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Behold the Wrath: Psychophysiological Responses to Facial Stimuli[1]

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The complex musculature of the human face has been shaped by natural selection to produce gestures that communicate information about intentions and emotional states between senders and receivers. According to the preparedness hypothesis, different facial gestures are differentially prepared by evolution to become associated with different outcomes. As attested by psychophysiological responses in Pavlovian conditioning experiments, expressions of anger and fear more easily become signals for aversive stimuli than do expression of happiness. Consistent with the evolutionary perspective, the superior conditioning to angry faces is stronger for male than for female faces, for adult than for child faces, and for faces directed toward the receiver rather than directed away. Furthermore, it appears to be primarily located in the right cerebral hemisphere. The enhanced autonomic activity to angry faces signaling electric shock is not mediated by conscious cognitive activity, but is evident also when recognition of the facial stimulus is blocked by backward masking procedures. Similarly, conditioned responses can be established to masked angry, but not to masked happy faces. Electromyographic measurement of facial muscle activity reveals a tendency for emotional facial expression to rapidly and automatically elicit its mirror image in the face of the receiver, typically accompanied by the appropriate emotional experience. The research reviewed in this paper supports the proposition that humans have been evolutionarily tuned to respond automatically to facial stimuli, and it is suggested that such early automatic reactions shape the subsequent conscious emotional processing of the stimulus.

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The human skull is embedded in two layers of muscles. The inner one is composed of very powerful muscles (e.g., the *masseter* and the *temporalis*) that control incision and chewing. Their power and their role in the first step of food ingestion give these muscles a central biological importance.

For the outer layer, the biological function may appear less obvious. Yet this layer is much more complex than the layer it covers. It is composed of more than 20 muscles that interact to produce an enormous number of configural contractions as a result of patterned neural outflow from six branches of the seventh cranial nerve, the *nervus facialis*. These muscles are smaller and less strong than those in the deep layer and they have a different embryonic origin. They differ from those in the deeper layer (as well as from most other striate muscles) by connecting to the soft facial tissue rather than to bone. As a result, their primary effect is to move the facial skin, e.g., lowering the brows, squinting the eyes, retracting the mouth corners, or pouting the lips (see Fridlund, 1994 for a review of the facial muscles and their neural innervation).

Some of these muscles obviously serve functions related to eating and drinking. For example, the *orbicularis oris,* which encircles the mouth, may adjust the lips for drinking or to get hold of food, assisted by other muscles that may elevate the lips (the *levator labii superioris* and the *zygomatic minor*) or retract them laterally (the *risorious*).

The other major facial sphincter muscle, the *orbicularis oculi,* may help protecting the eyes by shutting them or by producing more gentle closures such as eye blinks. The brows may be moved around by the *frontalis,* which raises them, the *procerus* that lowers them and the *corrugator supercilii* that pulls them together, in this way shading the eyes from the sun and assisting concentrated eye fixation.

But the muscles in the superficial layer are also used in other, more complex contexts. The orbicularis oculi may be used in flirting, the procerus and the corrugator may lower and contract the brows in a threatening gesture to ward off a challenger, the frontalis may rapidly lift the eyebrows in an "eyebrow flash," a universal gesture of greeting (Eibl-Eibesfeldt, 1972), and the lips may be moved around to help shape the phonemes of speech. Finally, the *zygomatic major,* a big muscle that appears to have nothing better to do than to produce biologically obscure elevations of the mouth corners, is used in smiles and friendly greetings. Its antagonists, the *depressor anguli oris* and the *depressor labii inferioris,* on the other hand, change a smiling mouth to one that we associate with grief and depression.

It has been a popular thought among students of human behavior that communicative use of the facial muscle provides examples of how learning and cultural conventions make use of underlying bodily structure in a novel context that transcends biology. Darwin (1872) himself, however, pioneered the opposite claim, suggesting that facial gestures result from natural selection, a proposition that has been reinforced by contemporary theorists (e.g., Fridlund, 1994). The complexity of the outer layer of facial muscles, therefore, is held to be no accident but something that has been cumulatively selected for as adaptations over millions of years of mammalian evolution. Consistent with that proposition, commonalties in facial expressions have been documented among primates, and plausible evolutionary histories can be derived across phyla (Andrews, 1963; Hinde, 1974; Redican, 1982).

Indeed, it could be argued that selection pressures not only shaped the facial musculature, but also the brain that controls them. Chevalier-Skolnikoff (1973) pointed out that the evolution of the complex human facial musculature, and the associated neural innervation that allowed the enormous number of combinations and facial configurations, coincided in time with the spurt in the evolution of the brain that set the behavioral capacity of our species apart from that of other primates. The selection pressure that prompted these vast changes in brain development was probably social, resting with the need to exploit social knowledge based on psychological understanding of fellow beings (Humphrey, 1984). Thus, the expanded intelligence of the hominoids may not have been primarily derived from a need better to understand and exploit the physical world, but from the need to develop a Machiavellian intelligence (Byrne, 1995) that would allow them to manipulate one another in the selfish interest of promoting genes to prosper in the next generation. Such Machiavellian intelligence would include an understanding of facial gestures and expressions to discern the intentions of conspecifics, and their use to announce or hide one's own (Byrne, 1995).

About two decades ago, we started a research program that examined facial expressions in the context of an evolutionary hypothesis (Öhman & Dimberg, 1978). Some years earlier, Seligman (1970) had tried to overcome the instinct-learning dichotomy in psychology by introducing the concept of *preparedness* to cover instances where learning was facilitated by evolutionarily derived predispositions to associate more easily some events than others. Previous work had demonstrated enhanced aversive Pavlovian conditioning to fear-relevant stimuli such as snakes and spiders in humans (e.g., Öhman, Eriksson, & Olofsson, 1975; Öhman, Fredrikson, Hugdahl, & Rimmö, 1976). Consistent with these findings we reported that human college students showed enhanced resistance to extinction of conditioned skin conductance responses (SCRs) after conditioning to a threatening angry as compared to a friendly happy facial expression (Öhman & Dimberg, 1978). At about the same time, conceptually similar findings, albeit inspired from a different theoretical perspective, were independently reported by Lanzetta and Orr (1980; Orr & Lanzetta, 1980). In the next section, we review this work as well as other more recent work by ourselves and by other authors.

Evolutionarily derived readinesses are likely to build on obligatory or automatic psychological mechanisms, typically with little room for voluntary, conscious deliberations (Öhman, in press). This hunch is vindicated by a series of recent papers from Öhman's laboratory demonstrating that SCRs can be both elicited and conditioned to threatening facial stimuli that have been effectively masked from conscious recognition (Esteves, Dimberg, & Öhman, 1994; Esteves, Parra, Dimberg, & Öhman, 1994; Öhman, Dimberg, & Esteves, 1989). This work is reviewed in a following section of the paper. The automaticity postulate entails that patterned responses are quickly elicited to facial stimuli. This has been demonstrated in an extensive series of studies by Dimberg (see review by Dimberg, 1990a) using electromyographical (EMG) recordings from facial muscles to discern facial responses to facial stimuli. We then review this as well as other work using EMG to probe facial reactivity. The paper terminates with an integrative discussion and partly new interpretation of the findings and their implications.

CLASSICAL CONDITIONING TO FACIAL STIMULI

A Theoretical Perspective

The evolutionary perspective on human facial behavior implies that the complex pattern of human facial muscles for displaying different facial expressions has co-evolved with an adaptive capacity to decode and respond appropriately to the facial displays of conspecifics. In other words, we could expect individuals to have an evolutionary derived readiness, not only to act as *senders*, but also to be prepared to act as *receivers*, by recognizing and reacting adaptively to different displays in face-to-face interactions (Buck, 1984; Dimberg, 1983, 1988a; in press; Öhman & Dimberg, 1984). Studies on nonhuman primates (e.g., Andrews, 1963; Hinde, 1974; Redican, 1982), evidence from infant studies (e.g., Izard, 1977) and cross-cultural studies (e.g., Ekman, 1973) all support the view that people are biologically predisposed to display as well as to recognize facial gestures related to emotional states we interpret as anger, happiness, fear, surprise, sadness, and disgust.

In a face-to-face situation, depending on context, regular relations could be expected between receiver's reactions and the sender's facial displays. For example, a friendly display is likely to be met with friendliness.

