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Emotion-Cognition Interaction in Recognizing Facial Expressions

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ABSTRACT

Certain facial expressions are universally recognized as signals of discrete emotional states. The recognition of these signals involves perceptual processing of the configuration of key facial features and retrieval of conceptual knowledge linked to the observed expression. These processes may be sensitive to the emotional context. In general, expressions that are congruent with the perceiver's emotional experiences are recognized more efficiently than expressions that are incongruent with the perceiver's emotional experiences.

The present series of studies examined the happy face advantage in facial expression recognition. Previous choice-reaction time studies have shown that positive (happy) faces are recognized more efficiently than negative (angry/disgusted/sad) faces. Study I of the present series confirmed this result by showing that happy faces were recognized more quickly than disgusted and sad faces. Moreover, Study I showed that the happy face advantage was not simply due to low-level physical differences between positive and negative faces or to rapid recognition of happy faces based on a single salient facial feature (i.e., a smiling mouth). Study II confirmed that the happy face advantage occurs exclusively at premotoric (cognitive) stages in the stimulus-response processing chain. There were no expression-category effects on response-execution processes. Study III showed that the happy face advantage can be modulated by emotional context: Happy faces were recognized more quickly than disgusted faces in a pleasant odor context, but this happy face advantage disappeared completely in an unpleasant odor context. Clinical depression did not, however, remove the happy face advantage (Study IV).

It is suggested that the happy face advantage reflects an effect of both cognitive and emotional factors on facial expression recognition. On the one hand, happy faces are recognized efficiently because they are familiar and unequivocal in meaning (i.e., they share few perceptual and conceptual characteristics with other expressions). On the other hand, subjective positive emotions originating from a positive baseline for affect and/or from positive emotional reactions evoked by observing a happy face may enhance the perception and recognition of happy faces.

As a whole, the responsiveness to happy faces may reflect the importance of the communication of positive emotions in human social interaction.

CONTENTS

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LIST OF ORIGINAL PUBLICATIONS

This thesis consists of the following four publications, which will be referred to by their Roman numerals:

I Leppänen, J.M., & Hietanen, J.K. (in press). Emotionally positive facial expressions are processed faster than negative facial expressions, but why? *Psychological Research.* Copyright © 2003 by Springer-Verlag. Adapted with permission.

II Leppänen, J.M., Tenhunen, M., & Hietanen, J.K. (2003). Faster choice-reaction times to positive than negative facial expressions: The role of cognitive and motor processes. *Journal of Psychophysiology, 17,* 113-123. Copyright © 2003 by the Federation of European Psychophysiology Societies. Reprinted with permission.

III Leppänen, J.M., & Hietanen, J.K. (2003). Affect and face perception: Odors modulate the recognition advantage of happy faces. *Emotion, 3,* 315-326. Copyright © 2003 by the American Psychological Association. Reprinted with permission.

IV Leppänen, J.M., Milders, M., Bell, J.S., Terriere, E., & Hietanen, J.K. (accepted). Depression biases the recognition of neutral faces. *Reports from the Department of Psychology*, *University of Tampere*.

1. FACIAL EXPRESSION RECOGNITION

Our ability to recognize the emotional states and behavioral intentions of other people is based to a large extent on the cues conveyed by facial expressions. Certain facial expressions are universally recognized as signs of specific emotional states. The most consistently expressed and recognized emotions in various literate and preliterate cultures include anger, disgust, fear, sadness, and happiness (reviewed in Ekman, 1999a; see also Russell, Bachorowski, & Fernández-Dols, 2003). In recent years, researchers have started to investigate not only what people can derive from different types of facial expressions but also the specific mechanisms that underlie these abilities. There are now several studies that illuminate the cognitive (Calder, Young, Keane, & Dean, 2000; Etcoff & Magee, 1992; White, 2000; Young et al., 1997), emotional (Dimberg, 1990; Niedenthal, Halberstadt, Margolin, & Innes-Ker, 2000), and neural (Adolphs, 2002; Haxby, Hoffman, & Gobbini, 2002) processes involved in the perception and recognition of facial expressions. In the following, I will first provide a general description of these processes, then turn to the topic of the present study; i.e., differences in the processing of positive and negative facial expressions.

1.1 Cognitive Processes Involved in Facial Expression Recognition

In general, visual object recognition involves several distinct stages at which different types of "descriptions" of the target object are achieved (Humphreys & Bruce, 1989). These stages and their approximate temporal order are illustrated in Figure 1. At the earliest processing stages that are here referred to as stimulus *perception* stages, a structural description of the target image is formed. In the case of facial expressions, this description (or representation) is formed by coding the presence of certain facial features and by coding the spatial relations (configuration) of these features (Adolphs, 2002). At later processing stages, additional stimulus *recognition* processes come into play. Specifically, the object can be classified as belonging to a familiar perceptual category (i.e., perceptual classification). This is based on a match between the structural description of the image and a stored representation of the image prototype. The perceiver may

also retrieve semantic or conceptual knowledge associated with the object (i.e., semantic classification). Knowledge associated with a facial expression may include, for example, associated past experiences, knowledge about the motor representations required to produce the observed expression, and knowledge about the changes in the perceiver's own emotional state evoked by the observed expression (Adolphs, 2002). Finally, the object can be linked to a particular lexical label (i.e., naming).
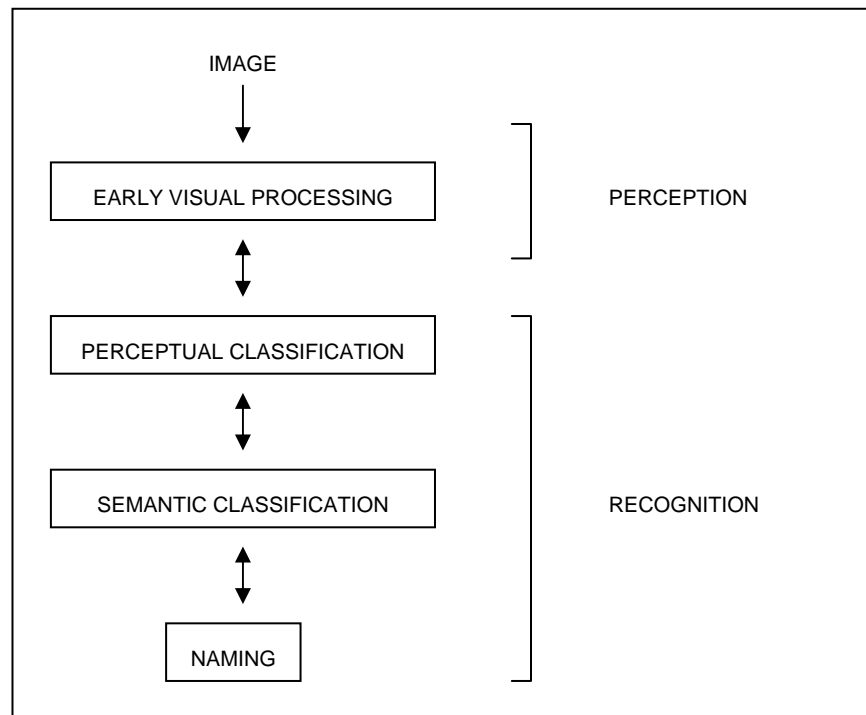
FIGURE 1. Stages involved in the visual object recognition (modified from Humphreys & Bruce, 1989).

