

Running head: The perception and categorization of emotional stimuli

The perception and categorization of emotional stimuli: A review

Tobias Brosch^{1,2}, Gilles Pourtois^{1,3}, and David Sander^{1,2}

¹Swiss Centre for Affective Sciences, University of Geneva, Switzerland

²Department of Psychology, University of Geneva, Switzerland

³Department of Experimental Clinical and Health Psychology, Ghent University,
Belgium

Corresponding author:

Tobias Brosch

Swiss Centre for Affective Sciences

University of Geneva

7, Rue des Batoirs

1205 Geneva, Switzerland

tobias.brosch@unige.ch

Phone: +41 (0) 22 379 98 12

Fax: +41 (0) 22 379 98 44

Abstract

When we perceive our environment, we rapidly integrate large amounts of incoming stimulus information into categories which help to guide our understanding of the world. Some stimuli are more relevant for our well-being and survival than others, for example stimuli that signal a threat or an opportunity for growth and expansion. In this review we examine the special role of such “emotional” stimuli in perception and categorization. To this end, we first discuss some fundamental aspects of perception, with an emphasis on the cognitive process of categorization. We then tackle the questions “what is an emotional stimulus”, and “what is an emotion category”. Afterwards, we illustrate with a review of key findings from the empirical literature (a) how stimuli are categorized as emotional, and (b) how the perceptual processing of emotional stimuli is prioritized to allow for a rapid preparation of adaptive responses. To conclude, we discuss how research on the perception of emotional stimuli can contribute to current debates in psychology, namely (a) about the role of bottom-up vs. top-down factors in emotional processing and experience, and (b) about the nature of the relationship between cognition and emotion.

Introduction

In order to successfully move about in the world and respond to its permanent challenges, we have to rapidly make sense of our multifarious and fast-changing environment. To do so, we create an internal mental representation of the stimuli which are immediately present in our surroundings. Any given external object in the environment, the *distal stimulus* (e.g., a stone) is not processed as such, but is represented in the organism as a physical stimulation pattern on the senses, the *proximal stimulus* (e.g., the pattern of light on the retina reflected by the stone). Perception is the transformation of the proximal stimulus into a *percept*, the accessible, subjective, reportable experience that takes the form of an activation of a certain category in the mind (e.g., the accessible visual experience of the stone). How we perceive our environment is thus profoundly shaped by categorization. When we categorize a stimulus, we group certain objects or concepts as equivalent or analogous, thereby reducing the information complexity of the external world. At the same time, a lot of information about the stimulus is inferred due to its association with a category. The act of categorization is therefore critical to cognition (see Harnad, 2005) and allows us to give meaning to the world.

Sometimes we are confronted with classes of stimuli that have more direct relevance for our well-being and survival than others. For instance, some stimuli may signal danger or threat, such as predators or enemies, whereas other stimuli signal chances for growing and expansion, such as potential mates or food sources. Such stimuli require rapid adaptive responses, such as evading the threat or approaching the positive stimulus. One might expect that, given the high importance of such “emotional” stimuli for the organism, the perceptual processing of these stimuli should be prioritized to allow for a rapid appraisal of the situation and consequently

the rapid preparation of an appropriate behavioral response. In line with this, many everyday examples suggest that the perception of emotional stimuli is somewhat special, or heightened, relative to non-emotional stimuli. Smiling people, cute babies, erotic scenes, but also poisonous snakes or scenes of war and mutilations seem to catch one's eye more easily than emotionally "neutral" stimuli. Moreover, as the process of categorization is crucial for the organization of perception, one may furthermore expect that extremely relevant stimuli are categorized into special emotion categories which may differ in some respects from other categories. In line with this, a lot of empirical evidence illustrates how people make use of such special categories to guide their perception of the environment. For example, it has been shown that people are able to rapidly and accurately classify emotional expressions into emotional categories, even when the sender has a cultural background different from their own.

In this paper, we will examine the special role of emotional stimuli in perception and categorization. We will first discuss some fundamental aspects of perception in general, with an emphasis on the central cognitive process of categorization. By introducing general principles of perception and categorization, we will be able to investigate if similar principles apply to the perception and categorization of emotional and neutral stimuli, or if different mechanisms may be involved. We will then tackle the question "what is an emotional stimulus", taking into account various definitions from different theories of emotion, and review different suggestions of how the emotional categories we use to classify and label highly relevant stimuli are determined, learned, and eventually used to guide our perception. Afterwards, we will illustrate the preferential perception of emotional stimuli by reviewing some of the key findings from the empirical literature. We will

address two main lines of research, (a) research focusing on *qualitative* effects of emotional stimuli, i.e. research addressing the question of how people are able to categorize different stimuli into emotional categories, and (b) research focusing on *quantitative* effects of emotional stimuli, i.e. research addressing the question of how the emotionality of a stimulus can modulate and sometimes even transform perception, independent of whether people are asked to (consciously) categorize them. We will conclude with some reflections on how research on the perception of emotional stimuli can contribute to some current debates in psychology, namely (a) about the role of bottom-up vs. top-down factors in emotional processing and experience, and (b) about the nature of the relationship between cognition and emotion.

A review on a topic as large as “perception and categorization of emotional stimuli” necessarily has to be selective. For example, we will restrict ourselves to research using relatively simple stimuli, such as emotional words, pictures of emotional scenes, or emotional expressions conveyed by face, body, or voice. We will not survey more complex emotional behaviors, behavior descriptions or emotional events and their effect on people’s inferences of emotions, traits, competences, or status and power characteristics. There is a large literature in social and clinical psychology on these topics (see, e.g., Augoustinos, Walker, & Donaghue, 2006, for a review). Furthermore, perception does not always involve a conscious subjective experience and we do not intend to reduce categorization to conscious experience. Research on “unconscious perception” shows that under certain conditions such as degraded stimulus input or lapse of attention or awareness, stimuli can nonetheless be categorized to some extent, be partly processed and eventually have an impact on behavior without being consciously experienced (Merikle & Daneman, 1998;

Winkielman, Berridge, & Wilbarger, 2005; Zajonc, 1980). Here, however, we focus on the perception of emotional stimuli, when the categorized percept of these stimuli presumably enters awareness.

Perception as a fundamental categorization process

What is categorization?

How do we perceive and categorize objects? Which fundamental psychological mechanisms underlie this ability? These questions have been central to psychology for many decades (see Cohen & Lefebvre, 2005; Palmeri & Gauthier, 2004, for reviews). In fact, perception and object recognition sometimes are considered the crucial issues that research on human cognition has to explain (Kourtzi & DiCarlo, 2006), as a deeper insight into these processes will also substantially further the understanding of downstream higher-order cognitive processes such as memory, language, or consciousness. Many scholars have stressed that perception profoundly depends on the process of top-down categorization (Barrett, 2006b; Davidoff, 2001; Palmeri & Gauthier, 2004; Rosch, 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). How we perceive our environment is thus shaped by categorization processes which guide and constrain the organization of incoming stimulus information and thus make a conscious representation and identification of this information possible. This principle is supposed to hold for all kinds of categories, no matter whether the perceived content is color, certain objects, faces, facial expressions of emotion, emotional feeling or any other attribute (Barrett, 2006b; Cohen & Lefebvre, 2005; Davidoff, 2001).

During categorization, a continuously changing stimulus is identified against discrete and pre-existing categories or conceptual boundaries. This can be

experienced, for example, when we are watching a rainbow. Even though a rainbow is composed of a continuous range of varying wavelengths, we perceive chunks of colors rather than a gradual continuum of changing colors. Due to the influence of top-down information about color categories, the linear physical changes of the distal and proximal stimuli have nonlinear effects on the percept.

Categorization allows to structure stimuli by grouping or classifying them according to certain principles, such as perceptual similarities (Rosch, 1978), semantic rules or theories (Murphy & Medin, 1985), implications for goal states (Barsalou, 1983) or evoked emotional responses (Niedenthal, Halberstadt, & Innes-Ker, 1999). By categorizing a stimulus we give meaning to it, as categorization allows to make inferences, analogies, and predictions about a stimulus and to communicate about the stimulus with people who share our concepts (Niedenthal et al., 1999).

Object categorization occurs very rapidly (Thorpe, Fize, & Marlot, 1996). An efficient categorization process allows us to constrain, guide and summarize the processing of stimuli encountered in the environment with minimal cognitive effort. When a stimulus is categorized, a large amount of relevant information related to the category is activated and made available, whereas irrelevant distinctions within categories are omitted for the sake of cognitive economy (McClelland & Rumelhart, 1985; Rosch, 1978; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976).

Ultimately, categorization operates as a strong filter which drastically reduces the information content available in the external world by grouping certain objects as equivalent. Categorization furthermore facilitates rapid object discrimination. It is easier to discriminate two colors of different shades when they cross color category boundaries than when they are within the same category, even though the differences in wavelength are identical for the two pairs (Bornstein & Korda, 1984). Similar

results have been obtained e.g. for the differentiation of speech phonemes (Liberman, Harris, Hoffman, & Griffith, 1957) and the discrimination of familiar faces (Beale & Keil, 1995). This effect, basically enhancing perceived between-category differences and reducing perceived within-category differences, was coined the *categorical perception effect* (Harnad, 1987).

How are categories determined?