A threatening angry display, on the other hand, may be met with anger or with submissiveness depending on the dominance relation between sender and receiver. Fear, finally, is ambiguous. In the context of dominance competition, it is likely to be met by dominance and anger, and in a context of an external threat, it may be contagious and help to focus the attention of the receiver on the threat perceived by the sender.

Our application of the preparedness theory (Seligman, 1970; 1971) to emotional reactions to facial stimuli (Öhman & Dimberg, 1978, 1984) examined whether these regularities in the reactions of senders and receivers could be modified and enhanced by aversive conditioning. We argued that an emotional response (presumably related to fear) would be more likely to be conditioned to a threatening facial display followed by an aversive outcome than a friendly display followed by an aversive outcome in a Pavlovian conditioning procedure. In other words, we hypothesized that humans were biologically prepared to easily learn to fear angry faces. Conversely, one could hypothesize that happy facial displays would be evolutionarily prepared to easily enter into associations with positive outcomes. This latter hypothesis, however, remains untested, probably because of the difficulties in finding a potent positive unconditioned stimulus for human experimentation.

The Basic Effect: Persistent Conditioning to Displays of Anger

Applying the preparedness hypothesis to facial gestures rests on the explicit claim that different facial expressions are differentially associable to different outcomes in Pavlovian conditioning arrangements. Thus, for example, we expected an angry face to be a very effective conditioned stimulus (CS) when followed by an aversive unconditioned stimulus (UCS). Human conditioning is conveniently indexed by psychophysiological responses such as heart rate and skin conductance responses (SCRs) (e.g., Hugdahl, 1996; Öhman, 1983). However, such responses are also sensitive to a host of nonassociative, activational, or sensitization effects that risk undermining straightforward conclusions about associative, Pavlovian conditioning effects. For example, introducing an aversive UCS, such as a mild electric shock to the fingers, may sensitize subjects to enhanced responding to any stimulus, but perhaps particularly to fear-relevant stimuli such as angry faces. Indeed, such differential sensitized responding to another class of fear-relevant stimuli, threatening animals such as snakes and spiders, after mere threat of aversive stimulation, was reported by Öhman, Eriksson, Fredrikson, Hugdahl, and Olofsson (1974). To control for such nonassociative effects, it is necessary to compare psychophysiological responses to a

CS explicitly paired with a UCS to some equally potent control stimulus which may have become the target for sensitization even though it was presented explicitly unpaired with the UCS. One such control procedure is to use a differential conditioning paradigm in which one stimulus, the CS+, is consistently followed by the UCS, whereas another stimulus, the CS-, is presented intermixed but nonreinforced with the paired presentations of the CS+ and the US. Thus, nonspecific sensitization effects of the US will affect both the CS+ and the CS- but, because of the regular pairing of the CS+ and the US, associative conditioning effects will exclusively pertain to the CS+. Reliably larger responses to the CS+ than to the CS-, therefore, will indicate that conditioning has occurred (see Öhman, 1983, for a general discussion of controls for associative effects in human autonomic conditioning).

In one of the first studies using facial stimuli as CSs (Öhman & Dimberg, 1978), we measured SCRs while three different groups of subjects were aversively conditioned to pictures of angry, happy, or neutral faces in a differential conditioning paradigm. The subjects were exposed to two different facial stimuli, the CS+ and the CS-, showing two different persons both displaying the same facial expression. During acquisition, the CS+ sender, but not the CS- sender, was followed by the aversive UCS, a mild electric shock to the fingers which for each subject was individually adjusted to an intensity level perceived as "uncomfortable but not painful." During the following extinction phase, the subjects were repeatedly exposed to unreinforced presentations of both the CS+ and the CS-. In accordance with the previously presented logic, the conditioning effects and resistance to extinction can be evaluated unconfounded by sensitization as differential responding to the CS+ and the CS-. The acquisition and extinction phases were preceded by a habituation phase in which the subjects were exposed to nonreinforced exposures of both CSs. The subject was located in a small room with slides exposed on a screen in front of him or her. The duration of exposure was 8 seconds and the pictures were presented with randomized intertrial intervals which varied between 20–45 seconds. Most subjects were university students.

The results from the first study (Öhman & Dimberg, 1978) showed that all three groups displayed differential conditioning effects during acquisition which did not differ among the groups. Importantly, however, the subjects conditioned to angry faces continued to respond differentially to the CS+ and the CS- during extinction in spite of the fact that the aversive UCS was withdrawn. The happy and neutral groups, on the other hand, extinguished their responding when the UCS was withheld (see Fig. 1).

Similar results were obtained in a number of experiments in our laboratory (Dimberg & Öhman, 1983; Dimberg, 1983, 1986a, 1987) and con-

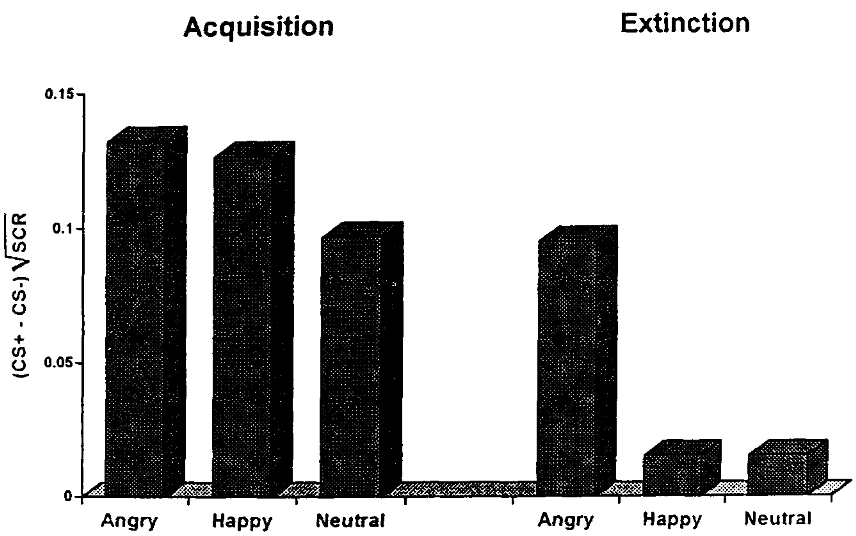

Fig. 1. Skin conductance conditioning effects (i.e., the difference in response to a shock-associated conditioned stimulus, the CS+, and a control stimulus not associated with shock, the CS-) for three groups of subjects conditioned to angry, happy or neutral faces. In each group, the CS+ and the CS– were two different persons expressing the same emotion (angry, happy, or neutral). The conditioning effect during acquisition is similar for the three groups. During extinction, however, only the group conditioned to angry faces showed reliable resistance to extinction. (The figure is a simplified version redrawn from Öhman and Dimberg, 1978.)

ceptually related findings have been reported from other laboratories (e.g. Orr & Lanzetta, 1980; Mazurski, Bond, Siddle, & Lovibond, 1996; Pitman & Orr, 1986). However, there are also occasional failures to replicate this basic effect available in the literature (Packer, Clark, Bond, & Siddle, 1991).

These results have been interpreted to suggest that humans are predisposed to associate facial stimuli with different outcomes. In general, they may be taken as support for the prepared learning theory (Seligman, 1971), which also has been used as a conditioning model to explain the emergence of pathological fears and phobias (e.g., Öhman, 1979a, 1996). This conception was supported by a study reported by Pitman and Orr (1986) in which subjects who suffered from anxiety disorders were aversively conditioned to angry and neutral faces. Although high anxiety subjects did not differ from a matched control group prior to conditioning, Pitman and Orr found that subjects with high anxiety levels showed specifically enhanced resistance to extinction to angry faces in spite of the fact that they were instructed that no more shocks would be presented. Anxiety patients conditioned to angry faces, therefore, kept on responding regardless of their knowledge that the situation had been changed to an innocuous one. This dissociation between conscious knowledge and autonomic responding was taken as a parallel to the irrational behavior sometimes seen in anxiety states. These results support a conditioning model of anxiety and, again, that angry faces are particularly effective as CSs in aversive conditioning.

Response Patterning During Conditioning to Angry Faces

So far, the reviewed studies have relied on skin conductance data. However, skin conductance is not a sufficient measure if the hedonic quality of the emotional reaction should be more specifically examined. In order to evaluate more appropriately the hedonic tone of the conditioned response, Dimberg (1987) measured autonomic, verbal, and expressive components of the total emotional response, while subjects were aversively conditioned to angry or happy facial stimuli. The autonomic measures included SCRs, SCR half recovery time, and heart rate (HR). Additionally, the subjects rated their subjective emotional intensity whereas facial expressive reactions were detected by help of the electromyographic technique (see below).