An important issue concerns the nature of the visual information used in the perception and recognition of facial expressions. Specifically, are facial expressions processed by coding the individual features of the face (e.g., mouth deflection, eyebrow deflection, see Ellison & Massaro, 1997), or are facial expressions processed by coding the spatial relations (configuration) of individual facial features? Calder et al. (2000; see also White, 2000) recently reported evidence in favor of the latter alternative. They asked people to recognize emotions from the top or bottom half of a face whose top and bottom halves expressed different emotions (e.g., angry/happy, respectively). The target and the non-target halves were presented either so that they were aligned and, thereby forming a new face (a composite stimulus), or so that the halves were misaligned thereby not forming a face (a non-composite stimulus). Interestingly, people performed the recognition task more slowly and less accurately in the composite than in the non-composite condition. This suggests that an individual

expressive feature (e.g., angry eye region) is not coded in isolation from the rest of the face (Calder et al., 2000). This is clearly consistent with the view that the perception and recognition of facial expressions is based on the configural relationship of the facial features. However, it remains open whether all types of facial expressions are processed using a similar strategy, or whether some individual emotional expressions could be processed by using a feature-based coding strategy (Adolphs, 2002).

1.2 Emotions and Facial Expression Recognition

Facial expressions are emotionally provocative stimuli. This is indicated by results showing that passive observation of facial expressions evokes emotion-specific facial muscle activity (Dimberg, 1990; Surakka & Hietanen, 1998) and subjective feelings (Wild, Erb, & Bartels, 2001) in the observing subject. Facial reactions may occur within 400 ms from stimulus onset (Dimberg & Thunberg, 1998). Even subliminally presented (i.e., not consciously recognized) happy and angry faces may provoke measurable changes in emotion-related behaviors (Berridge & Winkielman, 2003; Dimberg, Thunberg, & Elmehed, 2000; Murphy & Zajonc, 1993; Murphy, Zajonc, & Monahan, 1995).

Emotional reactions to facial expressions may reflect the influence of evolved emotional systems on human behavior. These emotion systems allow us to respond to biologically and socially relevant stimuli by such activities that have been adaptive in the history of our species or in the history of our individual life (Ekman, 1999b). Emotional reactions are typically relatively short-lived, they are based on a specific neurophysiological substrate, and they consist of motor (expressive) as well as experiential components (see Izard, 1993). Some theorists (e.g., Cacioppo & Gardner, 1999) posit that there are two anatomically separable emotions systems of which one is threat-related (negative) and the other safety-related (positive). Others, in turn, assume that there are several discrete emotions (e.g., joy, fear, disgust etc.), which have prototypical antecedent events and distinctive physiological, expressive, and experiential components (Calder, Lawrence, Young, 2001; Ekman, 1999b). Emotions are generally thought to be distinct from cognitive processes (Cacioppo & Gardner, 1999; Izard, 1993; Zajonc, 1980). Cognitive processes relate to the acquisition of knowledge, whereas emotions are primarily motivating forces that guide behavior towards certain goals (e.g., approach/avoidance, see e.g., Izard, 1993). Emotions and cognitive processes interact in various ways in human behavior, however, and the motivating and organizing effects of emotions are seen intriguingly in the way emotions influence elementary cognitive processes (Niedenthal & Kitayama, 1994).

How, then, do emotions affect the perception and recognition of facial expressions? One possibility is that emotions "tune" cognitive processes to emotion congruent information (Niedenthal, Setterlund, & Jones, 1994). This

occurs because emotional reactions and more enduring mood states prime emotion-congruent material at many levels (i.e., somatic, perceptual, conceptual, lexical; cf. Niedenthal et al., 1994). Consistent with this hypothesis, a recent study showed that experimentally induced mood states modulated facial expression perception (Niedenthal et al., 2000). Specifically, subjects induced into a happy or in a sad mood state were shown film clips in which the initial expression (happy/sad) gradually became neutral. The subjects in the happy mood condition perceived the offset of the expression of happiness later than the offset of the expression of sadness. In contrast, subjects who were induced into a sad mood perceived the offset of sadness later than the offset of happiness. These effects were interpreted to reflect top-down modulatory effects of emotions on early perceptual encoding of facial expressions (Niedenthal et al., 2000). Subsequently, Niedenthal and others (Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001) have, however, suggested that it is also possible that people mimic (on their own faces) emotion-congruent expressions more efficiently than emotion-incongruent expressions and this motor mimicry, in turn, modulates facial expression perception.

Besides their modulatory effects on the perceptual processing of facial expressions, emotions may contribute to the retrieval of conceptual knowledge associated to the facial expressions. It is possible that conceptual knowledge retrieval relies, in part, on the ability to experience the target emotion oneself. This is suggested by several findings. First, the accuracy of judging negative emotional states in others has been shown to be greatest among subjects demonstrating a pattern of physiological activity similar to that of the person observed (Levenson & Ruef, 1994). This led Levenson and Ruef to suggest that empathic subjects "would be most likely to experience the same negative emotions, albeit in miniaturized form, at approximately the same time as had the targets" (Levenson & Ruef, 1992, p. 242). Second, brain lesions that impair the ability to experience disgust normally also impair the ability to recognize this emotion in others' facial expressions (Sprengelmeyer et al., 1997). Third, patients with lesions in the right somatosensory cortex have been found to be impaired in recognizing facial expressions (Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000). It is possible that due to the lesions in the somatosensory cortices, the patients were not able to simulate how they would themselves experience the target person's emotion (Adolphs, 2002). An ability to experience an emotion oneself may, thus, be a prerequisite for the ability to recognize that emotion in others.

1.3 Neural Mechanisms

Results from brain lesion, event-related brain potential, and functional imaging studies have made it possible to propose relatively detailed neuropsychological models for the perception and recognition of facial expressions (Adolphs, 2002;

Haxby et al., 2002). Figure 2 shows some of the key brain structures that have been found to be involved in the perception and recognition of facial expressions. The perception of facial expressions relies on areas of the occipitotemporal cortex that are involved in the processing of visual information in general (V1/V2) and also on higher-level visual areas that respond selectively to faces and facial expressions (fusiform face area, superior temporal gyrus). Adolphs (2002) suggested that a construction of a detailed perceptual representation of the seen facial expressions takes about 170 milliseconds from the stimulus onset. After this, information from the visual systems is fed forward to emotion-related brain circuits (amygdala, orbitofrontal cortex) which serve to link the visual representation of the face to its emotional meaning (i.e., emotion recognition). This is probably based on three strategies (Adolphs, 2002). First, emotion-related brain structures may modulate the formation of a perceptual representation of the facial expression in visual areas. This may occur via feedback connections from emotion-related structures (amygdala, orbitofrontal cortex) to structures subserving the visual analysis of faces (inferior occipital gyrus, superior temporal gyrus). The modulatory effects may involve allocation of attention to different parts of the facial image. Second, through their connections to different cortical areas and to the hippocampus, emotion–related structures may activate conceptual knowledge associated with a particular facial expression (i.e., its category, name etc.). Third, emotion-related brain structures are connected to motor structures, the hypothalamus, and brainstem nuclei, and via these structures, they may trigger an emotional response in the perceiver. These subjective emotional experiences (represented in somatosensory cortices) may help the perceiver to retrieve conceptual knowledge associated with the expression observed.
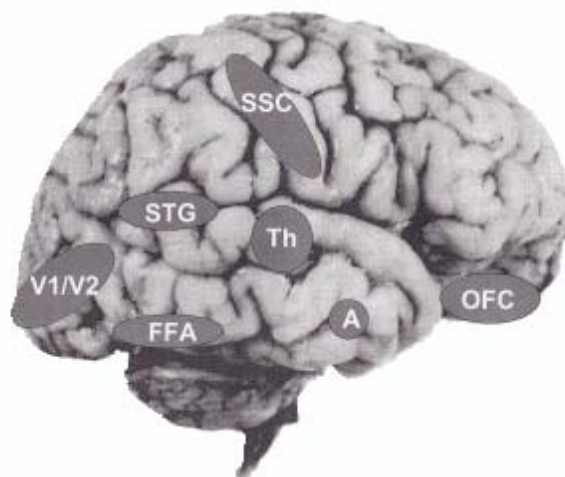
FIGURE 2. Brain areas thought to be involved in the recognition of facial expressions (see text for details). A, amygdala, FFA; fusiform face area; OFC, orbitofrontal cortex; SSC, somatosensory cortex; STG, superior temporal gyrus; Th, thalamus.