How exactly categories and their boundaries are determined is a matter of debate. Even for a rather simple domain such as color categories, the theoretical positions that have been advanced span all the space between *universalistic* (categories are determined by perceptual factors based on the properties of color-coding neurons; Berlin & Kay, 1969) and *relativistic* views (categories are arbitrarily set based on language and cultural conventions about concepts of color; Whorf, 1956). Strong support for the universalistic view came from evidence showing that the Dani, a remote branch of a hunter-gatherer tribe, showed the same cognitive organization of color as speakers of English, even though they only used two basic terms for the whole range of visible colors (Rosch Heider, 1972). This was interpreted as showing that a certain categorical organization of colors may be found universally in humans and may be predetermined genetically. On the other hand, results showing that the possession of certain linguistic color terms influences the organization of categories suggested that it is mostly language and semantic concepts which shape the organization of incoming stimulus information (Roberson, Davies, & Davidoff, 2000). In this view, the placement of the boundaries between categories is not considered to be based on preexisting universals, but rather on conventions within a cultural group.

As will be outlined in the next section, a similar debate exists for emotional categories (see also Boster, 2005). Theoretical suggestions on how emotional

categories are defined go from the universalistic perspective that there are biologically based universal emotion categories, the “basic emotions¹” (Ekman, 1992; Izard, 2007; Panksepp, 1998), to the notion that multicomponent patterns of emotional responses that occur with a relatively high frequency are categorized into “modal emotions” (Scherer, 1994b), and finally to the constructivist perspective that emotional experience is based on the categorization of a raw affective quality into emotional categories which are considered to be man-made concepts (Barrett, 2006a).

Emotional categories

What is an emotional stimulus?

When comparing the role of emotional and non-emotional stimuli in perception, an important issue that needs to be tackled is the definition of “emotional stimulus”: Why is a stimulus perceived or categorized as “emotional” at all? One way to address this question is to find a definition based on functional considerations. Following this line, one can begin by asking why “emotional stimuli” – which constitute a group of rather heterogeneous stimuli – should be categorized together and treated in a preferential manner by the organism. To this end, we will briefly review how different influential psychological theories of emotion provide important clues to what actually renders a stimulus emotional. One should keep in mind that, generally, theories of emotion are concerned with the elicitation of emotional responses (see also Moors, 2009), but less with the definition of “emotional stimulus” or the processes involved in the perception of such stimuli. However, these issues are

¹ In this context, one finds frequent analogies between perceptual and emotional categories. For example, according to Izard (2007), “it is possible to argue by analogy that the capacity to discriminate among basic-emotion feeling states, like discriminating among basic tastes, is innate and invariant across the lifespan” and “the data relating to the underlying neural and behavioral processes suggest that the emergence of discriminable basic emotion feelings is analogous to that for basic tastes” (see Sander, 2008).

highly intertwined, as very often, the perception of a stimulus as “emotional” will subsequently elicit an emotional response. Thus, it should be possible to draw some conclusions about the conditions under which a stimulus is perceived as “emotional” (and another one is not) based on the different theoretical approaches. In addition to the distinction between emotional and non-emotional stimuli, different theoretical views furthermore allow to gain insight on the actual cognitive processes involved in the perception and categorization of emotional stimuli. In reviewing the different theoretical approaches, we will first outline the main points of agreement and disagreement between the theories. Afterwards, we will discuss some of the issues about which the different approaches disagree in the light of the empirical evidence on the perception and categorization of emotional stimuli.

Most emotion theories agree that emotional stimuli represent a special type of stimulus as they possess high relevance for the survival and well-being of the observer. For instance, some stimuli may signal threats, such as predators or enemies, whereas other stimuli signal chances for growing and expansion, such as potential mates or food sources. Such stimuli require rapid responses, like evading the threat or approaching the positive stimulus. Emotional responses are adaptive responses to an eliciting stimulus, including action tendencies, bodily responses, behavioral responses and a change in subjective feeling. They prepare the organism for action, while allowing for some flexibility in terms of the response, as an emotional stimulus is not associated reflex-like with a specific response, but an emotion primes an arsenal of potential adaptive responses (Frijda, 2007; Scherer, 1994a). In the context of adaptive responding, it appears furthermore functional to assume that the perceptual processing

of emotional stimuli is prioritized to allow for a more rapid computation and situation analysis.

Whereas most theories of emotion agree that emotions serve to organize adaptive responses to stimuli that are important for the survival and well-being of the organism, different theories disagree with regards to the mechanisms underlying this adaptive function.

Basic emotion theories assume a number of distinct basic emotions, including, e.g., anger, fear, sadness, happiness, disgust or surprise. In this tradition, the term “basic” is used to express three postulates (Ekman, 1992): First, it conveys the notion that “there are a number of separate emotions which differ from one another in important ways”, second, it indicates that “evolution played an important role in shaping both the unique and the common features which these emotions display as well as their current function”, finally, the term refers to the notion that the existence of nonbasic emotions can be explained by combinations of the basic emotions. Basic emotions are defined as affect programs that are triggered by appropriate eliciting events to produce emotion-specific response patterns such as prototypical facial expressions and physiological reactions (Ekman, 1992), driven by specific neural response systems (Panksepp, 1998). According to basic emotion theories, perceptual processing of emotional stimuli is assumed to be essentially organized in a categorical manner, with innate categories being universally found in humans. Some theorists suggest a special role for the basic emotion of fear (Öhman & Mineka, 2001). Due to evolutionary reasons, fear/threat-related stimuli such as angry facial expressions, snakes or spiders are thought to be attended to, perceived, recognized, remembered and associated with adaptive behavioral output faster or more readily than any other emotional stimulus.

Appraisal theories of emotion suggest that that emotional processes are elicited as the individual continuously appraises objects, behaviors, events and situations with respect to their relevance for his/her needs, goals, values, and general well-being (Ellsworth & Scherer, 2003). Emotions are elicited and differentiated on the basis of the subjective evaluation of a stimulus or event on a set of standard criteria or objectives such as novelty, intrinsic pleasantness, goal conduciveness, and normative significance, as well as the coping potential of the organism. Appraisal is subjective and thus a function of the individual and the specific situation/context, therefore allowing for differences between, e.g., species, age groups, personal dispositions, and cultural contexts. The outcome of the appraisals of these different criteria is predicted to directly drive response patterning of physiological reactions, motor expression, and action preparation (Scherer, 2001). With regards to emotion categories, it has been suggested that the subjective experience of the response patterning (“qualia”) is categorized into “modal emotions” (Scherer, 1994b), reflecting the relatively frequent occurrence of some patterns of responses which are associated with core concerns or core relational themes (Smith & Kirby, in press; Smith & Lazarus, 1990).

Dimensional theories of emotion emphasize the role of a few key dimensions, usually valence and arousal, in the organization and categorization of emotional stimuli. The dimensional approach allows distinguishing between negative and positive emotions of different intensities, which reflects two basic motivational systems, the appetitive and the aversive systems that underlie approach and withdrawal behavior, respectively (Davidson & Irwin, 1999; Lang, 1995; Schneirla, 1959). According to Russell (2003), *core affect*, the primary, consciously accessible internal emotional state, consists exclusively of an integral blend of valence and

arousal. The affective quality of a stimulus is the capacity of this stimulus to change core affect.

Constructivist theories of emotion emphasize the role of culture, language, and high-level cognition in the emergence of emotional experience. Barrett (2006a, 2006b) recently adapted Schachter's theory of emotion (see also Moors, 2009) to propose a *conceptual act approach* based on the core affect notion put forward by Russell (2003). According to this view, emotion categories are not natural entities, but man-made concepts. The experience of emotions is based on a process which categorizes a readout of core affect into language-based emotion categories. According to this relativistic view, language provides conceptual categories, which in turn constrain the process that attributes meaning to stimuli, including emotional ones, and thus biases perception. Thus, the perception of a stimulus as emotional should depend heavily on the language context of the observer (Barrett, Lindquist, & Gendron, 2007).

To summarize, different theories of emotion differ in the way they conceptualize how stimuli are categorized as emotional. Basic emotion theories claim that certain classes of stimuli trigger predefined affect programs which then elicit specific response patterns. In contrast to this rather inflexible mechanism which is mainly based on a schema evaluation or a pattern-matching process between a stimulus and a template, appraisal theories emphasize the importance of the subjective evaluation of the stimulus according to its importance for the individual. This allows for a greater amount of flexibility and individual adjustment of person, situation and what is perceived as emotional. Dimensional theories propose a very general, economical mechanism linking stimulus processing to an evaluation that basically distinguishes between positive and negative stimuli and between stimuli leading to

different degrees of activation. Finally, constructivist theories emphasize the constraining role of language context on the mapping of these dimensions into emotion categories. Thus, different theories of emotion differ with regards to how much emphasis they put on bottom-up mechanisms and top-down mechanisms determining what makes a stimulus emotional, how it is categorized and how it is perceived, with basic emotion theories arguing that it is mainly (but not always) stimulus driven bottom-up processes, appraisal theories suggesting a more flexible and dynamic mechanism taking into account the interaction of stimulus and the needs and goals of the observer, and constructivist theories mainly focusing on the constraining top-down effects of mental representations and language knowledge.

How are emotion categories determined?

Whereas the previous section mainly focused on theoretical issues regarding the distinction between emotional and non-emotional stimuli, now we will address the related question of how our internal emotional categories, i.e. the categories we use to classify and label emotions and emotionally relevant stimuli, are determined, and to which extent these categories may be similar to or different from non-emotional categories.