The results are shown in Fig. 2. As in the earlier studies, resistance to extinction was observed only for angry faces. First, persistent differential SCRs to the CS+ and the CS- was obtained in the group conditioned to angry faces but not in the group conditioned to happy faces. This effect was accompanied by slower SCR half recovery time in the angry group, suggesting a defense type of SCR (e.g., Öhman, Fredrikson, & Hugdahl, 1978) in this condition. This group further showed differential HR responding during extinction which was manifested as an HR accelerative response to the angry CS+ (during the UCS omission interval). The happy group, on the other hand, reacted with a HR deceleration which was almost identical to the two CSs. Thus, the autonomic response pattern to angry faces showed characteristics of a defense reflex (e.g. Graham, 1979). The interpretation that angry faces tend to evoke a negative emotional reaction was further supported by the fact that subjects conditioned to angry faces showed more self-reported fear than subjects conditioned to happy faces. A similar pattern composed of persistent SCRs, HR acceleration, and change in emotional valence was observed for subjects who initially showed accelerative HR responses to the CSs and was interpreted as reflecting conditioned fear by Hodes, Cook, and Lang (1985). Additional support for such a conclusion was generated by the facial-EMG data, which showed that only subjects conditioned to angry faces continued

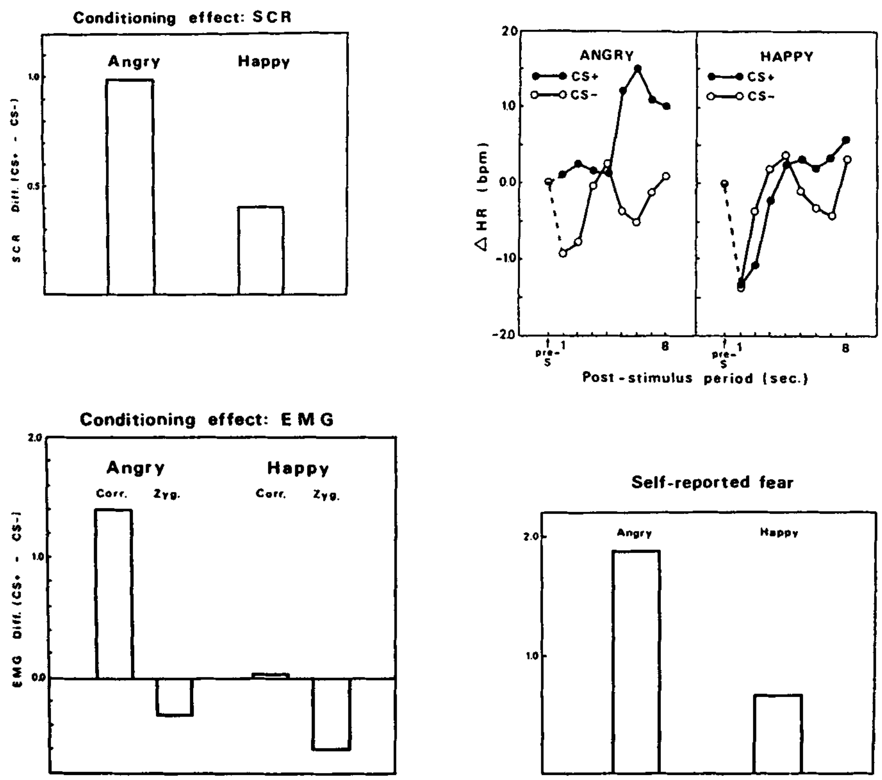

Fig. 2. The pattern of remaining conditioning effects (i.e., differential response to a shock-associated, CS+, and a control stimulus, CS-) during the extinction phase for two groups of subjects conditioned to angry or happy faces. The upper left panel illustrates that skin conductance responses aversively conditioned to angry faces show reliable resistance to extinction whereas responses conditioned to happy faces do not. The upper right panel illustrates the heart rate (HR) response expressed as difference in beats per minute (bpm) from a pre-stimulus level. This panel demonstrates that the remaining conditioned response to angry CS+ is a heart rate acceleration. The left lower panel illustrates the differential conditioning effect during extinction for the *corrugator supercilii* and the *zygomatic major* muscles. In this panel it can be seen that the facial EMG reaction conditioned to angry faces is dominated by a remaining increased *corrugator supercilii* activity which indicates a negative emotional response. This interpretation is further supported by the data in the right lower panel which illustrates that the group aversively conditioned to angry faces reported more experience of fear than did the group conditioned to happy faces (from Dimberg, 1987).

to respond with more corrugator activity (indicating a negative emotional response) to the CS+ during extinction. Consistent with the preparedness perspective these results together indicate that angry facial stimuli evoked a negative emotional response, suggesting a genuine fear reaction.

Expectancies, Cognitive Capacity, and Conditioning to Facial Stimuli

Flykt, Esteves, and Öhman (1996; preliminarily reported by Öhman, Esteves, Flykt, and Soares, 1993) extended the data on superior conditioning to angry facial displays to a new data domain, that of information processing measures. They showed pictures of angry and happy faces to a large group of subjects, half of which had the angry and the other half the happy faces followed by an aversive shock UCS. To measure expectancies of the UCS, some of the subjects rotated a knob to indicate their shock expectancy on a scale from -100 (sure of no shock) to +100 (sure of shock). In other subjects, utilization of cognitive resources was analyzed by help of a probe reaction-time (RT) task. Assuming that cognitive processing requires use of limited processing resources (e.g., Kahneman, 1973), the deployment of such resources during a primary task can be tracked by its interference with a subsidiary task, often measured as RT slowing (e.g., Spinks & Kramer, 1991). In the present experiment, some of the subjects had probe stimuli presented both during the CS-UCS and the intertrial intervals, and were instructed to provide RTs by means of a voice key. The results showed, as expected, larger resistance to extinction of conditioned SCRs with an angry than with a happy CS+ for subjects in a control condition not involving additional tasks. This effect, however, was wiped away by the additional tasks, which may be a methodological caveat to remember when combining SCR conditioning with other tasks (e.g., Packer et al., 1991). Subjects performing the rating task showed more UCS expectancy during the shock-associated CS+ than during the nonshocked CS- in acquisition regardless of which face served as the CS+. However, in agreement with typical SCR data, they showed less extinction of their ratings when the CS+ had been an angry as compared to a happy face. The RT data indicated significantly larger cognitive resource utilization to an angry than to a happy CS+, particularly during extinction and when probe stimuli were presented right after the CS rather than right before the UCS. These data, then, demonstrate that the enhanced associability between angry faces and aversive UCSs posited by the preparedness hypothesis can be detected by other measures than the traditionally used autonomic responses.

The Direction of the Facial Display

Certainly, the emotional display is a critical factor in social interactions. However, there are other facial factors which provide critical cues in a face-to-face interaction. Eye contact and head orientation have proved to be important cues indicating to whom the social attention is directed (e.g., Argyle & Cook, 1976). Many types of social relations, for instance, the development of dominance relationships (e.g., Hinde, 1974), is predicated on the ability to recognize specific individuals. Recognition includes appraising characteristics of the person such as whether one is interacting with a male or a female, his or her age, etc. Thus, in an evolutionary perspective it is critical to recognize not only the angry expression but also to be able to recognize the individual showing the display, and to determine whether the expression is directed toward the receiver or not.

To explore whether other facial factors interact with the emotional display, we performed a series of experiments to determine whether the functional significance of angry facial expressions is critically dependent on the direction of the face. Employing a similar conditioning paradigm to that used in the earlier reported studies, we found that angry faces were effective only when directed *toward* the subjects (Dimberg & Öhman, 1983). Angry faces directed away were ineffective in inducing conditioning that was resistant to extinction. In a second experiment (Dimberg & Öhman, 1983), the direction of the angry faces was shifted between the acquisition and extinction faces. We found the orientation during extinction to be the critical factor. That is, subjects who were conditioned to angry faces directed toward the receiver during acquisition stopped responding when the face was directed away during extinction. In contrast, a second group which had the reversed manipulation, showed resistance to extinction when the angry face was shifted toward them during extinction, in spite of the fact that they had been conditioned to an angry face looking away.

