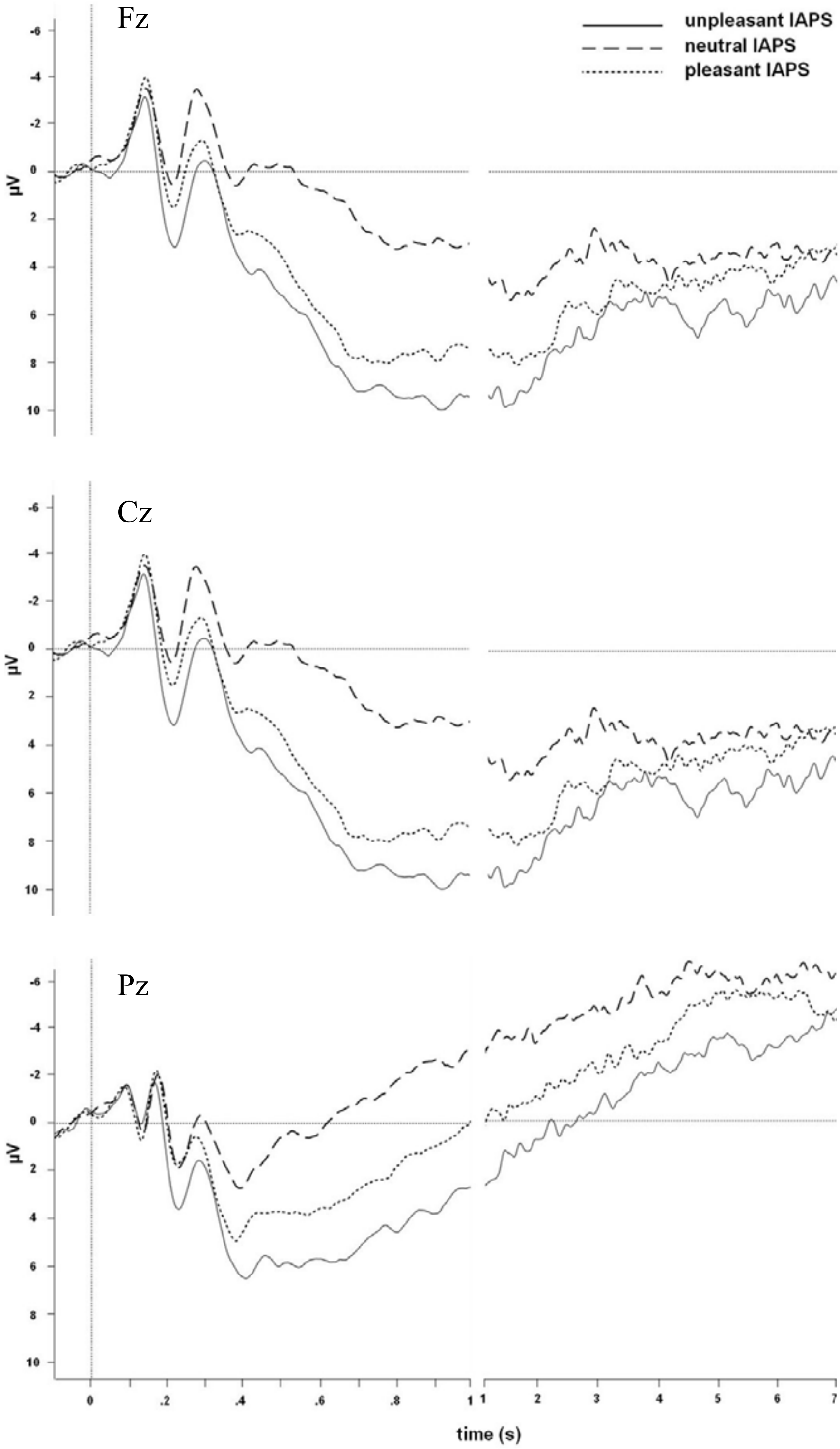

startle amplitude (T values)
53
51
49
47
45
unpleasant
neutral
pleasant
artGen
artPix
IAPS
art
unpleasant
pleasant

Figure 2.


Fz
unpleasant IAPS
neutral IAPS
pleasant IAPS
Cz
Pz
μV
-6
-4
-2
0
2
4
6
8
10
0
.2
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.8
1
1
2
3
4
5
6
7
time (s)

Figure 3.