Across many languages we find a large variety of categories that we use to describe our emotional experiences (e.g., “fear”) or the elicitors of such experiences (e.g., “threats”). According to basic emotion theories, the basic emotions constitute innate categories which are shaped by evolutionary pressures. However, as will be outlined in more detail in a later section of this paper, there are several lines of argumentation that go against the notion of universal or innate emotional categories.

If emotion categories like “fear” or “anger” are not innate, they may be learned, just like other categories such as “birds” or “furniture”. In this context, it has

been argued that the boundaries of emotion categories are not well-defined², but that membership in an emotion category is based on the extent of resemblance to a prototype (prototype theory of emotion, Russell & Fehr, 1987). States elicited by a certain event or stimulus are perceived to be instances of fear, anger, or happiness to the extent that they resemble certain ideal cases. Category membership thus is a matter of degree rather than all-or-nothing (*internal structure*), and no sharp boundaries separate category members from nonmembers (*fuzzy boundaries*). Based on early theoretical work by Rosch and colleagues (1976), emotion categories (and the category “emotion”) have been suggested to be hierarchically organized, with positive and negative emotions as superordinate categories, categories such as anger, fear, or happiness at the basic level, and subordinate categories such as wrath, rage, fury, annoyance (Russell & Fehr, 1987; Shaver, Schwartz, Kirson, & O’Connor, 1987).

Many prototype categories we use in daily life are created based on the correlational structure of properties that observers perceive in the world. Properties of objects do not occur randomly, but some combinations tend to co-occur frequently (such as “feathers” and “wings”), whereas some other combinations rarely occur together (such as “fur” and “wings”). Although atypical cases do exist, in general different stimuli sharing some common properties can be put into discrete categories (e.g., “birds”) to simplify the organization of the environment (Rosch, 1978; Rosch et al., 1976). Similar processes might be involved in the development of emotion categories, concepts, schemas, or scripts. An event that interrupts goal attainment might frequently be paired with a subjective experience of frustration and arousal, behavioral attempts at overcoming the blockage, and typical facial and vocal

² In well-defined categories, category membership can be defined by one or more individually necessary and jointly sufficient features, as is the case for example for “square” or “grandfather”.

expression patterns (Hess, Philippot, & Blairy, 1998), all of which might then be integrated into a semantic network representing the *anger* concept which guides the categorization of emotional expressions (Russell, 1991).

In addition to categories based on the correlational structure of the environment, other categorical grouping mechanisms have been proposed. For example, it has been suggested that facial expressions of emotion are examples of *goal-derived categories*, optimized to reach the goal of emotion communication, rather than *taxonomic categories* which help to economically describe the environment (Barsalou, 1985; Horstmann, 2002). When participants were asked to choose typical examples of facial emotion expressions out of several exemplars with different expression intensities, they chose the most extreme version (Horstmann, 2002). Thus, the facial expressions of emotion that are perceived as “most typical” are not the ones that are encountered frequently, but the ones that are most suitable to communicate a certain emotion (see also Smith, Cottrell, Gosselin, & Schyns, 2005). This suggests that the basic emotion categories may have been created to maximize communicative goal attainment.

Furthermore, the psychological concept of *core relational themes* (Smith & Kirby, in press; Smith & Lazarus, 1990) is of particular interest with respect to its categorical function. Core relational themes are categorical conceptualizations of emotion-eliciting appraisals. Each core relational theme is specific to a given emotion and refers to a combination of a set of appraisal outputs (e.g., high importance, high undesirability and other-accountability define the core relational theme of "other-blame", which may elicit “anger”). Therefore, each core relational theme may be seen as a functional category that has the potential to elicit a specific emotion.

The subjective emotional feeling elicited by a stimulus may be a further central feature in determining category membership. Stimuli that evoke the same emotional response may thus be grouped together and treated as equivalent things, even when they are perceptually, functionally and theoretically different. When participants had to categorize triads of concepts that shared both emotional and non-emotional relations (e.g., *joke*, *speech*, and *sunbeam*), participants for whom affective information was made salient by experiencing a positive or negative mood used emotional response categories (i.e. grouped together *joke* and *sunbeam*), whereas participants in a neutral mood grouped the concepts into non-emotional categories (*joke* and *speech*), indicating that the evoked subjective emotional feeling can be a category-defining property (Niedenthal et al., 1999).

To sum up, empirical evidence and theoretical considerations indicate that emotion categories are not principally determined universally or biologically, but are learned and continuously adjusted in a flexible way. Grouping of different stimuli into an emotional category can be based on a number of different principles, reflecting the correlational structure of the environment, the optimization of communicative goal attainment, the combination of a set of appraisal outputs, or the subjective emotional feeling elicited by a stimulus. Emotion categories thus can be considered as adaptive and flexible emotion scripts, integrating aspects of emotion elicitation (appraisal, core relational themes) and of the emotional response toward the emotional stimulus (bodily responses, motor responses, action tendencies, and subjective feeling). Some aspects of these may be relatively hard-wired (e.g., a simple response like a startle reflex), others mainly determined by culture (e.g., a more complex appraisal of norm compatibility). Together, the integrated emotion category then may guide the

perception and categorization of emotional stimuli, as will be outlined in the remainder of this paper.

Empirical studies on the perception and categorization of emotional stimuli

The theoretical considerations reviewed in the first part of this paper point to important questions that can be addressed in empirical research on how people actually perceive emotional stimuli. For example, as discussed above, a crucial prediction of basic emotion theories is the universal and presumably innate organization of fixed emotion categories, whereas other theories emphasize the flexibility, malleability, versatility, and context-dependency of emotional processing. Thus, in the next section, we will discuss what empirical research on the perception of emotional stimuli can contribute to the question of the relative contribution of bottom-up and top-down factors in emotional processing. Furthermore, we will evaluate empirical results showing how perception actually profits from having some stimuli tagged as emotional and others not, and we will discuss how such studies can help to answer the question of what actually defines an emotional stimulus, essentially by taking into consideration what kind of emotional stimuli are prioritized in perception. To shed some light on these questions, we will discuss primarily two broad lines of research, (a) research focusing on *qualitative* effects of emotional stimuli, addressing the question of how people categorize different stimuli into emotional categories, and (b) research focusing on *quantitative* effects of emotional stimuli, referring to how the emotionality of a stimulus may modulate and transform perception.

Qualitative effects of emotion on perception: The categorization of stimuli as emotional

Is there universality in emotional categorization?

A central tenet of basic emotion theories is the assumption that emotional stimuli, especially facial emotional expressions, are universally perceived in a categorical manner. In two very influential lines of research, Ekman (1972, 1992, Ekman & Friesen, 1975) and Izard (1971) have investigated the universality of the recognition of emotional facial expressions. In their studies, they asked participants to categorize facial displays of emotion into several basic emotion categories. For example, participants were shown a photograph of a person expressing prototypical facial configuration of fear, and then were given a number of response alternatives such as “fear”, “happiness”, “anger” or “disgust” to choose from. Alternatively, they were asked to freely describe the emotion they recognized in the picture without being given labels. Ekman and Izard both found that their participants were able to correctly categorize the facial expressions into a number of basic emotions. This was the case even when the receiver (the participant asked to categorize the expression) was from a different culture than the sender (the person posing for the photograph) and was in fact never exposed to the sender’s culture. These results have been confirmed in a more recent meta-analysis showing that facial expressions of emotion are correctly categorized across cultures with an accuracy of 58% (Elfenbein & Ambady, 2002). Similar results have been reported for the categorization of vocal emotional expressions. Another meta-analysis (Juslin & Laukka, 2003) showed that vocalizations of emotions are correctly categorized across cultures with largely above chance accuracy. Other studies have furthermore demonstrated above-chance categorization of bodily expressions of emotion (Atkinson, Dittrich, Gemmell, & Young, 2004; de Gelder, 2006). High intraindividual correlations have been observed for correct identification of different emotional signals in facial, prosodic and lexical channels. People who excel at correctly categorizing facial expressions of emotion

perform similarly high using other channels, leading to the suggestion that an amodal system might be involved in perceptual identification of various emotional expressions in different communication channels (Borod et al., 2000).

People are not only able to label emotional expressions with categories, but the actual percept of emotional expression seems to be influenced by category boundaries. Just like top-down category information transforms the gradually changing continuum of wavelengths in a rainbow into the perception of chunks of different colors (categorical perception effect, Harnad, 1987), instances of emotional facial expressions that are morphed into each other along a continuum between two emotions (e.g., from happiness to fear), are perceived as belonging to discrete categories (either happiness or fear). Moreover, pairs of emotional faces that differ from each other by a given physical amount on such a continuum can be discriminated more accurately when the pairs belong to two different emotion categories than when they belong to the same category (Calder, Young, Perrett, Etcoff, & Rowland, 1996; Etcoff & Magee, 1992; Young et al., 1997). Similar evidence has been provided for a categorical perception of vocal emotion expression (Laukka, 2005). These effects illustrate that, even though the participants' task is not to assign the faces or voices to emotional categories, the incoming information on facial and vocal emotion expression seems to be automatically transformed into categories. Furthermore, these results allow some conclusions about the actual *percept* of the perceived stimuli, namely that there is a qualitative difference in how similar expressions actually appear to a perceiver depending on whether or not they belong to the same emotional category: two facial expressions that differ by an exact physical amount on a continuum between two expressions appear more distinct from each

other when they cross a category boundary, but more similar when they do not cross such a boundary.