In a further study, the direction of the head and the eyes were separately manipulated (Dimberg, 1983). It was found that both the head direction and the direction of the eyes were critical factors for persistent conditioning to emerge. These data show that the direction of the face is a critical interacting factor for angry facial expressions to be effective in the aversive conditioning paradigm.

The Identity of the Displaying Person

To explore whether subjects also learn something about the specific stimulus person or if it is the angry expression itself which is the decisive factor in aversive conditioning, Dimberg (1986a) conditioned subjects to an angry face, which was shifted to a different stimulus person expressing anger during extinction. Thus, the subjects first learned to discriminate between person A looking angry and person B looking happy, and was then tested with persons C and D looking angry and happy, respectively. In spite of the fact that the subjects were exposed to an angry face, they stopped responding immediately when the stimulus person was changed during extinction. Following this phase, however, the subjects were again exposed to the same angry stimulus person as during acquisition, which resulted in persistent responding. These data demonstrate that the specific stimulus person is a critical mediating factor when subjects react emotionally to an angry expression.

Excitation and Inhibition from Facial Displays

The fact that the emotional display, the direction of the display, and the stimulus person all are critical stimulus properties during aversive conditioning was further utilized in a subsequent series of experiments (Dimberg, 1986a). In these experiments, it was demonstrated that angry faces have an excitatory effect whereas happy faces have the opposite effect, that is, an inhibitory influence, on aversively conditioned SCRs. In one of the experiments, subjects were conditioned to a happy face which was shifted to an angry face expressed by the same stimulus person during extinction. Although the subjects in this group were conditioned to a happy person (which do not themselves evoke persistent conditioning; see Fig. 1) they reacted with persistent responding when the person was shifted to anger during extinction, suggesting an excitatory influence from the angry display. A second group, the angry-to-happy group had the reversed manipulation. After being conditioned to an angry face during acquisition the subjects stopped responding when the angry stimulus person was shifted to a happy expression during extinction, suggesting an inhibitory effect from the happy display.

The assumption that happy faces have an inhibitory effect in aversive conditioning was further supported in a final experiment (Dimberg, 1986a). In this experiment, two groups were conditioned to happy faces with different orientations. One of the groups was conditioned to happy faces directed toward the receiver, whereas the second group was conditioned to happy faces directed away from the receiver. Because the happy expressions were not directed toward the receiver, it was hypothesized that the subjects in the latter group would not be exposed to the inhibitory influence of the happy face. During extinction, both groups were exposed to an identical condition composed of the same sender expressing anger directed toward the receiver. It was predicted that the absence of an inhibitory influence among subjects conditioned to a happy face turned away rather than directed toward the receiver would become manifested during extinction as enhanced resistance to extinction in this group. In agreement with the prediction, the happy-away group (during acquisition) showed more persistent responding during extinction than the happy-toward group. Thus, consistent with the results from Lanzetta and Orr (1981) (reviewed below) happy faces proved to have an inhibitory effect whereas angry faces, similarly to fearful faces, have an excitatory effect on aversively conditioned responses.

Sex and Age

The sex and age of the sender who directs anger toward the receiver provide further important factors in social interactions. It was early reported that pictures of males expressing anger tended to be more effective as CSs than females expressing anger (Öhman & Dimberg, 1978). These findings have been extended by Siddle and co-workers who more systematically explored the effect of gender of the sender on aversive conditioning. Based on the hypothesis that both males and females form hierarchies with the male hierarchy dominating that of the females (Öhman, Dimberg, & Öst, 1985), they argued that males should be more readily prepared to react to angry males than to angry females, whereas females should react to both sexes (Mazurski et al., 1996). Accordingly, males and females were aversively conditioned to angry faces expressed by a male or a female (matched for emotional intensity), with a neutral face serving as the CS-. They reported that males showed larger SCRs to angry males than to angry females during acquisition, whereas females responded equally in both conditions (Mazurski et al., 1996). This is consistent with the evolutionary perspective, but its relationship to the specific preparedness hypothesis is less clear. This hypothesis addresses associative processes, and thus it would predict larger differentiation between the shock-associated CS+ and the nonshocked CS- with a male CS+ for male subjects. The results, however, showed only overall larger responses to male than to female stimuli among males, but not larger differential response. It is interesting to note that the effects pertained to acquisition and not to extinction, and that this difference in SCRs was not paralleled in differences in ratings of UCS expectancies in the two conditions. The fact that the difference was obvious only in acquisition and that it pertained to reactivity to both the CS+ and the CS-, sets this result apart from the studies from our laboratories reviewed above.

In a second experiment Mazurski et al. (1996) explored whether the age of the angry stimulus person influences the efficiency to induce persistent conditioning. From the evolutionary perspective they argued that the superior conditioning effect to facial threat would exclusively pertain to adult senders, because preadolescent persons do not compete in adult dominance hierarchies. This hypothesis was confirmed in the experiment, which demonstrated better differentiation between the CS+ and the CS- during acquisition when the stimulus person was an adult male than when he was a preadolescent male both for male and female subjects.

Right Cerebral Hemisphere Location of Conditioning to Facial Stimuli

Although the actual data are complicated and hard to interpret (Sergent, 1995), it is a popular notion that the processing of emotional facial expressions is primarily located in the right cerebral hemisphere (e.g., Ley & Bryden, 1979). Hugdahl and Johnsen (1993; Hugdahl, 1995; Johnsen & Hugdahl, 1991, 1993) have reported a series of studies specifically examining the differential contribution of the two cerebral hemispheres to conditioning of SCRs to facial stimuli. These studies have relied on the visual half field (VHF) technique to present visual stimuli initially to either the right or the left hemisphere. The incomplete crossing of the visual nerve at the optic chiasm assures that stimuli presented in the left VHF (i.e., to the left of the subject's point of fixation) are directed to the right hemisphere, whereas stimuli in the right VHF go to the left hemisphere. It is important to stress that this is largely a matter of order: which hemisphere receives the stimulus information first. Because of the interhemispheric commisures such as the corpus callosum, what is initially accessible in one hemisphere is rapidly transferred to the other.

Johnsen and Hugdahl (1991) conditioned subjects to foveally presented angry and happy faces in a differential conditioning paradigm similar to the one used in our laboratories with the exception that the CS–UCS interval was very short, 210 ms. In spite of this short interstimulus interval, they replicated our findings in reporting better differential conditioning for subjects having an angry face as the CS+ and a happy face as the CS- than for subjects having the reversed contingency. In extinction, however, when stimulus exposure was shortened to 30 ms, and the stimulus presentation was lateralized to the right or the left VHF, they found reliable resistance to extinction only for subjects conditioned to angry CSs+ when the stimulus was presented in the left VHF (right hemisphere processing). With angry CSs+, SCRs were larger to stimuli in the left than the right VHF, whereas SCRs to happy CSs+ were unaffected by which hemisphere was initially stimulated. Thus, it appeared that the conditioned association was specifically stored in the right hemisphere.

To further support this interpretation, Johnsen and Hugdahl (1993) performed a new experiment with lateralized stimulation during conditioning training. Thus, half of their subjects had an angry face in the left VHF simultaneously with a happy face in the right VHF, whereas the other half had the reverse: a happy face in the left, and an angry face in the right VHF. To ascertain whether merely perception of stimuli in the different half-fields would result in enhanced SCRs, some of their subjects were shown these stimuli without any UCSs. The remaining subjects had the compound left/right VHF stimulus followed by a shock UCS at a 180 ms interstimulus interval. The rational for this procedure was that if conditioning is stronger to angry stimuli and the association with aversiveness is preferentially stored in the right hemisphere, then subjects having an angry face in the left VHF should show superior conditioning to those having the angry face in the right VHF. To test for conditioning to the different components of the compound stimuli, angry and happy faces were presented foveally for 30 ms in an extinction series. The extinction results confirmed the hypothesis: subjects exposed to an angry face in their left VHF during conditioning responded more than subjects exposed to an angry face in their right VHF. No lasting conditioning effects were reported for happy faces, nor were any differences observed between faces for subjects not exposed to the UCS. On the basis of these findings, as well as of supplementary heart rate and evoked potential data, Hugdahl (1995) has argued that emotional conditioning to facial stimuli is primarily a right hemisphere process.