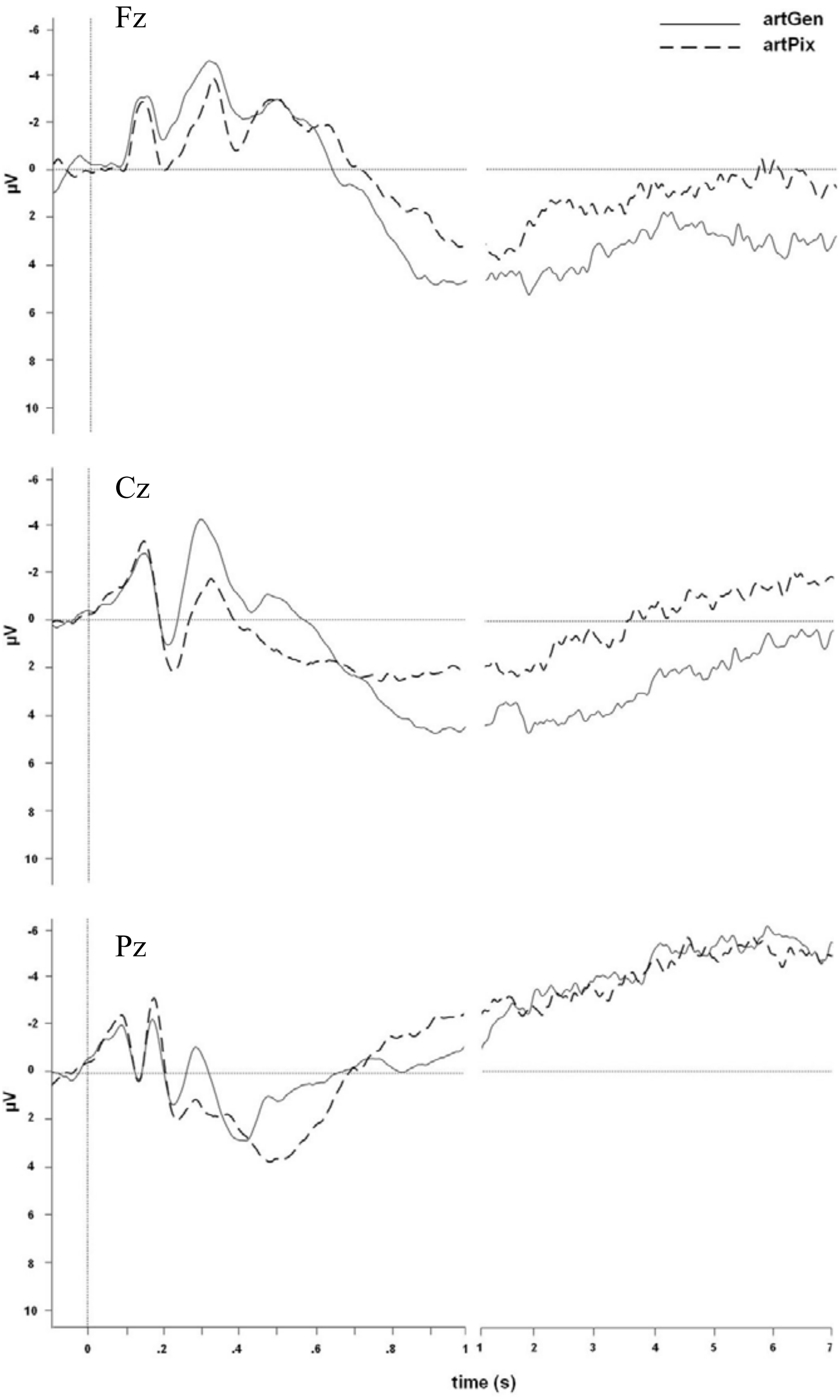


Figure 4.