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There are inevitably some neural mechanisms that participate in the processing of all facial expressions, but it is assumed that the neural systems for recognizing individual emotions are also partially separable. This is suggested by selective impairments in the recognition of emotional expressions from a specific emotion category as a consequence of certain brain lesions (Calder et al., 2001) and by category-specific activation of certain brain structures as identified by brain imaging studies (Phan, Wager, Taylor, & Liberzon, 2002). For example, the amygdala plays a central role in the recognition of fear-related signals, whereas the insula and basal ganglia seem to be critical for processing of disgust-related signals (Calder et al., 2001).

2. RECOGNITION OF HAPPY FACES

2.1 Happy Face Advantage in Facial Expression Recognition

A face with a smiling mouth and wrinkles at the corners of the eyes (crow's feet) is universally recognized as a signal of felt enjoyment or happiness (Ekman, 1982; Ekman & Davidson, 1993; Ekman, Davidson, & Friesen 1990), or as a signal of a readiness for friendly interaction (Izard & Ackerman, 2000). Interestingly, findings from diverse areas of experimental research show that happy faces are significantly more efficiently recognized than other meaningful facial expressions.

Infants are capable of discriminating and categorizing happy faces before they are capable of discriminating and categorizing other emotional expressions (Nelson, 1987). In adults, a processing speed advantage for happy faces has been found in reaction time (RT) studies in which subjects have been asked to categorize pictures of facial expressions into valence categories (positive/negative) or into discrete emotion categories (e.g., happy/sad). These studies show that happy faces are categorized faster than sad (Crews & Harrison, 1994; Feyereisen, Malet, & Martin, 1986; Hanaya, 1992; Kirita & Endo, 1995; Stanners, Byrd, & Gabriel, 1985), angry (Billings, Harrison, & Alden, 1993; Harrison, Corelczenko, & Cook, 1990; Hugdahl, Iversen, & Johnsen, 1993), disgusted (Ducci, 1981; Stalans & Wedding, 1985), and neutral (Hugdahl et al., 1993) faces. The RT studies are corroborated by evidence for significantly lower recognition thresholds for happy than angry and neutral faces (e.g., Esteves & Öhman, 1993). Hess, Blairy, and Kleck (1997), in turn, showed that the recognition accuracy of angry, disgusted, and sad faces improved linearly with an increase in the physical intensity (i.e., degree of facial muscle activity) of the facial expression to be recognized. In marked contrast, even relatively low intensity happy faces were recognized with a high (almost 100%) level of accuracy.

In line with the results described above, Mack and colleagues (Mack, Pappas, Silverman, & Gay, 2002; Mack & Rock, 1998; Shelley-Tremblay & Mack, 1999) have reported results showing that happy faces and certain other stimuli were recognized even when they were presented under conditions in which most stimuli went unnoticed. Mack and Rock (1998) asked subjects to perform a

simple discrimination task (i.e., to decide which arm of a cross was longer). After this task was performed repeatedly over several trials, a critical trial was run in which another, unexpected, object was presented along with the cross. Subjects were later asked whether they had noticed anything new in this trial. The results showed that most subjects were "blind" to the new objects. This phenomenon is known as inattentional blindness and it suggests that even novel and salient objects may fail to capture attention when the perceiver is engaged in an attention-demanding task. However, and most interesting in the present context, most of the subjects managed to recognize happy faces, their own names, and a stick figure of a man in the critical trials. Sad faces did not have a similar capacity to enter awareness.

2.2 Why Happy Faces?

Tomkins (1962) wrote quite extensively about the social and biological significance of happy faces (or human smiles) and the emotion they convey; joy. He suggested that the sight of another person's smiling face is one of the key elicitors of positive affective reactions in an individual. As noted above, there is now much evidence showing that mere passive observation of a smiling face is sufficient to elicit positive emotional reactions in the observer, as measured by emotion-specific facial muscle activity (Dimberg, 1990; Surakka & Hietanen, 1998) and subjective feelings (Wild et al., 2001). According to Tomkins (1962), these positive affective reactions have a crucial role in the initiation and maintenance of interpersonal interaction and in the formation of social bonds. Specifically, "the mutual enjoyment of each other's presence is one of the most important ways in which social interaction is rewarded and perpetuated" (Tomkins, 1962; p. 399). Social interaction, in turn, is important for our individual survival and group reproduction (Tomkins, 1962). For example, the survival and development of the human infant relies heavily on social interaction.

Joy, of course, is not the only emotion that is elicited in social interaction. Both positive (joy) and negative (e.g., sadness) emotions have been shown to be contagious from observing the facial expressions of these emotions (Dimberg, 1990; Wild et al., 2001). It is possible, however, that observing a happy face elicits joy more likely than observing a discrete negative expression elicits the respective negative emotion. Tomkins (1962), for example, postulated that joy is the most central emotion that is elicited in social interaction. There is also evidence showing that, when people are asked to rate the strength of their own emotional responses to happy and sad faces, stronger responses are obtained for happy as compared to sad faces (see Tables 1 and 2 in Wild et al., 2001). In addition, sad faces evoke not only sadness, but also other negative emotions such as anger and fear (although to a lesser extent, Wild et al., 2001). These differences may partly ensue from the ambiguity of discrete negative facial

expressions (see Discussion section below), but it is possible that there are also other, motivational factors behind the differential responsiveness to positive and negative affective cues. Specifically, people may strive to maintain a positive affective state (Diener & Diener, 1996). This may be achieved, for example, by directing attention away from negative cues, at least when their threat value is low (e.g., Bradley et al., 1997). Indeed, the maintenance of a positive baseline for affect may be important because positive affect prompts exploratory behavior (Cacioppo & Gardner, 1999; Cacioppo, Gardner, & Berntson, 1999; Diener & Diener, 1996).

Emotional reactions to happy faces may, thus, reflect an adaptationally useful mode of behavior (Tomkins, 1962) and it is possible that people are normally more responsive to happy than to other (negative) facial expressions. Could this particular responsiveness to happy faces also explain why there is the above-described *recognition* advantage of happy faces? This is possible because emotional responses to facial expressions and the recognition of facial expressions may be partly based on the same processes. As noted earlier in this text, the recognition of facial expressions may be based on information provided by imitation of the target expression in one's own face and/or on information provided by the reproduction of the subjective emotional experiences associated with the target expression (Adolphs, 2002; Levenson & Ruef, 1992; Niedenthal et al., 2001). Consequently, the increased proneness of people to reproduce happy faces and joy originating from the rewarding consequences as well as the adaptive advantages of this behavior may form a basis for the recognition advantage of happy faces as well.

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3. THE PRESENT STUDIES

The present studies were planned to examine factors underlying the consistent recognition speed advantage of happy faces in choice-reaction tasks. Responsiveness to positive emotional cues may play an important role in human social interaction and people may normally respond more strongly to happy facial expressions than to other (negative) facial expressions, as indicated by the strength of their own emotional reactions during observation of these expressions. This particular responsiveness to smiling faces may explain the happy face advantage in the recognition of facial expressions. Though this is an intriguing possibility, emotional factors do not necessarily underlie the recognition advantage of happy faces in RT experiments. Namely, there are also reasonable alternative explanations for this result. People may, for example, recognize happy faces more quickly because happy faces contain physical characteristics that allow them to be more simply processed than other facial expressions. Such physical differences between positive and negative faces have not been adequately controlled for in previous studies.