Conditioning to Emotional Display of Fear

With a related but independent origin to that of our work, Lanzetta and Orr (1980, 1981, 1986; Orr & Lanzetta, 1980, 1984) performed a series of studies with another facial expression, that of fear, which resulted in conceptually similar findings to those reported by us. They argued that "particular patterns of facial-expressive cues are associated with and serve as signals for particular classes of outcomes (e.g., expressions of fear signal aversive outcomes and happy expressions signal pleasant outcomes)" (Orr & Lanzetta, 1980, p. 278), without taking an explicit stand on whether the origin of this assumption rested in evolution or the learning history of the individual. By assuming that "fear expressions and shock belong together, whereas happiness and shock do not" (Orr & Lanzetta, 1980, p. 279), they predicted and observed better SCR conditioning to facial expressions of fear than to expressions of happiness in experiments where each subject was exposed to several stimulus persons expressing fear or anger. Thus, in contrast to our studies, they arranged their experimental conditions to result in a generalized conditioned response to all instances of a particular facial emotion. Nevertheless, their data were very similar to ours.

Lanzetta and Orr went on to demonstrate that fearful faces have an excitatory effect, whereas happy faces have an inhibitory effect in aversive conditioning, using other procedures than those used by Dimberg (1986a) for a similar purpose. After aversive conditioning to a compound CS composed of a neutral tone paired with a fearful, a neutral, or a happy face, for different groups of subjects, the tone and the face were exposed separately during extinction (Lanzetta & Orr, 1980). The subjects reacted with larger SCRs to a fearful facial expression than to the tone stimulus, indicating that fearful faces "overshadowed" the tone, that is, it had an excitatory effect. Happy faces, on the other hand, had an inhibitory effect in the sense that subjects reacted with larger SCRs to the tone than to the happy face. These findings were successfully replicated in a subsequent study that also included a neutral face as a control condition (Lanzetta & Orr, 1981). There was no SCR difference between the neutral face and the tone when they were tested separately in extinction.

Orr and Lanzetta (1984) and Lanzetta and Orr (1986) conditioned subjects to a low intensity tone by pairing it with a shock UCS, and then tested different groups of subjects in extinction with a visual stimulus added to the tone. They reported higher skin conductance levels and larger SCRs (albeit of questionable statistical significance) to the tone–face compound when the visual stimulus was a fear as opposed to a happy or a neutral face (or indeed, a nonface). These differences were still present with instructions of "no more shocks" to the subjects and removal of the shock electrodes (Lanzetta & Orr, 1986), suggesting that the effect was not directly mediated by shock expectancies. Lanzetta and Orr (1986) concluded that these findings were consistent with the preparedness perspective in demonstrating that a fear face functions as an excitatory stimulus *per se* with "influence on emotional arousal that is independent of any veridical threat of an aversive outcome" (Lanzetta & Orr, 1986, p. 193).

PREATTENTIVE MECHANISMS IN THE PROCESSING OF FACIAL STIMULI

Automatic Discovery of Threat

Discovering threat is a good candidate for an evolutionary adaptation. Failure to discover a potentially lethal threat may leave the genes of the one who fails unrepresented in the next generation. In the case of social threats, a failure correctly to appraise facial cues may not only involve risk of physical injury, but may also relegate the failer to a position in dominance rank that impedes access to resources such as reproductive possibilities.

When it comes to threat detection, there is always a premium on speed. Social signaling involves a competitive situation with components of"arms races" and "bluffs" between the combatants (Fridlund, 1994; Krebs & Davies, 1987), and individuals who more quickly read their opponents' intentions have an advantage in the next step of the interaction. Thus, the understanding of social signals is likely to depend on automatic stimulus processing mechanisms that pick out informative stimuli (e.g., certain facial configurations), long before conscious thoughts intervene to interpret the situation. In Zajonc's (1980) version, we are sure that we like or dislike a person before we even start to develop hypotheses why this is so.

These considerations suggest that the evolutionary perspective gives automatic, preattentive and unconscious information processing mechanisms a key role in emotional reactions to facial stimuli. Indeed, it could be argued that "it is at this level that evolutionary facilitations and constraints on psychological events are likely to show up most clearly, uncontaminated by the culturally conditioned whims of consciousness" (Öhman, in press, p. 2). In this perspective, methodological avenues to the study of preattentive processing becomes of primary importance.

Backward Masking as a Method to Delineate Automatic Processing

When a brief patterned visual stimulus is immediately followed by another patterned stimulus, depending on temporal and intensity relations between the two, one may mask the other from conscious perception. For example, if the first stimulus is of short duration (e.g., up to 30 ms), backward masking, where the second stimulus, the *mask*, prevents perception of the first stimulus, the *target*, may be observed. However, even though the target is blocked from conscious access, it can be demonstrated that it is still processed to a considerable depth (e.g., Marcel, 1983). Thus, rapid, automatic processes may be directed toward the target stimulus before further more intentional processing is disrupted by the mask.

Esteves and Öhman (1993) studied backward masking of facial expression stimuli. Subjects were exposed to pairs of stimuli, in which a target stimulus depicting a facial affect (happy or angry) was followed by a second stimulus, which always portrayed a neutral expression. The stimulus-onset-asynchrony (SOA) between these two stimuli was systematically varied from very short (20 ms) to quite extended (about 300 ms), whereas the mask was always 30 ms. After each stimulus pair, the subject was asked whether the target was a happy or an angry face and to rate his or her confidence in this answer. Across several experiments, the data showed that subjects required at least a 100 ms SOA with a 30 ms exposure of the mask for confident correct decisions. When the SOA was 30 ms or less, the subjects actually performed and felt that they performed at chance levels. This finding has been robust across experimental conditions (Esteves & Öhman, 1993) including shock administrations during the perceptual task (Esteves, Parra, Dimberg, & Öhman, 1994b).

Preattentive Elicitation of Conditioned Responses to Facial Stimuli

The 30 ms SOA between a target and a mask has been used in several studies examining SCRs to masked facial stimuli (preliminarily reported by Öhman, 1986; Öhman, Dimberg, & Esteves, 1989). Esteves, Dimberg, and Öhman (1994a) reported three experiments in which subjects were conditioned to angry faces by a shock UCS in paradigms similar to those previously reviewed. However, in these experiment the CS–UCS interval was typically short (about 500 ms). After conditioning had been established (documented by enhanced SCRs to the CS+), the subjects were tested by masked presentations of the CS+ and the CS-. In spite of the fact that the masking conditions prevented conscious perception of the stimuli, SCR data consistently showed larger responses to the CS+ than to the CS-, if the CS+ was an angry face, but not if it was a happy face.

A second series of experiments was reported by Parra, Esteves, Flykt, and Öhman (1996). Two of these experiments used a more complex conditioning paradigm in which several exemplars of angry and happy faces were presented to the subjects. Some of the angry faces were followed by shock during an acquisition phase. In a subsequent extinction phase, the previously shocked faces were either presented as targets and masked by neutral faces, or as (recognizable) masks for (masked) neutral faces. Regardless of whether the presentation was nonconscious or conscious (i.e., the CSs were presented as targets or masks) the subject showed reliable differential SCRs that did not differ between conditions. However, whereas the verbal recognition of previously presented faces was good when they occurred in the mask position it was very poor when they occurred as targets. Thus, there was a clear and instantaneous dissociation between the SCRs that showed strong conditioning and no effect of masking, and the verbal recognition ratings which showed no conditioning effects and a strong effect of masking.

In a third experiment, Parra et al. (1996) compared masked and nonmasked extinction after conditioning to (nonmasked) angry CSs+ and happy CSs- while the subjects rated their shock expectancy in the 3.5 s interval between the CS and the UCS. Again, a dramatic dissociation between the conscious and the nonconscious measures was observed. Skin conductance responses showed equal and reliable differential response to the CS+ and the CS- with no effect of masking. The ratings, on the other hand, showed a highly significant interaction between conditioning and masking to the effect that the differentiation between CS+ and CS- was much larger in the nonmasked than in the masked condition. However, closer analysis revealed a small but consistent and reliable differentiation between the CS+ and the CS- in ratings performed during the masked condition, suggesting that some information about the targets was consciously accessible (see Fig. 3).