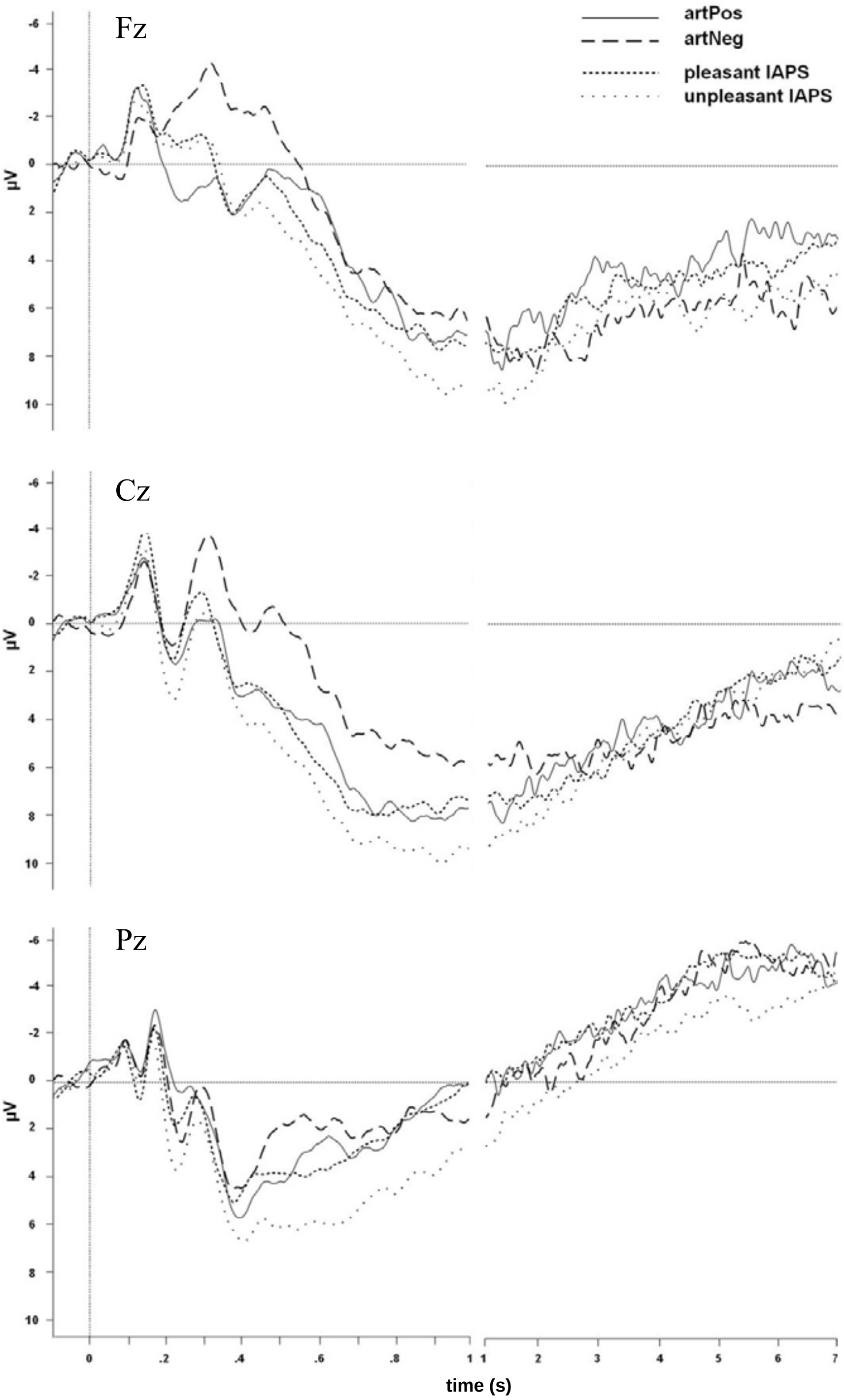
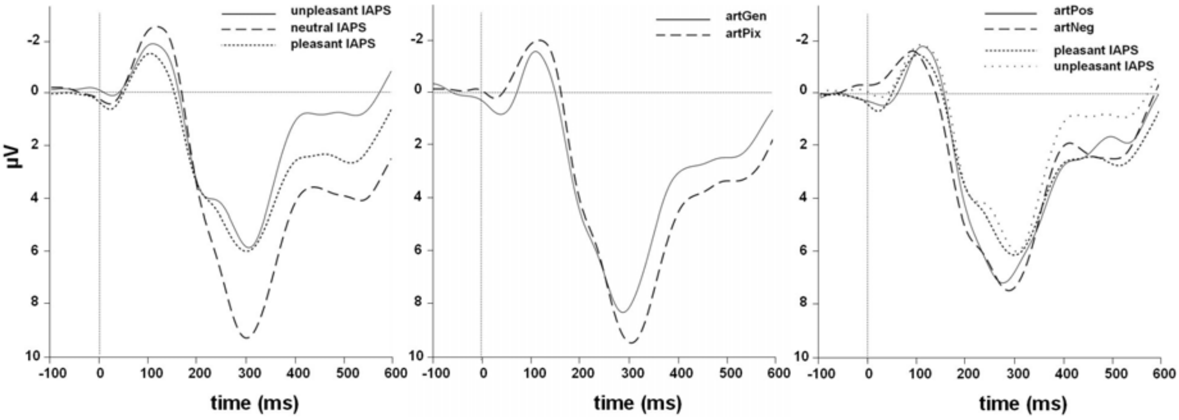