The first goal of the present studies was to establish to what extent the happy face advantage is attributable to low-level physical differences between positive and negative facial expressions. Second, we examined at which stage in the stimulus-response processing chain the RT advantage for happy faces occurs. Specifically, does the RT advantage for happy faces reflect faster cognitive processing of happy faces (i.e., processes leading up to, and including, response selection) exclusively, or might it also reflect differential effects of positive and negative faces on motor-execution processes? The third goal was to examine whether emotional factors affect the happy face advantage. There is good reason to assume that positive emotional reactions in the perceiver enhance the recognition of happy faces but there is no direct evidence to support the view that there are such effects in RT tasks.

3.1 The Role of Low-Level Stimulus Characteristics in the Happy Face Advantage

The happy face advantage may reflect the differential quality or differential physical characteristics of positive and negative facial expressions. In most of the studies showing the happy face advantage, photographs of people with different facial expressions have been used as stimuli. Negative emotional

expressions are probably more difficult to produce voluntarily than positive expressions are (Öhman, Lundqvist, & Esteves, 2001). Therefore, in the pictures of people's facial expressions, negative expressions may be more heterogeneous, less well posed and, hence, also more difficult to recognize than positive expressions. Another possibility is that negative expressions are physically more similar to neutral faces than positive expressions are (Johnston, Katsikitis, & Carr, 2001). This may complicate the discrimination of negative and neutral expressions and, consequently, prolong their processing times. Together, these considerations clearly imply that the processing advantage of natural happy faces should be interpreted cautiously.

Study I of the present series was planned to replicate earlier results showing the happy face advantage and to examine whether this advantage is due solely to low-level physical differences between positive and negative facial expressions. In Experiment 1, recognition times of happy, neutral, and disgusted faces were investigated in a 3-choice reaction time task. Photographs of people with these three different facial expressions were used as stimuli. The primary interest was to show that happy faces are recognized more quickly than neutral and disgusted faces (cf. Ducci, 1981; Hugdahl et al., 1993; Stalans & Wedding, 1985). In Experiment 2, the first experiment was replicated by using schematic drawings of facial expressions as stimuli. Schematic facial expressions convey anger, happiness, sadness, and emotional neutrality effectively (e.g., Fox et al., 2000; Öhman et al., 2001; White, 1995). In Experiment 2, we used eyebrowless faces with an upward-curved, straight, and a downward-curved line as the mouth to signal happiness, sadness, and emotional neutrality, respectively (Figure 3). Importantly, the drawn happy and sad faces differed to a comparable extent from expressionless neutral faces and they also contained the same number of critical features. It was expected that if low-level physical characteristics underlie the faster recognition of happy faces, this effect would disappear when schematic faces are used. On the other hand, if the results still show faster recognition times for happy than sad faces, the likelihood of the existence of other explaining factors increases.

FIGURE 3. Examples of the schematic happy, neutral, and sad faces used in Experiment 2 of Study I.

The use of the schematic facial expressions did not solve all the problems, however. Specifically, there may be differences in the detection/recognition

speed of up- and down-turned curves *per se* that could possibly produce differences to the recognition times of schematic happy and sad faces. This possibility was tested in Experiment 3 of Study I. The recognition times of the mouth-parts of the schematic faces were examined by presenting them in isolation (i.e., not in the context of a face).

Experiment 3 also allowed us to examine an additional issue related to the happy face advantage. Namely, the processing of happy faces may be based on a very different cognitive strategy than the processing of other (negative) facial expressions. It is possible that, unlike other facial expressions, happy faces are recognized on the basis of a single diagnostic facial feature (i.e., a smiling mouth, see Adolphs, 2002). This is a very important factor to control for as evidence suggests that when a salient feature can be used to categorize a stimulus, reaction times can be very short; most likely because no complete visual analysis of the stimulus is performed (cf. Fabre-Thorpe, Delorme, Marlot, & Thorpe, 2001). On the other hand, a feature-based responding strategy may be less likely when the objects to be recognized are human facial expressions (cf. Calder et al., 2000). Facial organization may block access to low-level facial features as shown by inhibited detection of a curved line when it is presented in a face context (Suzuki & Cavanagh, 1995). Here the possibility that happy faces are recognized on the basis of mouth-line alone was examined by comparing the recognition times of schematic happy faces (Exp. 2) to those obtained when the mouth-parts of the schematic happy faces were presented in isolation (Exp. 3). If the recognition times of isolated upturned curves equaled those of schematic happy faces, it would suggest that the happy faces are processed using a feature-based coding strategy.

3.2 The Role of Cognitive and Motor Processes in the Happy Face Advantage

It has been generally assumed that the happy face advantage reflects a difference in the perception and/or recognition of positive and negative facial expressions. In line with this assumption, there are clear indications that the happy face advantage occurs, at least partly, at stimulus perception and recognition stages. For example, the P300 component of the event-related brain potential has a shorter onset latency to happy than to sad (Orozco & Ehlers, 1998) and angry (Kestenbaum & Nelson, 1992) faces. The onset of the P300 is assumed to be determined by processes involved in stimulus evaluation and categorization (McCarthy & Donchin, 1981). However, these findings do not rule out the possibility that the happy faces are more quickly processed at some other information processing stages as well. Performance in a choice reaction time task consists not only of cognitive (stimulus recognition and response selection), but also of motor (response execution) processes (Grice, Nullmeyer, & Spiker, 1982; McClelland, 1979; Sternberg, 1969). In Study II, we examined whether the

happy face advantage might also involve a difference in the speed of motor-execution of responses to positive and negative facial signals. This was important as the existence of motor-effects would point to quite a novel explanation for the happy face advantage. It is possible, for example, that the happy face advantage reflects facilitative effects of positive cues and inhibitory effects of negative cues on motor processes. Inhibitory effects by negative cues may be especially likely. Negative cues may, for example, trigger extensive cognitive analysis, which slows their processing (Stenberg, Wiking, & Dahl 1998) and possibly also interferes with response selection and execution (Dijksterhuis & Aarts, 2003). Derryberry (1991) showed that negative feedback signals inhibited response execution and, importantly, this inhibition took place after the selection of the response to be executed. Derryberry (1991) suggested that the inhibition effects reflected an activation of the behavioral inhibition system (BIS), which suppresses the execution of already selected response programs. To examine the possibility that positive and negative facial expressions produce differential effects on motor processes, we measured the speed of cognitive (i.e., all processes up to and including response selection) and motor-execution processes in speeded recognition of happy and disgusted/angry faces.

3.3 The Effects of Emotional Context on the Happy Face Advantage

There is good reason to assume that emotional factors give a head-start for happy faces over other facial expression in facial expression recognition. There is a positive baseline for affect in humans (Cacioppo & Gardner, 1999; Cacioppo et al., 1999; Diener & Diener, 1996) and joy especially is efficiently elicited by observation of others' facial expressions (Tomkins, 1962; Wild et al., 2001). Positive affect may facilitate the recognition of happy faces via two mechanisms. First, as suggested by emotion-network models (see Niedenthal et al., 1994 for a review), memory may be emotionally structured and, thus, emotional reactions and more enduring mood states may temporarily increase the accessibility of emotion-congruent perceptual and conceptual material in memory. As a consequence, the processing of emotion-congruent stimuli is facilitated. Such emotion-congruency effects have been demonstrated in the perception of facial expressions (Niedenthal et al., 2000). Second, subjective positive emotional experiences may act as an additional cue or as an independent extra source of information that guides decision processes. Several researchers have suggested that subjective emotional experiences that are compatible with the signal value of the observed facial expression form a basis for the ability to understand the meaning of others' facial expressions (Adolphs, 2002; Levenson & Ruef, 1994; Sprengelmeyer et al., 1997).