Results on the categorization of emotional expression have provoked a great amount of debate (see e.g., Ekman, 1994; Izard, 1994; Russell, 1994, 1995). Main criticisms stemmed from some methodological aspects of the conducted research. For example, the caricatural nature of facial expression stimuli used in the research was questioned, which mainly showed extreme versions of facial expression which are rarely observed in daily life (Carroll & Russell, 1997). Furthermore, people make more errors when they are not given forced-choice response alternatives, but have to respond freely. This suggests that available language based emotion categories drive the answer in a top-down manner. A third point of criticism concerns the fact that, even though there is still above-chance accuracy when sender and receiver come from different cultures, accuracy is reliably higher when both come from the same culture (Elfenbein & Ambady, 2002; Juslin & Laukka, 2003), suggesting that emotional categories are to some extent shaped by cultural factors and language-based representations.

Thus, consistent with the predictions of basic emotion theories, it has been shown that humans are able to categorize prototypical facial, vocal and bodily expressions of emotion into discrete emotion categories with above chance accuracy. However, consistent with theoretical approaches emphasizing the role of culture and language based top-down factors, cultural knowledge has been shown to further improve performance on categorization tasks, leading to the conclusion that emotional categories are no innate universals, but (at least to some extent) shaped by top-down cultural factors.

The role of context and top-down effects in emotional categorization

Alternative approaches to facial expression and its recognition have been developed based on dimensional theories of emotion, predicting that facial expressions are not categorized directly into specific basic categories, but convey values of valence and arousal, which are subsequently used to attribute an emotion to the face (Russell, 1997), and on appraisal theories of emotion, emphasizing the link between appraisal outcomes and facial expression patterns (e.g., Scherer, 1992). According to the latter view, the facial expression of a given emotion expresses a differential sequential and cumulative response pattern based on a series of appraisal outcomes. Decoders should thus be able to recognize a facial expression of emotion from the outcomes of the pattern of cognitive appraisals that have produced the emotion. Sander et al. (2007) tested the hypothesis that operations involved in orienting the focus of attention (e.g., gaze direction) and operations concerned with evaluation of events would interact in the decoding of facial emotions. They found that the perceived specificity and intensity of fear and anger depend on gaze direction (direct gaze for anger and averted gaze for fear; see also Adams & Kleck, 2003; Sander, Grafman, & Zalla, 2003). Using a judgment paradigm, Scherer and Grandjean (2008) had people assign pictures of facial expressions of emotions to underlying patterns of appraisal (“something unexpected has happened”, “I am in a dangerous situation and I don’t know how to get out of it”) and to basic emotion labels (“surprise”, “fear”) and demonstrated similarly high success rates both for the appraisal criteria categories and the basic emotion categories.

Constructivist theories of emotion, appraisal theories and, to a lesser extent, also dimensional theories underline the importance of context in determining why and how a stimulus is perceived as emotional. Confirming the important role of context, it

has been shown that the same facial expression can be interpreted as showing different emotional states (e.g., fear or anger, surprise or happiness) – and thus classified into different emotion categories – depending on the situational context that has been given to the observer (Carroll & Russell, 1996; Kim, Somerville, Johnstone, Alexander, & Whalen, 2003; Kim et al., 2004; Russell & Fehr, 1987; Wallbott & Ricci-Bitti, 1993). For example, if a participant is shown a prototypical expression of anger, together with the information that this person has just been in a frightening situation, the face will be categorized as fearful. Contextual information influences perception already at very early perceptual levels. When subjects judged a facial expression of disgust presented in an anger context, they did not only drop substantially in their categorization accuracy (from 87% to 13% compared to a disgust context), but their early eye movements followed the visual scan path usually elicited by facial expressions of anger (Aviezer et al., 2008). Furthermore, perceptual memory encoding has been shown to be influenced by conceptual knowledge: When participants viewed ambiguous facial stimuli (morphed faces depicting a blend of two emotion categories) while category knowledge about one of the emotions was made more accessible, participants later remembered the face stimuli in line with the conceptual knowledge that was active during encoding (Halberstadt & Niedenthal, 2001). These results highlight the role of contextual information in the perceptual categorization of emotional stimuli.

To summarize, research has shown that when people are asked to classify expressions of emotion, they are able to do so with high accuracy. Similarly good performance is observed whether the classification is based on basic emotion categories (Elfenbein & Ambady, 2002), a dimensional system (Bradley & Lang, 1994; Russell & Fehr, 1987), or appraisal criteria (Scherer & Grandjean, 2008). Thus,

even though results from categorization or classification tasks are frequently taken as main evidence supporting basic emotion theory, they seem not to be unequivocally in favor of any theoretical approach, but rather compatible with several of them.

However, what can be concluded from the empirical results reviewed here is that contextual top-down effects are extremely important for the categorization of a stimulus as emotional. Contextual or cultural information strongly influence the outcome of categorization. Contextual effects do not just modulate late, high-level interpretation processes, but impact at the most basic levels of visual processing. It is nevertheless possible that there is some innate or universal core that plays a role in the definition of the extension of emotion categories. For example, with regards to facial expressions of emotion there may be aspects that are conserved genetically due to their high adaptive functionality. It has been demonstrated that when subjects show facial expressions of fear, they have a larger visual field, allowing for a more efficient scanning of the environment for threats, whereas when they pose expressions of disgust, nasal volume and air velocity during inspiration are reduced, lowering the intake of potentially repulsive substances (Susskind et al., 2008). Such features may be universal parts of the definition of the extension of emotion categories, and one can speculate that they may contribute to the above-chance performance in categorization tasks that is not due to methodological artifacts and cultural facilitation. However, emotional categories and emotional categorization are also to a large extent shaped by top-down contextual and cultural factors determined by language. Emotion categorization serves as a rapid and reliable mechanism for complexity reduction and response preparation, however, it is highly sensitive to situational and contextual factors.

Quantitative effects of emotion on perception: The perception of emotional stimuli

So far we have considered studies where participants are asked to make direct/explicit categorizations of emotional stimuli, mainly expressions of emotion in different modalities. Whereas such results may shed light on emotion categories, their boundaries, how they are defined and how people use them when they are asked to, they do not address a crucial question, maybe the most important one: what is the advantage of having special emotion categories, how does perception profit from having some stimuli tagged as emotional and others not? In summarizing some of the theoretical and empirical work reviewed above, one can conclude that categorization serves complexity reduction, whereas emotions serve the optimization of adaptive behavior towards stimuli that are relevant for the needs, goals and well-being of the organism. The role of emotion in perception and categorization thus should ultimately be related to a perceptual prioritization of categories of relevant stimuli in order to facilitate further processing and response preparation.

In the next part of the paper, we thus focus on quantitative effects of emotional stimuli in perception, investigating how the emotionality of a stimulus can modulate and transform perception, even when people are not consciously categorizing the stimulus as emotional. Thus, we will consider studies where participants' explicit task is not a categorization task, but, for example, to search for a specific picture in a display, or to identify rapidly presented words. Nevertheless, the tasks require some implicit form of emotional categorization and contain emotional and neutral stimuli. In these paradigms, the emotionality of the stimuli modulates the efficiency with which the task is performed, suggesting interaction between emotion and perception. By integrating these studies in our review, we will be able to provide a more targeted overview of the diversity of subprocesses and effects involved in perceptual

processing of emotional stimuli. Furthermore, studies on the categorization of emotion usually employ facial (or less often vocal and bodily) expressions of emotion, whereas the studies we are going to present now also use other kinds of stimuli, such as emotional words and affective pictures of scenes or objects.

How does perception profit from having stimuli tagged as emotional?

In the *visual search task* participants are instructed to search for a target within a search grid containing the target as well as a varying number of distracter stimuli, which may or may not share some similarities with the target stimulus. The task is either to indicate whether all stimuli belong to the same object category or not (thus a categorization task, but not an explicit categorization of “emotional” vs. “neutral”) or to search for a predefined target. Typically, faster detection times are obtained when the target has some emotional value, such as an angry face among neutral faces (Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001) or a snake among flowers (Öhman, Flykt, & Esteves, 2001), indicating that the emotional target is either identified in a preattentive manner or that processing resources are very rapidly allocated toward its position. The search advantage for emotional stimuli was originally interpreted as a parallel search leading to a “pop out” effect (Öhman, Flykt et al., 2001; Treisman & Gormican, 1988). However, there is now increasing consensus that the search process for emotional stimuli is essentially serial, but characterized by smaller increases in response time when more distractors are added (see e.g., Horstmann, 2007). Emotional stimuli have been shown both to speed up the orienting of attention and to prolong the disengagement of attention (Fox, Russo, & Dutton, 2002; Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004); faster detection of an emotional target among neutral distractors (compared with detection of a neutral target among emotional distractors) may thus be due to either

faster orienting of attention to the target or faster disengagement from the neutral distracters. Studies using a full factorial design (including, e.g., threatening targets and threatening distractors) suggest that both attention capture and disengagement prolongation by emotional stimuli contribute to the search advantage for emotional stimuli in the visual search task (Flykt, 2005).

In the *attentional blink paradigm* (Raymond, Shapiro, & Arnell, 1992), participants are presented with a series of stimuli such as words or pictures at high presentation rates (rapid serial visual presentation, RSVP, around 10 stimuli per second). Participants then have to identify one or more of these targets. Any single target can be reported accurately, but reporting a second target is considerably impaired when the two targets are presented within a short interval (200-500 ms). Impaired performance is thought to reflect capacity limitations which restrict access to awareness (Shapiro, Arnell, & Raymond, 1997). It has been shown that the deficit in performance is greatly attenuated for emotional stimuli, which can be reported with higher accuracy than neutral stimuli when appearing as second target (Anderson, 2005). Conversely, the deficit in performance may increase for a neutral target that follows an emotional stimulus. These results indicate that emotional stimuli are selected preferentially from a perceptual temporal stream, thus facilitating processes leading to stimulus awareness.