Fz
Cz
Pz
artPos
artNeg
pleasant IAPS
unpleasant IAPS
µV
-6
-4
-2
0
2
4
6
8
10
0
.2
.4
.6
.8
1
1
2
3
4
5
6
7
time (s)

Figure 5.

Pz



unpleasant IAPS
neutral IAPS
pleasant IAPS
artGen
artPix
artPos
artNeg
pleasant IAPS
unpleasant IAPS
µV
time (ms)
time (ms)
time (ms)

Figure 6.

Table 1

Mean reports of valence and arousal ratings, and physiological responses when viewing pleasant, neutral, and unpleasant IAPS pictures.

Dependent measure	Pleasant		Neutral		Unpleasant	
	M	*SD*	*M*	*SD*	*M*	*SD*
Valence ratings (1-9)	6.47	.87	5.08	.63	2.65	.85
Arousal ratings (1-9)	5.69	1.35	2.31	1.08	6.58	1.18
Skin Conductance Δ [log(μS+1)]	.011	.028	.002	.028	.012	.033
Corrugator EMG Δ (μV)	-.07	.81	.18	.92	1.21	2.14
Zygomaticus EMG Δ (μV)	.31	1.13	.19	.39	.03	.32
Blink amplitude (T score)	52.25	7.56	49.65	6.98	46.76	5.82
Late positive potential (μV)	3.14	3.14	-.10	2.62	4.59	3.59
Positive slow wave (μV)	2.42	3.85	.39	3.67	3.12	4.36
Probe P3 (μV)	2.52	2.62	4.77	2.82	2.98	2.04

Note. EMG = electromyographic. The amplitudes for the ERPs (LPP, PSW, P3) are averages across all electrode locations (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4)

Table 2

Mean reports of valence and arousal ratings, and physiological responses when viewing general art pictures (artGen), control pictures (artPix), pleasant (artPos) and unpleasant art pictures (artNeg).

Dependent measure	ArtGen		artPix		ArtPos		ArtNeg	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Valence ratings (1-9)	5.66	.86	3.88	1.24	5.41	1.00	3.13	1.24
Arousal ratings (1-9)	5.09	1.31	3.03	1.75	5.53	1.30	6.57	1.33
Skin Conductance Δ [log(μS+1)]	-.002	.032	.002	.032	-.006	.035	-.008	.042
Corrugator EMG Δ (μV)	.34	1.05	.49	1.63	.49	1.83	1.14	1.83
Zygomaticus EMG Δ (μV)	.20	.68	.24	.65	.22	1.39	.02	.78
Blink amplitude (T score)	50.34	7.05	51.64	8.12	49.15	6.03	49.69	8.20
Late positive potential (μV)	.10	4.13	.45	3.10	2.65	3.46	1.00	4.10
Positive slow wave (μV)	1.15	5.34	-.53	4.46	2.64	6.08	2.22	4.42
Probe P3 (μV)	3.58	2.70	5.00	3.35	3.07	3.01	3.04	4.05

Note. EMG = electromyographic. The amplitudes for the ERPs (LPP, PSW, P3) are averages across all electrode locations (F3, Fz, F4, C3, Cz, C4, P3, Pz, P4)

Erklärung

Erklärung gemäß § 8 Abs. 1 Buchst. b) der Promotionsordnung der Universität Heidelberg für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften

Ich erkläre, dass ich die vorgelegte Dissertation selbstständig angefertigt, nur die angegebenen Hilfsmittel benutzt und die Zitate gekennzeichnet habe.

Erklärung gemäß § 8 Abs. 1 Buchst. c) der Promotionsordnung der Universität Heidelberg für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften

Ich erkläre, dass ich die vorgelegte Dissertation in dieser oder einer anderen Form nicht anderweitig als Prüfungsarbeit verwendet oder einer anderen Fakultät als Dissertation vorgelegt habe.

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Datum, Unterschrift ______________________________________