A related and very interesting finding was reported by Wong, Shevrin, and Williams (1994) in a replication and important extension of our work. They used schematic negatively and positively evaluated faces and included measurement of slow cortical potentials as an additional measure. After conditioning with the negative stimulus serving as the CS+ and the positive stimulus serving as the CS-, subjects were exposed to masked presentations

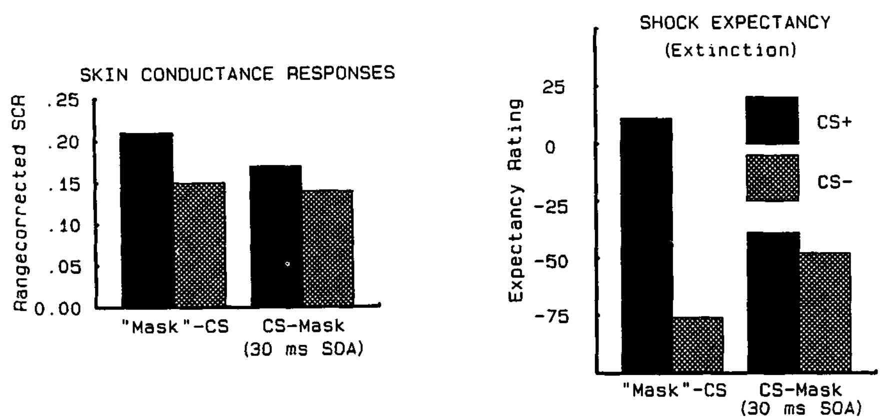

Fig. 3. Extinction skin conductance responses (left panel) and ratings of shock expectancy (right panel) to an angry face previously associated with an electric shock unconditioned stimulus (CS+) and a happy face not associated with the shock (CS-). One group of subjects had the CSs followed by an effective masking stimulus (CS-mask), whereas another group had an ineffective masking arrangement with the CS as the second stimulus ("mask"-CS). The anchor points for shock expectancy ratings were +100 ("sure of shock") and -100 ("sure of no shock"). (Reprinted from Öhman, 1992, with permission from Lawrence Erlbaum Associates.)

of the stimuli below rigorously defined individual thresholds for recognition. Their SCR data replicated ours in demonstrating reliable differential response between masked presentations of the CS+ and the CS- during extinction. The electrocortical data showed a distinct slow negative potential that uniquely preceded the temporal point of previous UCS presentations after the CS+ during the masked extinction trials. This waveform was identified with a previously described expectancy wave occurring before an expected emotionally or motivationally relevant stimulus (e.g., Simons, Öhman, & Lang, 1979). This finding suggested to the authors that "an anticipatory process...can be elicited entirely outside awareness" (Wong et al., 1994, p. 87). The small but consistent expectancy rating differentiation between masked CSs+ and CSs- reported by Parra et al. (1996) may indicate that this expectancy process could indeed by accessible to subjects to influence their ratings of shock probabilities.

Conditioning to Masked Facial Stimuli

This research with masked facial stimuli has demonstrated that SCRs conditioned to angry faces resist masking when tested in extinction. This finding strongly suggests that emotional responses to at least some facial stimuli can be elicited after only a preattentive analysis of the stimulus. Thus, emotional responses that already are in the repertoire of the individual may not, under some conditions, require conscious mediation for their elicitation (see Öhman & Soares, 1994 for another example). However, a perhaps more fundamental question concerns whether emotional responses can be connected to new stimuli if they are prevented from reaching awareness through backward masking. To test this hypothesis, it is, in a sense, necessary to reverse the previously described method. Thus, what is required here is an acquisition series with masked CSs, followed by tests for conditioning with nonmasked stimuli.

Such a series of studies was reported by Esteves et al. (1994b). They exposed subjects to an angry face CS+ and a happy face CS- that were followed by a neutral face either after an effective (30 ms) or ineffective (330 ms) masking interval. Subjects in two conditioning groups (with effective or ineffective masking intervals, respectively) had a shock UCS presented 500 ms after the onset of the CS+. For control subjects, the UCS was presented after one of the neutral masking stimuli with no preceding target stimulus. In a subsequent extinction session, subjects in all groups were presented with unmasked presentations of the angry and happy faces. Both conditioning groups showed larger responses to the angry than to the happy face, whereas the control groups did not differentiate between the two facial categories. Thus, regardless of whether the masking interval resulted in effective masking or not, subjects were able to associate the CS+ with the UCS. In other words, conditioning proved possible even in the absence of conscious perception of the CSs. These data are shown in Fig. 4.

In a second experiment, Esteves et al. (1994b) again conditioned subjects to facial stimuli using effective or ineffective masking intervals to prevent or allow conscious perception of the CSs. However, in this experiment some subjects were conditioned with an angry CS+ and some with a happy CS+. Control groups were given effectively and ineffectively masked CSs with random, nonpaired UCSs to control for sensitization effects. In the subsequent nonmasked extinction series, reliably larger responses were observed to angry than to happy faces among subjects who had been exposed to an angry CS+ even with the effective masking interval. Subjects conditioned to a happy CS+, however, showed no evidence of conditioning. Rather, like the sensitization control groups they showed equal SCRs to happy and angry faces.

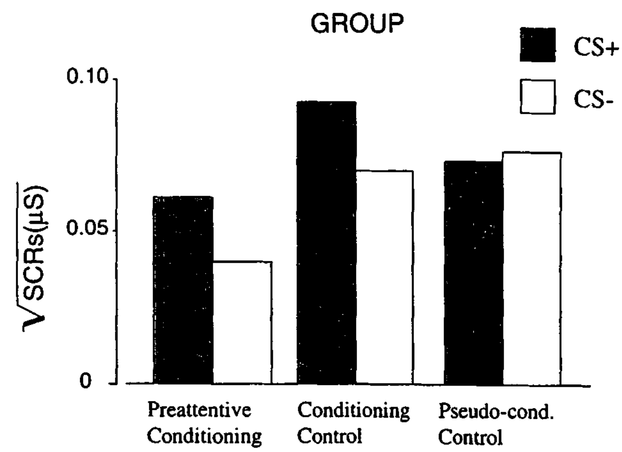

Fig. 4. Skin conductance responses during extinction to nonmasked angry (CS+) and nonmasked happy (CS-) faces after a conditioning procedure with the masked angry face followed by shock and the masked happy face not followed by shock. The Preattentive Conditioning Group had an effective masking interval (30 ms) that resulted in complete masking of the CSs, the Conditioning Control Group had a long, ineffective (330 ms) masking interval, and the Pseudo-Conditioning Control Group had no targets and only masks during conditioning. Note the conditioning effects were present in both the conditioning groups but not in the control group. (Reprinted from Esteves et al., 1994b, with permission from Cambridge University Press.)

These results show quite conclusively that conscious perception of a facial CS is not necessary for conditioning, *provided that the CS is a threatening angry display*. With a nonthreatening happy display, such conditioning effects are not observed. Thus, again, it is demonstrated that angry facial displays have a special affinity with aversive outcomes, exactly as posited by the preparedness hypothesis. Indeed, conditioning to masked stimuli could be taken as a prototype of conditioning with "degraded input," a condition that was used by Seligman and Hager (1972) in defining the preparedness continuum.

FACIAL REACTIONS TO FACIAL EXPRESSIONS

The evolutionary perspective not only suggests that people should be prepared to *learn* to react emotionally to specific facial stimuli (e.g., Öhman & Dimberg, 1978, 1984; Dimberg, 1983) but also that they should have a readiness to *spontaneously* react with specific emotional responses to particular facial expressions (Dimberg, 1982, 1988, in press). Most studies reviewed so far have been concerned with aversive Pavlovian conditioning. A simpler way to approach the question whether people have a readiness to react to facial expressions would be to measure how they react if exposed to different facial stimuli, without any reinforcement contingencies (e.g., Dimberg, 1988a).

It was an early finding that subjects did not spontaneously differ in skin conductance activity when exposed to angry and happy facial stimuli (Öhman & Dimberg, 1978; Dimberg, 1982). The studies reviewed in this section are therefore based upon another response system, namely the facial-expressive one. It is obvious that the face can serve both as a readout system and as a visual stimulus for the sender and the receiver in a face-to-face interaction. One way to detect different response patterns would then be to measure the facial reactions of the receiver him/herself. For this purpose, Dimberg performed a series of studies in which the facial electromyographic (EMG) technique was used. This technique has a number of advantages.