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Studies III and IV tested the hypothesis that positive emotions facilitate the recognition of happy faces. In Study III, pleasant and unpleasant odors were used to examine the influence of evaluative context on the processing speed of facial expressions. Odors offered an effective way to manipulate the hedonic impact of the context as they may directly affect emotion-related brain circuits (Anderson et al., 2003; Royet et al., 2000; Zald & Pardo, 1997; Zatorre, Jones-Gotman, & Rouby, 2000). Odors have also been shown to have effects on several emotion-related behaviors, including startle reflex (Ehrlichman, Kuhl, Zhu, & Warrenburg, 1997), facial electromyographic responses (Jäncke & Kaufmann, 1994), voice pitch (Millot & Brand, 2001), and mood states (e.g., Schiffman, Sattely-Miller, Suggs, & Graham, 1995; Schiffman, Suggs, & Sattely-Miller, 1995). It was predicted here that, if emotional factors contribute to the processing of facial expressions, a pleasant odor context should amplify the happy face advantage by facilitating the recognition of happy faces. It was also expected that an unpleasant odor context diminishes the happy face advantage because it interferes with the recognition of happy faces.

In Study IV, we tested whether depressed patients show impairments in the recognition of happy faces. Depression reduces positive emotional reactions to pictorial stimuli (Sloan, Strauss, Quirk, & Sajatovic, 1997; Sloan, Strauss, & Wisner, 2001). Thus, it was predicted that if positive emotional experiences play a role in the rapid recognition of happy faces, then the happy face advantage should be smaller in depressed patients than in matched healthy controls. To examine this, the recognition speed and accuracy of happy, neutral, and sad faces was measured in clinically depressed patients and matched healthy controls.

4. METHOD AND RESULTS

4.1 General Methodology

The experiments were designed to measure the speed of recognizing positive (i.e., happy), negative (i.e., angry/disgusted/sad), and, in some experiments, also neutral faces. In one experiment (Exp. 2, Study I) schematic drawings of facial expressions or parts of them (Exp. 3, Study I) were used as stimuli. Otherwise, the stimuli were chosen from Ekman's and Friesen's (1976) Pictures of Facial Affect, which is a widely used and standardized picture set. Ekman's and Friesen's set contains pictures of 14 models, who were trained to contract or to relax facial muscles associated with expressions of anger, disgust, fear, happiness, sadness, and surprise. There is also a neutral (expressionless) face for each model.

In the present studies, the faces were briefly (200 ms) presented on a computer screen. The participants were always asked to recognize which discrete emotion (e.g., happiness, neutrality, disgust) was expressed in the face, and respond accordingly by pressing a key in a button box or computer keyboard. This sort of task necessitates not only the processing of the physical characteristics of the facial expressions (i.e., *perception*), but also *recognition* of the meaning (i.e., category; name etc.) of the expression (cf. Adolphs, 2002). The markings of the response keys (e.g., happy-neutral-disgusted/disgusted-neutral-happy) were balanced between the participants. The participants were instructed to respond as quickly as possible and to avoid incorrect responses as best they could.

As a main dependent variable, the reaction time (RT) from the onset of the facial expression to the registration of a manual response for different facial expressions was measured. The mean RTs were always based on a substantial number of repetitions of stimuli from a particular emotion category (i.e., 30-96 trials per condition). Before calculation of the mean reaction times, incorrect responses and responses with reaction times beyond certain cut-off points were removed. In addition to RTs, the recognition accuracy of facial expressions was assessed. The use of the recognition accuracy as a dependent variable was, however, limited by the fact that, in some experiments, the accuracy scores were close to ceiling.

In addition to RTs, movement-related brain potentials (lateralized readiness potentials, LRP) were recorded in order to examine the speed of cognitive and motor performance separately (Study II). The LRP reflects hand-specific motor preparation in the precentral motor cortex. In a two-choice RT task in which both hands are used in responding, the LRP occurs when the subject has decided by which hand to respond and starts a hand-specific motor preparation (Coles, 1989). Thus, the LRP can be used to divide the stimulus-response chain into two processing stages, i.e., into all processes up to and including response selection (from stimulus to LRP onset) and response execution (from LRP to behavioral response onset).

4.2 Results

Study I

In Experiment 1, subjects were asked to recognize happiness, neutrality, and disgust from photographs of people with these facial expressions. The results replicated earlier findings by showing significantly shorter RTs to happy compared to neutral and disgusted faces (Figure 4, left). In Experiment 2, a new group of subjects performed the same task as that used in Experiment 1 but now the stimuli were schematic drawings of happy, neutral, and sad faces. Happy faces and now also neutral faces were recognized more quickly than sad faces (Figure 4, middle).

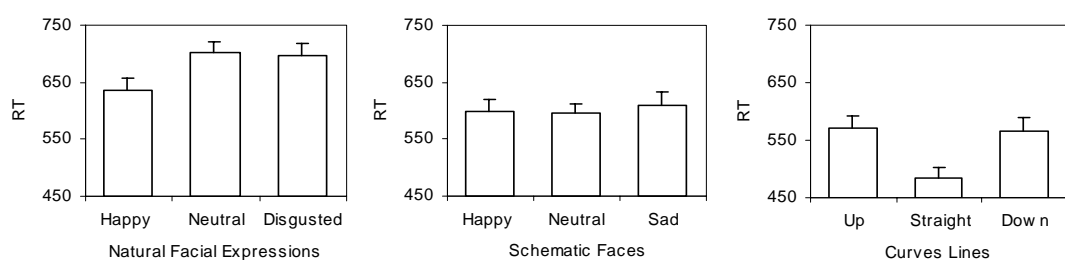FIGURE 4. Mean reaction times (RT) as a function of stimulus type in Experiments 1, 2, and 3 of Study I.

In Experiment 3, the mouth-lines of the schematic faces were presented in isolation (i.e., not in the context of a face). There was no difference in RTs to up-turned as compared to down-turned curved lines (Figure 4, right). This suggested that the recognition advantage of schematic happy faces over schematic sad faces

in Experiment 2 was not simply due to more efficient processing of up- than down-turned mouth-lines. The results of Experiment 3 also revealed some additional differences in RTs to faces and isolated mouth-parts. First, the RTs to the isolated mouth-parts (Exp. 3) were, overall, shorter than the RTs to the schematic faces (Exp. 2). Second, there was a robust RT advantage for straight lines as compared to up-turned and down-turned lines. No such "straight line advantage" was observed in Experiment 2. Together, these two differences in RTs to schematic faces (Exp. 2) and to isolated mouth parts (Exp. 3) suggested that faces and isolated mouth-parts were recognized by using different types of processing strategies.

Study II

Here LRPs were recorded to examine whether the processing time advantage for happy faces takes place exclusively at the cognitive processing stages (i.e., at stimulus recognition and response selection processes), or whether it also involves an advantage in the speed of motor-execution. In Experiment 1, subjects were asked to recognize happiness and disgust from pictures of people with these expressions, and respond accordingly by pressing one of the two buttons by using their left or right hand. The results showed significantly shorter behavioral RTs to happy than to disgusted faces (Figure 5, left). The time interval from the stimulus onset to the LRP was also shorter for happy than disgusted faces but this difference did not reach statistical significance. The difference was significant when only those subjects showing a happy face advantage in behavioral RTs were included in the analysis. No differences in the time interval from LRP to behavioral response onset were found.
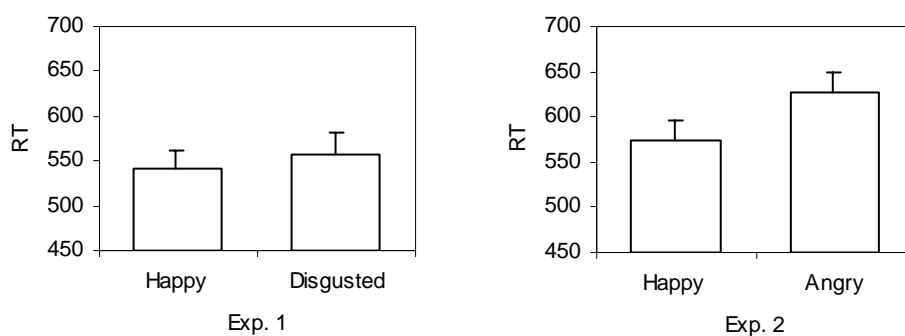

FIGURE 5. Behavioral reaction times (RT) to happy and disgusted (Exp. 1) and to happy and angry (Exp. 2) faces in Study II.