Increased processing of emotional stimuli was furthermore demonstrated in a *perceptual identification task* (Zeelenberg, Wagenmakers, & Rotteveel, 2006), where emotional words were presented for around 25 ms and masked immediately. Afterwards, subjects had to indicate the word they had seen by choosing between two words. Word recognition was increased for both positive and for negative emotional words compared to neutral words. Interestingly, in a similar task, when people were

asked to recognize rapidly presented and masked images of snakes and spiders, recognition rates were correlated with individual disgust sensitivity, whereas individual fear of spider correlated with the tendency to falsely report having perceived spiders (Wiens, Peira, Golkar, & Öhman, 2008), showing that individual differences in emotional sensitivity measures can influence perception both objectively (improved perception) and subjectively (increased misperceptions).

Taken together, these results show that the emotional quality of a diverse range of stimuli (such as words, pictures, or faces) can be extracted rapidly under suboptimal processing conditions and facilitate the further perceptual processing of the stimulus (Phelps, 2006; Vuilleumier, 2005).

What is the defining “emotionality” criterion for perceptual prioritization?

Although some basic emotion theories state that rapid perceptual processing is specific for threat stimuli that are evolutionarily prepared (Öhman & Mineka, 2001), it has repeatedly been shown that ontogenetically acquired threatening stimuli (such as guns or knives) show similar effects (Blanchette, 2006; Brosch & Sharma, 2005; Fox, Griggs, & Mouchlianitis, 2007). Furthermore, even though the visual search paradigm is frequently cited to support preferential detection of threat-related stimuli, and some early visual search studies found faster detection of threatening information when comparing symbolic happy and angry faces (“smilies” and “frownies”) (e.g., Eastwood, Smilek, & Merikle, 2001), recently it has been argued that the finding of preferential attention capture by angry compared to happy faces is due to the lower relevance of happy faces compared to angry faces, but that attention capture as such is driven by stimulus relevance in general, not by fear-relevance (Brosch, Sander, Pourtois, & Scherer, 2008; Brosch, Sander, & Scherer, 2007).

With regards to the empirical evidence for a potential threat specificity in the visual search paradigm, results are quite mixed (Wolfe & Horowitz, 2004). Some studies report a search advantage for angry faces, that is sometimes driven exclusively by the eye region (Fox & Damjanovic, 2006), sometimes by the mouth region (Horstmann & Bauland, 2006). Other studies report a search advantage both for angry and happy faces (Williams, Moss, Bradshaw, & Mattingley, 2005), or for happy compared to angry faces (Juth, Lundqvist, Karlsson, & Öhman, 2005). Furthermore, faster detection of animals is not specific to threat-related animals such as snakes or spiders (Öhman, Flykt et al., 2001), but has also been observed for cute, positively valenced animals (Tipples, Young, Quinlan, Broks, & Ellis, 2002). Generally, the results from visual search studies for emotional stimuli do not indicate a faster detection specific to threat stimuli, but rather seem to support the notion of a faster detection of emotional stimuli in general (see Frischen, Eastwood, & Smilek, 2008, for a similar argumentation). Similarly, the attenuation of the attentional blink has been demonstrated both for negative and for positive high-arousing stimuli (Anderson, 2005; Anderson & Phelps, 2001; Keil & Ihssen, 2004; Most, Smith, Cooter, Levy, & Zald, 2007).

Taken together, the empirical evidence indicates that increased perception is not restricted to fear-relevant stimuli, but is observed for stimuli with both positive and negative valence, consistent with the assumption of a perceptual prioritization of highly relevant information (Brosch et al., 2008).

Is increased perception due to emotional effects or basic stimulus characteristics?

Most researchers studying the preferential perception of emotional stimuli assume that the prioritization of the stimuli is due to the emotional quality of the stimulus as assessed by the individual. Nevertheless, one cannot exclude that the

effects are due to associated characteristics of stimulus or task (e.g., spatial frequencies, low level perceptual correlates) and not direct effects of the stimulus emotionality (see, e.g., Cave & Batty, 2006). It has been shown, for example, that the degree of attentional capture by an emotional stimulus does not always correspond to the strength of affective evaluations for the same stimulus when measured by implicit tests such as affective priming (Purkis & Lipp, 2007). However, in other tasks, ratings of emotional intensity correlate with degree of response facilitation (Brosch et al., 2007). A role of emotional processes is also supported by the findings that attentional biases can be modulated by individual state and trait differences related to emotion. For example, attentional bias toward threatening information is often enhanced in people with specific phobia: attention is directed faster to pictures of snakes than spiders in snake phobics, but vice versa in spider phobics (Öhman, Flykt et al., 2001). Such individual differences strongly suggest that prioritized attention is determined by an appraisal of the emotional meaning and personal relevance of a stimulus, rather than just salient sensory features. Furthermore, it is important to consider that the emotionality of a stimulus may actually be conveyed by some very simple perceptual features, such as the v-shape of the eyebrows in a threatening facial expression (Aronoff, Barclay, & Stevenson, 1988) or the basic configuration of the baby schema (Lorenz, 1943).

Are there differences between the effects of emotional words and emotional pictures?

The various studies reviewed in this paper used emotional and neutral words as well as images of emotional or neutral scenes or expressions. With regards to the activation of emotion concepts, it would be interesting to know whether there are fundamental processing differences between emotional words and nonverbal displays of emotion. One might assume, for example, that words activate emotion concepts

more easily than other emotional stimuli, and thus lead to stronger top-down effects on processing. On the other hand, one may argue that pictures represent stronger or ecologically more valid stimuli than words, and thus may lead to stronger concept activation. The studies reviewed so far do not give any definitive answers on this question. For example, studies investigating the attentional blink have found rapid attentional prioritization of both emotional words (Anderson, 2005) and emotional pictures (Most, Smith, Cooter, Levy, & Zald, 2007), but no study has compared the perceptual effects of the two types of stimuli. Linguistic studies in general find that pictures allow access to semantic information more rapidly than words, as the latter have to go through phonological processing first; only after a word string has been recognized as a word will its semantic properties be accessed (see Glaser, 1992, for a review). Some more direct evidence for stronger or more automatic concept activation by emotional pictures than words comes from studies showing that the emotionality of a picture interferes with the affective categorization of words, whereas the emotionality of words does not (or only to a lesser extent) interfere with the affective categorization of pictures (Beall & Herbert, 2008; De Houwer & Hermans, 1994).

Which mechanisms underlie the prioritized perception of emotional stimuli?

The increased perception of emotional stimuli, shown across a wide range of paradigms and methods, may depend both on memory-based processes and an online evaluation of the stimulus. Emotional stimuli such as words or objects may have stronger memory representations than neutral ones (LaBar & Cabeza, 2006; Phelps & Sharot, 2008), probably due to the higher implicit or explicit goal-relevance of such stimuli for the organism (see Levine & Edelman, in press). The emotional significance of a stimulus enhances the formation of long-term memory traces, shown by better memory performance for emotional than neutral stimuli (Hamann, Ely,

Grafton, & Kilts, 1999). The stronger memory representation may lead to a facilitated activation of the representations, which accounts for findings such as the preferential identification of masked emotional words compared to neutral words (Zeelenberg et al., 2006) or the facilitated selection of emotional words from a temporal stream of rapidly presented words (Anderson, 2005). Furthermore, memory representations of emotional stimuli, for example information membership of the stimulus in an emotional category, either on the basis of individual stimuli or on the basis of emotional stimulus categories, may already include emotional information in the sense of evaluation results, i.e. one might already know from earlier interactions with a stimulus that it has high relevance, both via explicit knowledge (e.g., when I see the face of a person that I don't like because I am aware that he has been mean to me) and via implicit pathways (e.g., when I smell a food for which I have a taste aversion). In this sense the stored information acts as an evaluation shortcut, so that no new elaborate evaluation is necessary. Other forms of affective evaluation cannot solely rely on memory processes. Context-sensitive processes need to take into account the current situation as well as the need or goal state of the organism and match it with the properties of the stimulus. This kind of processing needs an online appraisal (see, e.g., Moors, in press). Both kinds of processes may play a role in the evaluation of the affective value of a stimulus.

Discussion

Why do we need emotional stimulus categories?

The research that we have reviewed here shows that emotion is a strong incentive for perception and that emotionally relevant words or images may produce both qualitative and quantitative changes in the speed and amount of what is

eventually perceived by the individual. People are able to categorize stimuli into emotional categories, be they based on basic emotions, dimensional approaches, or appraisal criteria. The category boundaries affect the actual percept of emotional stimuli, as shown by the *categorical perception effect*. Furthermore, independent of any categorization task, emotional stimuli are perceived preferentially.

A special role for emotional stimuli in perception is obviously useful, as emotional stimuli, i.e. stimuli that possess high relevance for the survival and well-being of the observer, usually require rapid behavioral responses, a preferential perception being the first step in the coordination of such an adaptive response. Emotional categories allow the organism to rapidly organize the processing of environmental information based on the relevance of the information with regards to current needs and goals. Just as one main function of categorization in general is the rapid access to and retrieval of a lot of information about the incoming stimulus, a function of emotional categorizing seems to be the rapid access to and retrieval of information that makes a quick adaptive response possible. Emotional categorization thus can be conceptualized as an automatic, adaptive “tag for high priority processing” (see Yantis & Johnson, 1990).