First, it is easy to quantify and compare different strength of facial muscle activities and it is also possible to detect activity which is not visible as an overt response. Second, the EMG-signal is almost instantaneously detectable which allows for the detection of rapid reactions with a short duration. In particular earlier research has shown that increased *corrugator supercilii* activity (which is the muscle used when frowning; Hjortsjö, 1970) reflects negative emotional imagery whereas increased activity in the *zygo-*

matic major muscle (the muscle used when smiling) correlates with positive emotional imagery (e.g., Schwartz, Fair, Salt, Mandel, & Klerman, 1976).

In one of the first studies, subjects were exposed to pictures of angry and happy faces (Dimberg, 1982) while their facial EMG reactions were measured from the *corrugator supercilii* and *zygomatic major* muscles. As shown in Fig. 5, the results indicated that angry and happy faces evoked different response patterns. Angry faces induced increased corrugator activity, whereas happy faces evoked increased zygomatic muscle activity. These data demonstrate that angry and happy facial expressions spontaneously evoke a negative and a positive emotional facial reaction, respectively, and the results have been consistently replicated in a number of different studies (Dimberg, 1988b; Dimberg & Christmanson, 1991; Dimberg & Karlsson, 1996; Dimberg & Lundquist, 1990; see Dimberg, 1990a for a review).

Lanzetta and co-workers (McHugo, Lanzetta, Sullivan, Masters, & Englis, 1985) extended these findings by using excerpts of dynamic, naturally occurring expressive displays rather than static pictures of facial expressions as stimuli. In a research program designed to study the effect of

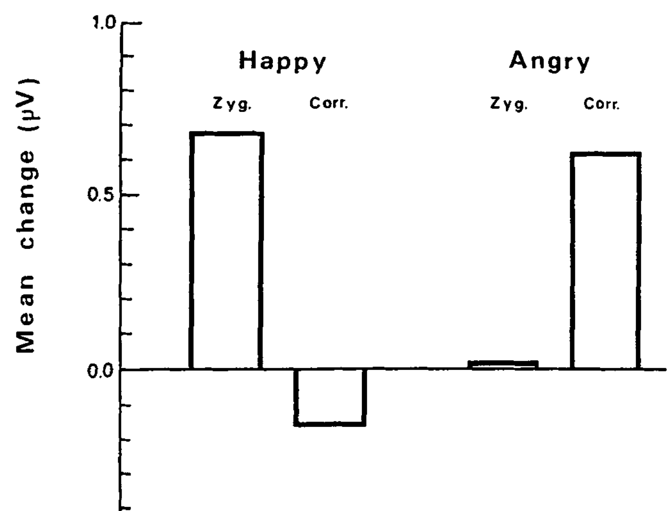

Fig. 5. Facial electromyographic (EMG) responses to happy and angry facial stimuli for the *zygomatic major* (Zyg.) and the *corrugator supercilii* (Corr.) muscle regions. The different facial stimuli spontaneously evoke different facial responses. Happy faces primarily evoke increased activity in the *zygomatic major* muscle whereas angry faces primarily evoke increased *corrugator supercilii* muscle activity (from Dimberg, 1982).

expressive displays of political leaders, they (McHugo et al., 1986) exposed subjects to videotaped excerpts from talks by president Ronald Reagan where he expressed anger, fear, and happiness. As in the studies reported by Dimberg (e.g., 1982), they found that negative expressions such as an angry display evoked increased corrugator activity, whereas happy expressions elicited increased zygomatic activity, in the receivers. Interestingly, these facial reactions were not influenced by the subject's prior attitude to president Reagan. This is consistent with the notion that the facial responses are automatic in the sense that they are unrelated to conscious cognitive processes such as reflected in self-reported attitudes.

In one study, facial-EMG was measured while males and females were exposed to angry and happy faces expressed by both males and females (Dimberg & Lundquist, 1990). As in previous research (e.g., Schwartz, Brown, & Ahern, 1980) and in accordance with research on nonverbal communication (Buck, 1984; Hall, 1978), it was found that females were more facially expressive than were males. Interestingly, however, the gender of the stimulus faces did not influence the facial reactions. That is, the facial expressions of females were not more effective than the expressions displayed by males in inducing distinguished facial-EMG responses (Dimberg & Lundquist, 1990).

These results support the hypothesis that subjects have a readiness to spontaneously react emotionally to different facial expressions. However, an alternative way to interpret the findings is that the facial reaction is an outcome of mimicking behavior, without any necessary emotional concomitants. Data against that interpretation was obtained by Dimberg (1988b) who found that distinguished facial reactions to faces were accompanied by a corresponding self-report of emotion. Angry faces evoked more fear than happy faces, whereas happy faces induced feelings of happiness. These findings were extended by Lundquist and Dimberg (1995) who exposed subjects to faces portraying anger, happiness, fear, sadness, disgust, and surprise while facial-EMG activity was measured from several different facial muscle regions. This study showed that subjects tended to react with a facial reaction which to some degree mirrored the facial expression which they were exposed to. Importantly, however, these reactions were accompanied by a corresponding self-report of emotion indicating that the facial-EMG reactions had experienced emotional concomitants. These data were further interpreted as support for that facial expressions of emotions are contagious (Hatfield, Cacioppo, & Rapson, 1994; Lundquist & Dimberg, 1995).

Further support that facial EMG reflects emotional activity in the present paradigm was obtained in a second series of studies. In these studies, subjects were exposed to different types of negative and positive emotional stimuli such as pictures of snakes and flowers (Dimberg, 1986b, 1990, 1995;

Dimberg & Karlsson, 1996; Dimberg & Thell, 1988). The results showed that snakes evoked increased corrugator activity whereas flowers evoked increased zygomatic activity (for a review see Dimberg, 1990).

The facial-EMG research demonstrates that people have a readiness to spontaneously react to different facial expressions. If facial reactions are controlled by biologically given affect programs (Tomkins, 1962), one could expect these programs to operate automatically and to be more or less independent of conscious cognitive processes. Such a notion also implies that the responses to facial stimuli would be quickly activated (Dimberg, 1991, in press). To specifically explore the speed of facial reactions to facial stimuli, Dimberg performed a series of studies in which the subjects were exposed to angry and happy faces while corrugator and zygomatic muscle activity was detected and scored in intervals of 100 ms (Dimberg, 1991, 1994, 1996a, in press). The results (see Fig. 6) showed that people spontaneously reacted with increased zygomatic activity to happy faces as compared to angry faces as early as 300 ms after stimulus onset. The corrugator response increased to both happy and angry faces during the first 100 ms intervals. After these first intervals, however, the corrugator response tended to differ between the facial stimuli and was significantly larger to angry faces as early as 400 ms after stimulus onset.

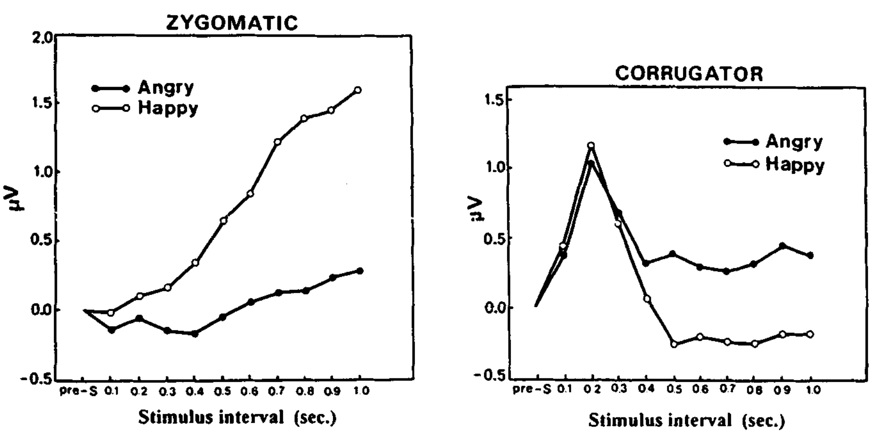

Fig. 6. The facial EMG responses to happy and angry facial expressions, plotted in intervals of 100 ms, during the first second of exposure to angry and happy facial stimuli. In the left panel, it can be seen that the *zygomatic major* muscle activity is larger to happy than to angry faces already after 300 ms after stimulus onset. The right panel shows that both angry and happy stimuli initially evoke increased activity in the *corrugator supercilii* muscle region, which can be interpreted as a nonspecific effect of visual stimulation. After 400 ms, the *corrugator supercilii* muscle response was larger to angry than to happy faces (from Dimberg 1996a).