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Experiment 2 was planned to replicate and extend the results of Experiment 1. Similarly as in Experiment 1, RTs and latencies of stimulus and response-locked LRPs for expressions of positive and negative emotions were measured. However, two changes were made to the recognition task. First, angry instead of disgusted faces were used as emotionally negative stimuli. It was reasoned that threatening signals may be especially capable of affecting motor processes. Second, neutral faces were also presented as no-go signals (i.e., as stimuli requiring no response). This was because a two-choice (happy/angry) RT task would have been susceptible to the use of simplified processing strategies (i.e., happy/not-happy classification). The results of Experiment 2 showed faster behavioral RTs to happy than to angry faces (Figure 5, right). The mean time interval from the stimulus onset to the LRP was now significantly shorter for happy than angry faces (Figure 6, left), but there was no difference in the time interval from the LRP to the response registration (Figure 6, right). Taken together, these results suggest that there is a processing time advantage for happy faces at stimulus recognition and response selection stages, but there is no processing time advantage for happy face at the later, response-execution stages. It would therefore appear that motor facilitation for happy faces and motor inhibition for negative faces do not play a role in explaining the RT advantage for happy faces.
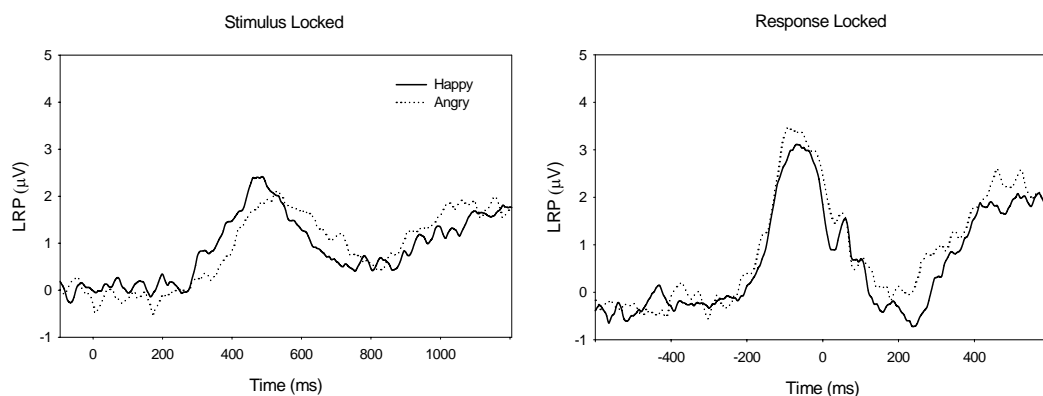
FIGURE 6. Stimulus and response-locked grand average lateralized readiness potentials (LRP) for happy and angry faces in Experiment 2 of Study II.

Study III

Study III included two experiments that examined the effects of emotional context on the happy face advantage observed consistently in the previous experiments. In Experiment 1, subjects were asked to recognize happy and disgusted faces in two sessions. In one session, subjects were exposed to diluted

pyridine (an unpleasant odor) and, in another, subjects were exposed to either benzaldehyde or lemon, both pleasant odors. The order of the two sessions was counterbalanced between subjects. The results showed a significant interaction between odor condition and facial expression category. As illustrated in Figure 7 (left), happy faces were recognized more quickly than disgusted faces in the pleasant odor condition. However, in the unpleasant odor condition, the happy face advantage disappeared and disgusted faces were recognized slightly faster than happy faces. Inspection of Figure 7 also shows that the happy face advantage disappeared because of slow recognition of happy faces in the unpleasant odor condition. There was no evidence for a facilitated recognition of disgusted faces in the unpleasant odor condition.
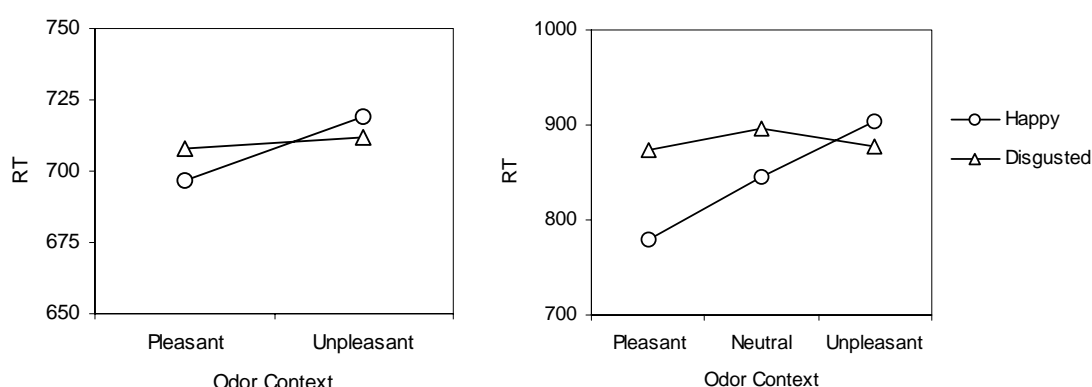
FIGURE 7. Reaction times (RT) to happy and disgusted faces as a function of odor context in Experiments 1 (left) and 2 (right) of Study III.

Experiment 2 was intended to replicate and extend the results of Experiment 1 in several ways. First, a neutral (no-odor) condition was added and the within-subject design was switched to a between-subject design. The inclusion of a no-odor control group made it possible to examine whether both pleasant and unpleasant odors or only one of these affected the processing of facial expressions. Second, less intense facial expressions than those used in Experiment 1 were used as stimuli. The intensity of the facial expressions was only half of the intensity level used in Experiment 1. It was hypothesized that emotional context might have stronger effects on the recognition of low intensity facial expressions than on the recognition of prototypical, clearly visible facial expressions. Third, the two-choice categorization task (happy/disgusted) was switched to a three-choice categorization task (happy/neutral/disgusted). This was done in order to avoid the use of simplified processing strategies (i.e., happy/not-happy classification). However, as the main purpose was still to examine odor-effects on the happy face advantage over disgusted faces, the recognition time/accuracy of neutral faces was not considered in the statistical analyses.

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The results of Experiment 2 again showed significant odor effects on the happy face advantage (Figure 7, right). The pleasant odor group and the no-odor group did not differ significantly in the magnitude of the happy face advantage but, in the unpleasant odor group, the happy face advantage disappeared completely. This was due to slow recognition of happy faces in the unpleasant odor group. Now odors also affected the recognition accuracy scores. The advantage of happy faces over disgusted faces in the recognition accuracy scores was greater in the pleasant odor group than in the no-odor group. This amplification of the happy face advantage in the pleasant odor group originated from odor effects on the recognition of happy faces. Specifically, happy faces were more accurately recognized in the pleasant than in the no-odor group (facilitation).