How do we categorize emotional stimuli: On the influence of bottom-up and top-down mechanisms

One central, frequently reoccurring debate in research on the processing, perception and categorization of emotional stimuli is centered around the question of the relative importance of universal, biological bottom-up factors, as emphasized, e.g., by adherents of basic emotion theories, versus culturally and socially determined top-down factors, as emphasized especially by constructivist theories. This question has recently returned to the attention of emotion psychology due to a debate in

Perspectives in Psychological Sciences (Barrett, 2006a; Barrett, Lindquist, Bliss-Moreau et al., 2007; Izard, 2007; Panksepp, 2007, 2008). Based mainly on the argument that there is a lack of human neurophysiological evidence for discrete response patterning, Barrett promotes a constructivist approach claiming that emotion categories are not natural entities, but man-made concepts. The experience of emotions is understood as the categorization of core affect, an internal state describable only in terms of valence and arousal, into language-based emotion categories (Barrett, 2006a). In contrast, based on a large amount of animal data showing discrete emotional response systems for a number of fundamental behaviors (e.g., FEAR, RAGE, PLAY; Panksepp, 1998), Panksepp rejects the extreme constructivist position and suggests that human emotion researchers need to take into account cross-species data indicating basic emotional systems to understand the “primal sources of human emotional feelings” (Panksepp, 2007, 2008).

What can the study of the perception of emotional objects contribute to this hotly debated issue? Some of the principal claims of the debate can be evaluated under the light of the empirical data and conceptual arguments that we discuss here. The data on categorization tasks leave very little doubt about the fact that the claim of a strong universality of emotion categories put forward in support of basic emotion theories is not supported by the empirical evidence. The data rather indicate a large role of culture and context in an ongoing and flexible development of the categories that we use to carve our environment. Emotion categories seem to be learned and refined over time by integrating emotion-related information that frequently occurs together. This may nevertheless include some biological bottom-up aspects, such as adaptive responses like the opening of the eyes in a fear expression (Susskind et al., 2008), but furthermore includes culture-specific, socially determined aspects.

Emotional categorization is furthermore based to a great extent on available information about the current situational context.

Thus, whether and how a stimulus is perceived as emotional is not static, fixed or invariant, but critically depends on and fluctuates according to the person's particularities (such as the current mood or motivations) and specific context (e.g., situation, time, culture). Hence, a given stimulus can be emotional for one person, while being perceived as carrying less or even lacking any emotional meaning by another individual. Furthermore, the emotional meaning of a given stimulus may fluctuate for the exact same individual according to the specific context (situation and time) in which this stimulus is encountered. It is mainly for that reason that it is not easily possible to compile a fixed list of "emotional stimuli" that elicit an emotional effect in all people and on all occasions. A given stimulus becomes emotional for a person due to the individual interaction of that stimulus with the perceiving organism, assessing the individual emotional relevance of the stimulus for the person. To put it simply, a snake by itself is not an emotional stimulus, nor does it guarantee the elicitation of an emotion, but it takes a snake and somebody who is afraid of snakes to have an emotion. There might be some stimuli that elicit highly similar emotional responses across all persons, for example a strong fear-eliciting stimulus such as a painful electric pricking. However, even such extreme cases should be conceptualized as reflecting an interaction between the person and the stimulus, as demonstrated by interindividual differences in pain perception related to factors such as race, sex, catastrophism or anxiety level (Ploghaus et al., 2001; Sheffield, Biles, Orom, Maixner, & Sheps, 2000).

Thus, categorization, while acting as an efficient mechanism for rapid complexity reduction, takes into account situational and contextual factors. The

outcomes of the rapid categorization mechanisms should not be mistaken for a modular mechanism for emotional processing which is restricted to a few basic categories. Whereas the perception of emotional stimuli can be easily described in terms of basic categories or dimensions, the actual process that renders a stimulus emotional must be conceived of as more complex, highly flexible and context-dependent. To explain the perception and categorization of emotional stimuli, it is thus not sufficient to rely on a few basic, inflexible, hardwired categories. Emotional categorization is modulated by our language capacities and available labels, and emotional categories seem to be similar to non-emotional categories in that they reflect correlational structures that we experience in our environment. They may be different from non-emotional categories, however, in that they integrate information about the different components of emotions, such as appraisal, action tendencies, bodily responses, behavioral responses and changes in subjective feeling, and in that emotional categorization functions as a tag for high priority processing in the service of adaptive response preparation toward relevant stimuli.

It is furthermore doubtful that a purely constructivist position can account for results obtained in research on the perception of emotional stimuli. Especially in tasks where multiple stimuli are presented or stimuli are presented in a rapid visual stream with one stimulus every 100 ms or less, it is not clear how a preferential processing of emotional stimuli can be accounted for when the only emotional quality that is available for guiding perception is an unspecified internal core affect reflecting changes in a “neurophysiological barometer” (Barrett, 2006a). As constructivist theories mainly focus on the mechanisms underlying the subjective experience of emotions, they do not formulate relevant predictions or explanations about the topic of automatic perceptual prioritization of emotional stimuli.

Componential appraisal theories of emotion (e.g., Scherer, in press) focus on the effects of stimulus appraisal on the response patterning of physiological reactions, motor expression, and action preparation, which then may be integrated into an emotion category that can be used to structure the environment, guide perception, and give rise to a subjective feeling. Like constructivist approaches, appraisal theory can thus account for the richness and flexibility of the extension of the emotional categories, as appraisal is not hard-wired, but takes into account individual particularities and specific contexts (e.g., Frijda, 2007). Unlike constructivist approaches, however, it postulates more specific mechanisms that give rise to the emotional quality that is categorized (core affect in the case of Barrett, 2006 *versus* a response pattern of appraisal results, physiological reactions, motor expression, and action preparation, in the case of Scherer, in press). From this perspective, effects like the rapid prioritization of emotional stimuli by the perceptual system thus can be understood as embedded in the patterning of appraisal processes, action preparation and physiological orienting responses, and may serve to optimize perception even before a conscious categorization has occurred.

The relation of perception/cognition and emotion

Another important psychological debate is centered on the question of whether separate mechanisms exist for a dedicated processing of emotional stimuli or whether emotional and non-emotional stimuli are processed by the same cognitive mechanisms (Duncan & Barrett, 2007; Eder, Hommel, & De Houwer, 2007; Lazarus, 1984; Leventhal & Scherer, 1987; Pessoa, 2008; Storbeck, Robinson, & McCourt, 2006; Zajonc, 1980). If emotion and cognition are treated as separate or dissociable psychological processes, researchers would gain little insight on emotional perception by studying cognitive mechanisms of perception and categorization. If, however,

emotional stimuli are a special class of stimuli which are processed by the same cognitive mechanisms as “neutral” stimuli, one can investigate cognitive mechanisms to elucidate a special role of emotional stimuli in perception in the sense of preferential treatment within cognitive processing (Moors, 2007).

The so-called “trilogy of the mind” (Hilgard, 1980), separating cognition, emotion and motivation into distinct entities, still seems to be very influential in the current literature. However, in most theories, the question of whether affective processes are dissociated from cognitive processes (such as Zajonc’ (1980) strong claim that “preferences need no inferences”) can be reduced to the question of whether sensory processes are considered as cognitive in nature or not (see also Parrott & Schulkin, 1993). If one defines with Neisser (1967) cognitive processes as those processes “by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used”, it would still remain to be shown that sensory input alone can indeed elicit emotion without any kind of transformation.

The evidence reviewed in this article shows that perceptual and emotional processing are highly intertwined. In contrast to the view that perception is an encapsulated process that is not influenced by top-down influences such as expectations or prior knowledge (Pylyshyn, 1999), the evidence suggests that perception is a highly dynamic, proactive process, which influences and is reciprocally influenced by other processes, including emotional processes, through dynamic interactions. The perception of an emotional stimulus is both stimulus-driven and concept-driven, i.e. the result is shaped by sensory information as well as by memory-based conceptual information and online evaluation capacities. In extreme cases, emotional top-down concepts may even bias the perception of nonemotional stimuli. For example, in one study participants were shown ambiguous figures that

could be interpreted as a “B” or as a “13” and were told that if they see a “B” they would be assigned to a condition where they would taste orange juice, whereas if they see a “13” they would taste a green, foul-smelling vegetable smoothie. Participants tended to report having seen the version that later would assign them to the favored outcome (Balcetis & Dunning, 2006). Perception can be conceived as an interaction of bottom-up sensory signals that are processed and integrated by the sensory pathways, and top-down knowledge systems already present in the observer which are used to structure and understand the new incoming information (Bar, 2004, 2007; Yantis, 1992). The emotional meaning of the stimulus emerges from interactions between the stimulus content and the actual state of the individual, during a proactive process. This conclusion is consistent with a recent analysis of neuroimaging studies suggesting that a segregation of the brain into “emotional” and “cognitive” areas is not supported by the empirical evidence (Pessoa, 2008).

The current review thus suggests that the perception of emotional stimuli does not seem to require special dedicated kinds of “emotional” processing mechanisms. The emotional quality of a stimulus rather seems to trigger a high-priority processing mode inside an integrated cognitive-affective system.

Conclusions

In the present paper, we have shed some light on the perception and categorization of emotional stimuli, by integrating theoretical perspectives on what makes a stimulus emotional and on how emotional categories are formed, as well as

empirical data illustrating how stimuli are categorized as emotional as well as how the perception of emotional stimuli³ is prioritized.