These data show that distinct facial reactions can be differentially evoked by angry and happy faces as early as 300–400 ms after stimulus onset. This is in good agreement with the previously reviewed results from the masking paradigms, which also suggested that reactions to at least some facial stimuli can be activated after only a minimal duration of stimulus exposure. In concert, these results support the hypothesis that facial reactions may be automatically elicited and controlled by rapidly operating facial affect programs (Dimberg, 1991, press; Ekman, 1992).

CONCLUDING COMMENTS

The data reviewed in this paper clearly show that faces are effective emotional stimuli, exactly as one would expect from an evolutionary perspective. Conditioning studies document that facial expressions are differentially prepared to enter into associations with aversive outcomes, so that an angry face is a much more effective CS for an aversive UCS than is a happy face. There is a good deal of data conforming to the evolutionary perspective in showing expected effects of a number of distinct variables, including the gender, age, orientation, and the displayed emotion of facial stimuli. Even when concealed by a masking stimulus, facial displays of anger previously paired with aversiveness are effective in eliciting emotional responses. Similarly, masked angry faces can become associated with aversiveness even though they are not consciously perceived by the subject. Thus, it appears that a good deal of the processing of threatening angry faces takes place at an automatic nonconscious level. There is also consistent data suggesting that these effects of conditioning to facial displays of anger are localized to the right cerebral hemisphere.

The psychophysiological study of responses to facial stimuli is not restricted to Pavlovian conditioning paradigms. Merely showing an emotional face to an observer elicits systematic responses in the face that tend to mimic the emotion displayed by the sender. Like for the conditioned responses to facial stimuli, there is good reason to claim that facial responses reflect the outflow of automatic, very fast stimulus processing algorithms.

Similar claims have been raised from other research domains. For example, Hansen and Hansen (1988) reported that an angry facial expression was automatically picked out in a crowd of happy faces, whereas a serial search was necessary to locate a happy face in an angry crowd. This attentional bias to detect a threatening face among other faces is particularly obvious in high-anxiety subjects (Byrne & Eysenck, 1995). However, the "face-in-the-crowd-effect" is controversial and the claims of its demonstration have, in fact, been retracted by the authors themselves (Hansen & Hansen, 1994).

The Interpretation of the Conditioning Data

In his last paper on conditioning to facial stimuli, John Lanzetta (Lanzetta & Orr, 1986) came to the conclusion that facial displays of fear functioned to enhance emotional responding, independently of conditioning and expectancies of aversive outcomes. This is an important conclusion that challenges some of the established beliefs in the field (some of which are traceable to our own previous writings).

Indeed, this idea provides an alternative interpretation of the effects we have reported from experiments where some aspects of the CSs were shifted between acquisition and extinction (Dimberg, 1986a; Dimberg & Öhman, 1983). We assumed that the subjects learned something about the person, and that this learning was shown in performance as enhanced resistance to extinction when the person made facial gestures of anger. However, if the person in our studies is seen as parallel to the tone used by Lanzetta and Orr (1980, 1981, 1986; Orr & Lanzetta, 1984) in their compound conditioning work, the extinction data can be understood in terms of boosting the emotional arousal produced by the person component of the CS by presenting facial gestures of fear (either as a fear or an anger face). Friendly facial expressions, on the other hand, would inhibit the fear response elicited by the person component of the CS.

This formulation covers most of the data we have reviewed in this paper. It still regards facial gestures as important emotional stimuli, with a likely evolutionary origin, but it departs radically from the original preparedness hypothesis (Seligman, 1970, 1971; Seligman & Hager, 1972) in attributing the effect to performance rather than to learning. It simply says that once some aversive emotional state is activated (with or without previous conditioning training of some component of the stimulus), then facial displays of anger and fear enhance this state.

Put in this way, Lanzetta's (Lanzetta and Orr, 1986) statement appears virtually identical with the sensitization account of the preparedness effects for snake and spider stimuli proposed by Lovibond, Siddle, and Bond (1993). In the very first publication on preparedness from our group, Öhman et al. (1974) reported that the mere presence of shocks and shock electrodes potentiated responses much more to fear-relevant stimuli such as snakes than to neutral stimuli such as houses. This finding is similar to the one reported by Lanzetta and Orr (1986) and it was taken as the point of departure by Lovibond et al. (1993) in suggesting that so called prepared stimuli actually only sensitized an already existing emotional activation in the subjects. To back up this assertion, they presented two compound conditioning experiments, much in the spirit of Lanzetta and Orr (1986; Orr & Lanzetta, 1984).

There is one finding, however, which appears hard to reconcile with this theoretical perspective. This is the finding that conditioning can be established to masked stimuli (Esteves et al., 1994b). Both the experiments reported by Esteves et al. (1994b) had very stringent controls for sensitization. A sensitization interpretation of the findings in the conditioning groups would claim that the only important event during the so called acquisition phase was the presentation of the shock UCSs. This aversive stimulation sensitized the subjects, and, as a result, when the angry or happy faces were presented nonmasked during extinction, the angry face enhanced the sensitization process so that significant differential response to the angry and happy faces was observed. However, exactly the same reasoning can be applied to the control groups in the two experiments and also to the groups allegedly conditioned to happy faces. Yet none of these groups showed any differential response to the angry and happy faces in the extinction series even though they had been exposed to as much shock. Thus, one must assume that an associative conditioning effect was present in the groups conditioned to the effectively (and ineffectively) masked angry faces that was not present with a happy face CS or in the sensitization groups.

The obvious alternative in this context is to argue that angry (and probably fearful) faces affect *both* conditioning and sensitization processes. The emotional effect of threatening facial displays in most instances can be attributed to sensitization (Lanzetta & Orr, 1986; Lovibond et al., 1993), yet with proper experimental techniques (Esteves et al., 1994b; Öhman & Soares, 1996) it is possible to demonstrate a definite role for associative processes to the effect that only a threatening display can be associated with aversiveness outside of awareness.

Preattentive Processing of Facial Stimuli

The masking studies suggest that the angry facial displays exert most (if not all) of their effect on the receiver virtually instantaneously at onset. This means that emotional responses to facial stimuli may be initiated independently of conscious awareness. Thus, we may react to inconspicuous facial cues from a person and this emotionally colored response may determine our feeling of liking or disliking for him or her regardless of our conscious thoughts. Even more dramatic, the speed of facial muscle responses to facial displays documented by Dimberg (1991, 1994, 1996a; in press) suggests that we automatically may respond to the facial display without conscious awareness that we have perceived the display in the first place. Thus, the results we have reviewed suggest that long sequences of interactions between people may be partly determined by nonconscious perceptions and automatic responses on the part of both the sender and the receiver. Their conscious understanding of what is going on in the interaction that they can formulate verbally, on the other hand, may be quite independent of this basic level of interaction.

It is, of course, still unclear exactly what type of information processing goes on at the preattentive level. Öhman (1992, 1993) has developed a theoretical perspective in which attentional processes play a critical role. According to this perspective, attention is automatically drawn to functionally important aspects of the environment by capacity independent monitoring systems that scan the surroundings for potential threats. When threat is encountered (e.g., in a facial display) attention is centered on this display for further and more conscious analysis. Similar arguments can perhaps be launched for other types of important stimuli, such as food when one is hungry, or as already exploited in the advertising industry, erotic cues for catching the attention of males.

These type of preattentive mechanisms may be critical for the activation of emotion. Indeed, any theorist giving bodily feedback an important role in emotion (e.g., James, 1884; Schachter & Signer, 1962; Mandler, 1975; Damasio, 1994) must assume that bodily responses are automatically activated by some classes of stimuli. Dimberg's (e.g., 1991, 1994, 1995, in press) finding that differential responses to different classes of emotional stimuli are discernible in the human faces within a few tenths of a second actually provides a necessary foundation for the facial feedback hypothesis (e.g., Izard, 1977; for reviews see, e.g., Buck, 1980; Adelman & Zajonc, 1989). Thus, the data we have reviewed shows that continuous and automatic scanning for, and reaction to, facial cues may result in emotional activation that, in turn, helps to shape further cognitive activity appraising the situation and the ongoing social interaction. This type of analysis may be generalized to a broader set of contexts, in which the interplay between preattentive localization of threats or promises, emotional activation, and conscious appraisals shapes the emotional activities of the person, and where, indeed, the conscious level comes in late and must act under the constraints shaped by earlier and less consciously accessible mechanisms (Zajonc, 1980).

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