Study IV

Study IV examined whether depressed patients show impairments in the recognition of happy faces. A task similar to those used in previous experiments was employed to examine the recognition of happy, neutral, and sad facial expressions in clinically depressed patients and matched healthy controls. It was expected that the recognition speed advantage of happy faces over sad faces would be less in depressed patients than in healthy controls. Results regarding the recognition of neutral faces are not considered here.
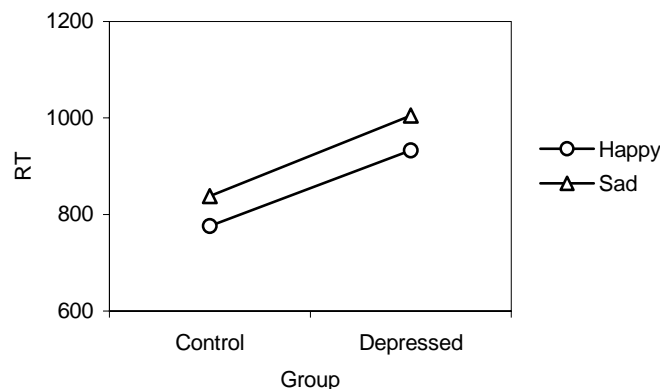
FIGURE 8. Reaction times (RT) to happy and sad faces in healthy controls and clinically depressed patients (Study IV).

The results showed, first, that depressed patients showed slower overall RTs than healthy controls (Figure 8). However, contrary to the expectations, the pattern of RTs to happy and sad faces within the groups was identical. Specifically, the RT advantage for happy faces over sad faces was evident not

only for controls, but also for depressed patients. There was also no evidence for diminished recognition accuracy of happy faces in depressed patients.

In the second part of Study IV, twelve depressed patients (and matched controls) were re-tested after showing signs of symptom remission. The patients in remission showed a decrease in self-reported depressive symptoms, and a marginally significant increase in the intensity of positive affects. The mood changes were not, however, accompanied by changes in the recognition of happy, neutral and sad faces (Figure 9).
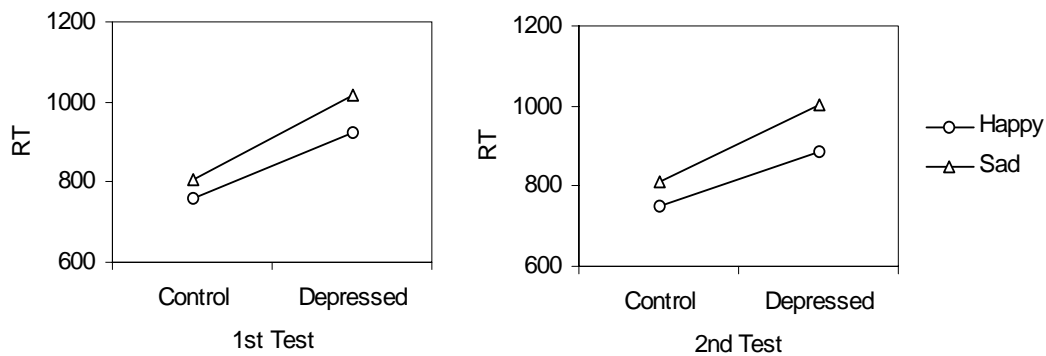

FIGURE 9. Reaction times (RT) to happy and sad faces in re-tested depressed patients and non-depressed controls in the first and second test (Study IV).

5. DISCUSSION

The happy face advantage over other (negative) facial expressions has been documented in a number of studies over several years. Study I of the present series of studies replicated this finding and suggested that the happy face advantage is not simply attributable to low quality (heterogeneity) of negative facial expressions. Study I further suggested that the happy face advantage may not ensue from a rapid detection of an up-turned mouth-line in happy faces. Instead, the observed findings were more consistent with the idea of configural/holistic coding of faces and facial expressions (Calder et al., 2000; Suzuki & Cavanagh, 1995; White, 2000). Study II showed, quite consistently, that the happy face advantage occurs exclusively at premotoric stages in the stimulus-response processing chain. These stages involve stimulus perception and recognition as well as response selection processes. Study III showed that the happy face advantage is significantly modulated by the emotional context. The happy face advantage was observed in a pleasant odor context, but not in an unpleasant odor context. This finding supported the hypothesis that the influences of positive emotions on cognitive processes may partly explain the processing advantage of happy faces. Clinical depression did not, however, impair the recognition of happy faces (Study IV).

It seems most plausible that the happy face advantage reflects an effect of several separate factors. In the following, I will first consider all those factors that presumably facilitate the recognition of happy faces and all those factors that complicate the recognition of negative facial expressions. I will then focus more specifically on one of the discussed factors, the facilitatory effect of positive emotions, and discuss possible mechanisms through which emotional context may influence facial expression processing.

5.1 Multiple Causes of the Happy Face Advantage

There are at least three possible ways in which the processing of happy faces may be facilitated. First, happy faces are unique in the sense that there are no other perceptually similar facial expressions or conceptually similar (positive) emotions. This makes it unlikely that happy faces are misinterpreted as signs of other positive/negative emotional states. In a choice-reaction task, this factor is likely to cause substantial facilitation since the speed of performance depends on how unequivocally the information extracted from the stimulus favors one of the

alternative response options (emotion categories) (cf. Grice et al., 1982; McClelland, 1979). Second, happy faces are very common in everyday life (Bond & Siddle, 1996; Öhman et al., 2001). High-frequency stimuli are more efficiently processed than low-frequency stimuli, perhaps due to higher baseline activation of the relevant processing units (McClelland & Rumelhart, 1981) or stronger associative links for high-frequency stimuli (McClelland, 1979). An important question concerns the effects of environmental experiences (e.g., the frequency of encountering certain facial expressions) on the development of facial expression processing (Nelson, 1987; Pollak & Kistler, 2002). If the happy face advantage ensues from the fact that happy faces are encountered more often than other facial expressions, it would imply that environmental factors play a role in the development of facial expression processing. Indeed, there are indications that early affective experiences may modify the development of facial expressions recognition (Pollak & Kistler, 2002). The third possibility is that the positive baseline for affect in normal contexts (Cacioppo et al., 1999; Diener & Diener, 1996) and positive emotional experiences evoked by happy faces (Dimberg, 1990; Surakka & Hietanen, 1998; Tomkins, 1962; Wild et al., 2001) facilitate the recognition of happy faces. Support for this hypothesis was obtained from the finding that the happy face advantage was more pronounced in a pleasant than in a neutral or unpleasant context (Study III). There are several possible ways in which a positive emotional context may affect the recognition of happy faces, as will be detailed later in this discussion.

Two factors may impede the recognition of discrete negative emotions from faces. First, and perhaps most importantly, a particular negative facial expression (e.g., disgust) may share a great degree of changes in the configuration of facial features with some other negative facial expression (e.g., anger) (Johnston et al., 2001). This also applies to schematic facial expressions. A schematic sad face, for example, shares a downward curved mouth-line with a schematic angry face. Indeed, a schematic sad face may sometimes be classified as angry (see Fox et al. 2000, p. 77). As regards reaction times, these considerations imply that an individual negative expression may favor more than one of the response categories available (or some other categories not in the response set) at the same time (cf. Russell & Bullock, 1986). This undoubtedly causes a response delay because there is a conflict at the response selection stage (Grice et al., 1982; McClelland, 1979). Although the delay in the recognition of separable negative emotions may be based on the perceptual similarities between these expressions, different negative emotions may also share similarities at the conceptual level (cf. Adolphs, Tranel, & Damasio, 2003). Fear, anger, and disgust may, for example, evoke similar types of responses (autonomic activation, flight etc.) (Johnston et al., 2001).