Emotional categorization is a very important mechanism by which we structure our environment. Emotion is a strong incentive for perception, and emotional stimuli may produce both qualitative and quantitative changes in the speed and amount of what is eventually perceived by the individual. People classify facial, vocal and bodily expressions of emotion with high accuracy, allowing them to rapidly assess the emotional state of interaction partners. This classification can occur according to “basic” emotion categories, dimensions such as valence or arousal, and appraisal criteria such as relevance or coping potential. Furthermore, emotional stimuli in general are prioritized in perception, are detected more rapidly and gain access to conscious awareness more easily than nonemotional stimuli.

Emotion categories are not determined universally or biologically, but are flexible and continuously adjusted. Like other categories, they reflect correlational structures experienced in the environment. However, they are special in that they integrate different aspects of the emotional response toward a stimulus (such as appraisal components, core relational themes, action tendencies, bodily responses, behavioral responses, subjective feeling). Furthermore, contextual top-down information is extremely important for the categorization of a stimulus as emotional. This flexibility in categorization helps to rapidly and economically perceive the environment by focusing on relevant information, but nevertheless allows adjusting

³ One should be aware that “emotional stimuli” as used in the studies presented here only very rarely elicit a full-blown emotion with an intense subjective feeling component. Reading the word “snake” will probably not very often be linked with experiencing strong feelings of fear. However, as shown by the evidence reviewed in this article, the perceptual processing of the word may still be increased compared to emotionally neutral words.

the definition of what is relevant at a given moment, congruent with the view of emotion as a highly flexible interface between stimulus input and adaptive response.

References

- Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General*, *134*, 258-281.
- Aronoff, J., Barclay, A. M., & Stevenson, L. A. (1988). The recognition of threatening facial stimuli. *Journal of Personality and Social Psychology*, *54*, 647-655.
- Augoustinos, M., Walker, I., & Donaghue, N. (2006). *Social cognition: An integrated introduction*. London: SAGE.
- Aviezer, H., Hassin, R. R., Ryan, J., Grady, C., Susskind, J., Anderson, A., et al. (2008). Angry, disgusted, or afraid? Studies on the malleability of emotion perception. *Psychological Science*, *19*, 724-732.
- Balcetis, E., & Dunning, D. (2006). See what you want to see: Motivational influences on visual perception. *Journal of Personality and Social Psychology*, *91*, 612-625.
- Barrett, L. F. (2006a). Are emotions natural kinds? *Perspectives on Psychological Science*, *1*, 28-58.
- Barrett, L. F. (2006b). Solving the emotion paradox: categorization and the experience of emotion. *Personality and Social Psychology Review*, *10*, 20-46.
- Barrett, L. F., Lindquist, K. A., Bliss-Moreau, E., Duncan, S., Gendron, M., Mize, J., et al. (2007). Of mice and men: Natural kinds of emotions in the mammalian brain? A response to Panksepp and Izard. *Perspectives on Psychological Science*, *2*, 297-311.

- Barrett, L. F., Lindquist, K. A., & Gendron, M. (2007). Language as context for the perception of emotion. *Trends in Cognitive Sciences, 11*, 327-332.
- Barsalou, L. W. (1983). Ad hoc categories. *Memory & Cognition, 11*, 211-227.
- Beale, J. M., & Keil, F. C. (1995). Categorical effects in the perception of faces. *Cognition, 57*, 217-239.
- Beall, P. M., & Herbert, A. M. (2008). The face wins: Stronger automatic processing of affect in facial expressions than words in a modified Stroop task. *Cognition and Emotion, 22*, 1613-1642.
- Berlin, B., & Kay, P. (1969). *Basic color terms: Their universality and evolution*. Berkeley: University of California Press.
- Bornstein, M. H., & Korda, N. O. (1984). Discrimination and matching within and between hues measured by reaction times: some implications for categorical perception and levels of information processing. *Psychological Research, 46*, 207-222.
- Borod, J. C., Pick, L. H., Hall, S., Sliwinski, M., Madigan, N., Obler, L. K., et al. (2000). Relationships among facial, prosodic, and lexical channels of emotional perceptual processing. *Cognition & Emotion, 14*, 193-211.
- Boster, J. (2005). Emotion categories across languages. In H. Cohen & C. Lefebvre (Eds.), *Handbook of categorization in cognitive science*. Amsterdam: Elsevier.
- Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: the Self-Assessment Manikin and the Semantic Differential. *Journal of Behavioural Therapy and Experimental Psychiatry, 25*, 49-59.
- Brosch, T., Sander, D., Pourtois, G., & Scherer, K. R. (2008). Beyond fear: Rapid spatial orienting towards positive emotional stimuli. *Psychological Science, 19*, 362-370.

- Brosch, T., Sander, D., & Scherer, K. R. (2007). That baby caught my eye... Attention capture by infant faces. *Emotion, 7*, 685-689.
- Carroll, J. M., & Russell, J. A. (1997). Facial expressions in Hollywood's portrayal of emotion. *Journal of Personality and Social Psychology, 72*, 164-176.
- Cave, K. R., & Batty, M. J. (2006). From searching for features to searching for threat: Drawing the boundary between preattentive and attentive vision. *Visual Cognition, 14*, 629-646.
- Cohen, H., & Lefebvre, C. (Eds.). (2005). *Handbook of categorization in cognitive science*. Amsterdam: Elsevier.
- Davidoff, J. (2001). Language and perceptual categorisation. *Trends in Cognitive Sciences, 5*, 382-387.
- De Houwer, J., & Hermans, D. (1994). Differences in the affective processing of words and pictures. *Cognition & Emotion, 8*, 1-20.
- Eastwood, J. D., Smilek, D., & Merikle, P. M. (2001). Differential attentional guidance by unattended faces expressing positive and negative emotion. *Perception & Psychophysics, 63*, 1004-1013.
- Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. K. Cole (Ed.), *Nebraska Symposium on Motivation* (pp. 207-283). Lincoln: University of Nebraska Press.
- Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion, 6*, 169-200.
- Ekman, P., & Friesen, W. V. (1975). *Unmasking the face*. Englewood Cliffs: Prentice-Hall.
- Elfenbein, H. A., & Ambady, N. (2002). On the universality and cultural specificity of emotion recognition: A meta-analysis. *Psychological Bulletin, 128*, 203-235.

- Ellsworth, P. C., & Scherer, K. R. (2003). Appraisal processes in emotion. In R. J. Davidson, H. H. Goldsmith & K. R. Scherer (Eds.), *Handbook of Affective Sciences* (pp. 572-595). Oxford: Oxford University Press.
- Flykt, A. (2005). Visual search with biological threat stimuli: accuracy, reaction times, and heart rate changes. *Emotion, 5*, 349-353.
- Fox, E., & Damjanovic, L. (2006). The eyes are sufficient to produce a threat superiority effect. *Emotion, 6*, 534-539.
- Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion, 16*, 355-379.
- Frijda, N. H. (2007). *The laws of emotion*. Mahwah, NJ: Erlbaum.
- Frischen, A., Eastwood, J. D., & Smilek, D. (2008). Visual search for faces with emotional expressions. *Psychological Bulletin, 134*, 662-676.
- Glaser, W. R. (1992). Picture naming. *Cognition, 42*, 61-105.
- Halberstadt, J. B., & Niedenthal, P. M. (2001). Effects of emotion concepts on perceptual memory for emotional expressions. *Journal of Personality and Social Psychology, 81*, 587-598.
- Hamann, S. B., Ely, T. D., Grafton, S. T., & Kilts, C. D. (1999). Amygdala activity related to enhanced memory for pleasant and aversive stimuli. *Nature Neuroscience, 2*, 289-293.
- Hansen, C. H., & Hansen, R. D. (1988). Finding the face in the crowd: an anger superiority effect. *J Pers Soc Psychol, 54*, 917-924.
- Harnad, S. (1987). *Categorical perception: The groundwork of cognition*. Cambridge: Cambridge University Press.

- Harnad, S. (2005). To cognize is to categorize: Cognition is categorization. In H. Cohen & C. Lefebvre (Eds.), *Handbook of categorization in cognitive science*. Amsterdam: Elsevier.
- Hilgard, E. R. (1980). The trilogy of mind: Cognition, affection, and conation. *Journal of the History of Behavioral Sciences, 16*, 107-117.
- Horstmann, G. (2002). Facial expressions of emotion: Does the prototype represent central tendency, frequency of instantiation, or an ideal? *Emotion, 2*, 297-305.
- Horstmann, G. (2007). Preattentive face processing: What do visual search experiments with schematic faces tell us? *Visual Cognition, 15*, 799-833.
- Horstmann, G., & Bauland, A. (2006). Search asymmetries with real faces: Testing the anger-superiority effect. *Emotion, 6*, 193-207.
- Izard, C. E. (1971). *The face of emotion*. New York: Appleton-Century-Crofts.
- Izard, C. E. (2007). Basic emotions, natural kinds, emotion schemas, and a new paradigm. *Perspectives on Psychological Science, 2*, 260-280.
- Juslin, P. N., & Laukka, P. (2003). Communication of emotions in vocal expression and music performance: different channels, same code? *Psychological Bulletin, 129*, 770-814.
- Juth, P., Lundqvist, D., Karlsson, A., & Öhman, A. (2005). Looking for foes and friends: Perceptual and emotional factors when finding a face in the crowd. *Emotion, 5*, 379-395.
- Koster, E., Crombez, G., Van Damme, S., Verschuere, B., & De Houwer, J. (2004). Does imminent threat capture and hold attention? *Emotion, 4*, 312-317.
- Kourtzi, Z., & DiCarlo, J. J. (2006). Learning and neural plasticity in visual object recognition. *Current Opinion in Neurobiology, 16*, 152-158.

- LaBar, K. S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews Neuroscience*, 7, 54-64.
- Laukka, P. (2005). Categorical perception of vocal emotion expressions. *Emotion*, 5, 277-295.
- Levine, L. J., & Edelman, R. S. (in press). Emotion and memory narrowing: A review and goal relevance approach. *Cognition and Emotion*.
- Liberman, A. M., Harris, K. S., Hoffman, H. S., & Griffith, B. C. (1957). The discrimination of speech sounds within and across phoneme boundaries. *Journal of Experimental Psychology*, 54, 358-368.
- Lorenz, K. (1943). Die angeborenen Formen möglicher Erfahrung [The innate forms of potential experience]. *Zeitschrift für Tierpsychologie*, 5, 233-519.
- McClelland, J. L., & Rumelhart, D. E. (1985). Distributed memory and the representation of general and specific information. *Journal of Experimental Psychology: General*, 114, 159-188.
- Moors, A. (2007). Can cognitive methods be used to study the unique aspect of emotion: An appraisal theorist's answer. *Cognition & Emotion*, 21, 1238-1269.
- Moors, A. (2009). A review of theories concerned with emotion causation. *Cognition and Emotion*.
- Moors, A. (in press). Automatic constructive appraisal as a candidate cause of emotion. *Emotion Review*.
- Most, S. B., Smith, S. D., Cooter, A. B., Levy, B. N., & Zald, D. H. (2007). The naked truth: Positive, arousing distractors impair rapid target perception. *Cognition & Emotion*, 21, 964-981.
- Murphy, G. L., & Medin, D. L. (1985). The role of theories in conceptual coherence. *Psychological Review*, 92, 289-316.

- Neisser, U. (1967). *Cognitive psychology*. New York: Appleton-Century-Crofts.
- Niedenthal, P. M., Halberstadt, J. B., & Innes-Ker, A. H. (1999). Emotional response categorization. *Psychological Review*, *106*, 337-361.
- Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General*, *130*, 466-478.
- Öhman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. *Journal of Personality and Social Psychology*, *80*, 381-396.
- Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: Toward an evolved module of fear and fear learning. *Psychological Review*, *108*, 483-522.
- Palmeri, T. J., & Gauthier, I. (2004). Visual object understanding. *Nature Reviews Neuroscience*, *5*, 291-303.
- Panksepp, J. (1998). *Affective Neuroscience: The Foundations of Human and Animal Emotions*. New York: Oxford University Press.
- Panksepp, J. (2007). Neurologizing the psychology of affects: How appraisal-based constructivism and basic emotion theory can coexist. *Perspectives on Psychological Science*, *2*, 281-295.
- Panksepp, J. (2008). Cognitive conceptualism: Where have all the affects gone? Additional corrections for Barrett et al. (2007). *Perspectives on Psychological Science*, *3*, 305-308.
- Parrott, W. G., & Schulkin, J. (1993). What sort of system could an affective system be?: A reply to LeDoux. *Cognition and Emotion*, *7*, 65-69.

- Pessoa, L. (2008). On the relationship between emotion and cognition. *Nature Reviews Neuroscience*, 9, 148-158.
- Phelps, E. A., & Sharot, T. (2008). How (and why) emotion enhances the subjective sense of recollection. *Current Directions in Psychological Science*, 17, 147-152.
- Purkis, H. M., & Lipp, O. V. (2007). Automatic attention does not equal automatic fear: preferential attention without implicit valence. *Emotion*, 7, 314-323.
- Pylyshyn, Z. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioral and Brain Sciences*, 22, 341-423.
- Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception and Performance*, 18, 849-860.
- Roberson, D., Davies, I., & Davidoff, J. (2000). Color categories are not universal: Replications and new evidence from a stone-age culture. *Journal of Experimental Psychology: General*, 129, 369-398.
- Rosch, E. (1978). Principles of categorization. In E. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization* (pp. 27-48). Hillsdale: Lawrence Erlbaum Associates.
- Rosch, E., Mervis, C., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, 8, 382-439.
- Rosch Heider, E. (1972). Universals in color naming and memory. *Journal of Experimental Psychology*, 93, 10-20.
- Russell, J. A. (1991). Culture and the categorization of emotions. *Psychological Bulletin*, 110, 426-450.

- Russell, J. A. (1997). Reading emotions from and into faces: Resurrecting a dimensional contextual perspective. In J. A. Russell & J. M. Fernandez-Dols (Eds.), *The psychology of facial expressions* (pp. 295-320). New York: Cambridge University Press.
- Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychological Review*, *110*, 145-172.
- Russell, J. A., & Fehr, B. (1987). Relativity in the perception of emotion in facial expressions. *Journal of Experimental Psychology: General*, *116*, 223-237.
- Sander, D. (2008). Basic tastes and basic emotions: Basic problems, and perspectives for a nonbasic solution [commentary]. *Behavioral and Brain Sciences*, *31*, 88.
- Sander, D., Grandjean, D., Kaiser, S., Wehrle, T., & Scherer, K. R. (2007). Interaction effects of perceived gaze direction and dynamic facial expression: Evidence for appraisal theories of emotion. *European Journal of Cognitive Psychology*, *19*, 470-480.
- Scherer, K. R. (1992). What does facial expression express? In K. Strongman (Ed.), *International review of studies on emotion* (Vol. 2, pp. 139-165). Chichester, England: Wiley.
- Scherer, K. R. (1994a). Emotion serves to decouple stimulus and response. In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 127-130). New York/Oxford: Oxford University Press.
- Scherer, K. R. (1994b). Toward a concept of “modal emotions.” In P. Ekman & R. J. Davidson (Eds.), *The nature of emotion: Fundamental questions* (pp. 25-31). New York: Oxford University Press.
- Scherer, K. R. (2001). Appraisal considered as a process of multilevel sequential checking. In K. R. Scherer, A. Schorr & T. Johnstone (Eds.), *Appraisal*

- processes in emotion: Theory, methods, research* (pp. 92-120). New York: Oxford University Press.
- Scherer, K. R. (in press). The dynamic architecture of emotion: Evidence for the Component Process Model. *Cognition and Emotion*.
- Scherer, K. R., & Grandjean, D. (2008). Facial expressions allow inference of both emotions and their components. *Cognition & Emotion*, 22, 789-801.
- Shapiro, K. L., Arnell, K. M., & Raymond, J. E. (1997). The attentional blink. *Trends in Cognitive Sciences*, 1, 291-296.
- Shaver, E., Schwartz, J., Kirson, D., & O'Connor, C. (1987). Emotion knowledge: Further exploration of a prototype approach. *Journal of Personality and Social Psychology*, 52, 1061-1086.
- Smith, C. A., & Kirby, L. D. (in press). Core relational themes. In D. Sander & K. R. Scherer (Eds.), *The Oxford Companion to Emotion and the Affective Sciences*. Oxford: Oxford University Press.
- Smith, C. A., & Lazarus, R. S. (1990). Emotion and adaptation. In L. A. Pervin (Ed.), *Handbook of personality: Theory and research* (pp. 609-637). New York, NY: Guilford Press.
- Susskind, J. M., Lee, D. H., Cusi, A., Feiman, R., Grabski, W., & Anderson, A. K. (2008). Expressing fear enhances sensory acquisition. *Nat Neurosci*, 11, 843-850.
- Thorpe, S., Fize, D., & Marlot, C. (1996). Speed of processing in the human visual system. *Nature*, 381, 520-522.
- Tipples, J., Young, A. W., Quinlan, P., Broks, P., & Ellis, A. W. (2002). Searching for threat. *Quarterly Journal of Experimental Psychology A*, 55, 1007-1026.

- Treisman, A., & Gormican, S. (1988). Feature analysis in early vision: evidence from search asymmetries. *Psychological Review*, *95*, 15-48.
- Whorf, B. L. (1956). The relation of habitual thought and behavior to language. In J. B. Carroll (Ed.), *Language, thought and reality: Essays by B.L. Whorf*. Cambridge: MIT Press.
- Wiens, S., Peira, N., Golkar, A., & Öhman, A. (2008). Recognizing masked threat: Fear betrays, but disgust you can trust. *Emotion*, *8*, 810-819.
- Williams, M. A., Moss, S. A., Bradshaw, J. L., & Mattingley, J. B. (2005). Look at me, I'm smiling: Visual search for threatening and nonthreatening facial expressions. *Visual Cognition*, *12*, 29-50.
- Wolfe, J. M., & Horowitz, T. S. (2004). What attributes guide the deployment of visual attention and how do they do it? *Nature Reviews Neuroscience*, *5*, 495-501.
- Yantis, S., & Johnson, D. N. (1990). Mechanisms of attentional priority. *Journal of Experimental Psychology: Human Perception and Performance*, *16*, 812-825.
- Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist*, *35*, 151-175.
- Zeelenberg, R., Wagenmakers, E. J., & Rotteveel, M. (2006). The impact of emotion on perception: Bias or enhanced processing? *Psychological Science*, *17*, 287-291.

Acknowledgements

The preparation of this article was supported by the National Centre of Competence in Research for Affective Sciences, financed by the Swiss National Science Foundation.