Another factor which may impede the recognition of negative signals relates to the hypothesis that negative cues trigger extensive and time consuming cognitive analysis (see Taylor, 1991 for a review). Measurements of the event-related brain potentials have shown preferential allocation of processing resources to emotionally negative cues (Carretié, Martín-Loeches, Hinojosa, &

Mercado, 2001; Carretié, Mercado, Tapia, & Hinojosa, 2001; Ito, Larsen, Smith, & Cacioppo, 1998; Smith, Cacioppo, Larsen, & Chartrand, 2003). Task irrelevant negative signals capture attention and interfere with performance (Eastwood, Smilek, & Merikle, 2003; Pratto & John, 1994). This bias in the allocation of processing resources may also delay the categorization of negative affective cues (Stenberg et al., 1998). Dijksterhuis and Aarts (2003) suggested that negative cues trigger greater processing and, in a choice-reaction task, this interferes with response selection and execution. There is, indeed, some evidence that certain types of negative cues (feedback signals) may inhibit motor execution (Derryberry, 1991). The present results do not rule out the possibility that negative facial cues interfere with premotoric response selection processes. However, there was no such interference which would affect motor-execution processes (Study II). This suggests that the interference effect by negative cues may be more limited than that suggested by Dijksterhuis and Aarts (2003).

5.2 Emotional Context and the Recognition of Happy Faces

The results of Experiment 2 in Study III (recognition accuracy scores) showed that, compared to a neutral (no-odor) context, a pleasant odor context amplified the happy face advantage by facilitating the recognition of happy faces. There was also an indication that an unpleasant context inhibited the recognition of happy faces. The happy face advantage over disgusted faces (recognition times) was significantly smaller in the unpleasant compared to the neutral odor context, mainly due to the slow recognition of happy faces.

Odors may have direct (i.e., not cognitively-mediated) influences on emotional processes (Izard, 1993) and several studies have shown odor-effects on key emotion-related brain circuits (Anderson et al., 2003; Royet et al., 2000; Zald & Pardo, 1997; Zatorre et al., 2000). These brain structures (amygdala, orbitofrontal cortex) may play a significant role in the perception and recognition of facial expressions as well (Adolphs, 2002). Thus, it is possible that the facilitative effects of pleasant odors on the recognition of happy faces reflect odor-induced bias in the functioning of brain structures involved in the recognition of happy faces. These structures may affect how attention is allocated to different parts of the facial image (Adolphs, 2002) and hence modulate the perceptual processing of happy faces. It may be that the weight of emotion-congruent aspects of the face is increased in the overall judgment (Niedenthal et al., 2000). A pleasant context may also facilitate the triggering of subjective positive emotional experiences in response to a smiling target face. These subjective reactions, in turn, may be used as one source of information when recognizing the target emotion (Adolphs, 2002; Levenson & Ruef, 1992; Sprengelmeyer et al., 1997). Although these mechanisms are plausible,

inferences about the exact locus of the odor-effects must be made cautiously since odors may affect postperceptual response selection processes as well.

Study III also showed some evidence for an inhibition caused by an unpleasant odor in the recognition of happy faces. It is possible that the engagement of negative emotional processes increased the weight of those perceptual aspects of happy faces that are not associated with happiness. Negative contexts may also diminish positive emotional experiences. Together, these effects may interfere with the recognition of happy faces. The unpleasant odor did not, however, facilitate the recognition of disgusted faces. It may be that discrete negative emotions (disgust) are very difficult to prime experimentally (Isen, 1985). However, an alternative explanation for the lack of facilitation effects for disgusted faces is that the negative odors caused a general interference (distraction) effect which inhibited recognition performance and hence obscured the facilitative effects of negative emotions. Performance inhibition by negative affective cues has been reported (e.g., Derryberry, 1991). Thus for the present it remains open whether there is a real asymmetry in the priming effects of pleasant and unpleasant odors or whether a general interference obscured the priming effects of unpleasant odors.

Depression reduces positive emotional reactions (Sloan, Bradley, Dimoulas, & Lang, 2002; Sloan et al. 1997; 2001). Based on this, it was expected here that depressed patients might not show the normal facilitation in the recognition of happy faces. Accordingly, we predicted that the happy face advantage over sad faces would be smaller in depressed patients than in healthy controls. Contrary to this, depressed subjects showed a completely normal happy face advantage in recognition times (Study IV). It is noteworthy that Ridout and colleagues recently reported totally congruent findings (Ridout, Astell, Reid, Glen, & O'Carroll, 2003). These results are somewhat surprising as findings from studies using other methods to evaluate facial expression processing have shown that depressed patients show abnormalities in the processing of happy faces. Depressed patients do not, for example, show normal positive emotional responses (i.e., facial muscle activation) while viewing pictures of happy faces (Sloan et al., 2002). Depressed people allocate less processing resources to positive cues than healthy controls as shown by the measurements of event-related brain potentials (Deldin, Keller, Gergen, & Miller, 2001). The amplitude of the face-specific N200 component of the event-related brain potential is also selectively reduced in response to happy faces in depressed patients (Deldin, Keller, Gergen, & Miller, 2000). On the other hand, antidepressant drugs selectively increase the recognition accuracy of happy faces in healthy people (Harmer, Hill, Taylor, Cowen, & Goodwin, 2003).

Do the findings of Study IV indicate that positive emotional reactions do not play a role in the happy face advantage? One can interpret these findings as indicating that normal positive emotional reactions are not *necessary* for the happy face advantage. If they were, depressed patients should have shown a smaller happy face advantage than healthy controls. However, the findings of Study IV should not be interpreted to show that positive emotions do not

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contribute to the happy face advantage in healthy subjects. As emphasized above, the happy face advantage may rely on many factors, including distinctive physical features, lack of alternative interpretations, and the presence of positive emotional experiences. In healthy people, the happy face advantage may reflect an effect of all these factors. Depression, in turn, may diminish the presence of positive emotional responses (Sloan et al., 2002), but due to other factors, depressed patients still show the happy face advantage in the recognition of facial expressions. Depressed patients may even compensate the lack of subjective positive emotional experiences by basing their responses to a larger extent on other existing and perhaps more "objective" cues (e.g., physical features of the expression). In light of this assumption, it would be interesting to examine whether depressed patients recognize happy faces normally when the visual cues in the observed face are not so clear; i.e., when the intensity of the expression is low. The results of Study III showed that the effects of emotional factors were more pronounced when the intensities of the expressions to be recognized were lower than normally. Similarly, Harmer et al. (2003) found that the modulatory effects of antidepressant drugs where visible only in the recognition of low-intensity happy faces.

6. CONCLUSIONS

Taken together, the present findings confirm that happy faces are more quickly and, in some cases, also more accurately recognized than other (negative) facial expressions in choice-reaction time tasks. The speed of performance in such tasks depends on how unequivocally the stimulus favors one of the alternative response options. In this respect, a happy face seems to constitute an ideal stimulus because it shares few perceptual and conceptual characteristics with other emotional expressions. Discrete negative facial expressions such as expressions of disgust, anger, fear, and sadness, in turn, share similarities at both perceptual and conceptual levels and, therefore, are not as unequivocal stimuli as are happy facial expressions.

Importantly, the present results suggest that the unambiguous nature of happy faces is also based, at least partly, on the biasing and organizing effects of positive emotions on processes involved in the recognition of facial expressions. There are reasonable mechanisms for such emotion-cognition interactions; i.e., emotional reactions may prime the processing of emotion-congruent material and/or function as a cue for the decision-making system. For the present, it remains open whether both or only one of these mechanisms are involved in the recognition of happy faces. In any case, it seems that the happy face advantage is best understood by taking into account not only the physical characteristics of the stimuli but also the biasing effects of emotions on human cognitive functioning.

Positive emotional reactions (joy) play a crucial role in the regulation of interpersonal behavior. The communication of positive emotions, in turn, may rely substantially on the expression and recognition of happiness in the face (Tomkins, 1962). If expressions of happiness have such an important role in human social behavior, it makes adaptive sense that people are predisposed to respond to these signals especially efficiently. This responsiveness is, perhaps, shown primarily in the contagion of positive emotional experiences from observing a happy face, but it is also manifest in efficient cognitive processing of happy faces.

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