Affect and action : contrasting conscious and nonconscious processes

Rotteveel, M.

Publication date
2003

CHAPTER 2

STRONGER SUBOPTIMAL THAN OPTIMAL AFFECTIVE PRIMING?*

The finding of stronger affective priming in less conscious (suboptimal) conditions than in fully conscious (optimal) conditions (Murphy & Zajonc, 1993) is theoretically important because it contradicts notions that emotions are primarily reflected by conscious states. In two experiments this pattern of results was obtained. Happy and angry faces were presented both optimally and suboptimally and were masked by unknown ideographs. In Experiment 1, instructions for the conscious and less conscious affective priming conditions were matched and affective ratings of ideographs were determined. In Experiment 2, a more implicit affective measure (facial electromyography of m. corrugator and m. zygomaticus supercilii) served as the dependent variable. Stronger suboptimal than optimal affective priming was found in both experiments. It is concluded that stronger suboptimal than optimal processing is characteristic for affective processing and that it can also be found when instructions are matched and when a more implicit measure is assessed.

Many emotion theories acknowledge the role of nonconscious processes in emotion, but, in the final analysis, base their theoretical notions, such as appraisal (Frijda, 1986; Lazarus, 1991) primarily on subjective, conscious, report, or even introspection. The influence of affectively valenced material may, however, sometimes be stronger when presented under conditions of reduced consciousness than when presented fully consciously (MacLeod & Hagan, 1992; Murphy & Zajonc, 1993; Murphy, Monahan & Zajonc, 1995). When a reduction in consciousness is accompanied by larger effects this seems to contradict the notion that affect is available to consciousness. Perhaps, the most direct effects of affective stimuli can, in fact, be obtained when interference by conscious processing is eliminated. In this study, the generality and robustness of this pattern of results is investigated in two experiments that primarily sought to replicate the results of Murphy and Zajonc (1993), but differed from these experiments in the instructions (Experiment 1) and the dependent variable (Experiment 2).

*This Chapter is a slightly adapted version of Rotteveel, M., de Groot, P., Geutskens, A., & Phaf, R.H. (2001). Stronger suboptimal than optimal affective priming? *Emotion, 1,* 348-364.

Murphy and Zajonc (1993) investigated in a series of six experiments effects of different types of primes on the affective and non-affective evaluation of unfamiliar Chinese ideographs. Affective (i.e., faces with happy or angry emotional expressions) and non-affective (e.g., polygons, faces with neutral expressions) stimuli were presented either in a suboptimal (4 ms) or optimal fashion (1000 ms) by means of a projection tachistoscope. Suboptimal presentation was, however, probably not 4 ms but rather about 10 ms due to shutter delay (see Winkielman, Zajonc, & Schwarz, 1997). The more cautious terminology of suboptimal and optimal, instead of subliminal and supraliminal, or even nonconscious and conscious, was adopted by Murphy and Zajonc (1993) because the absence of an effect in a (direct) task measuring conscious effects does not guarantee that all conscious processing has been excluded with suboptimal presentation (Cheesman & Merikle, 1984).

Happy and angry faces led to reliable, valence-congruent, shifts in affective evaluation of the ideographs (compared to empty and polygon priming conditions) only with suboptimal presentation of these primes (Murphy & Zajonc, 1993, Experiments 1 & 2). In optimal conditions the direction of the priming effect even tended to reverse (i.e., incongruent), at least in Experiment 1. Non-affective priming of size (Experiment 3) and symmetry (Experiment 4), however, only revealed congruent shifts in optimal conditions. Evaluation of whether the ideograph represented a feminine or masculine object (Experiment 5), when preceded by male or female faces also revealed congruent priming only in the optimal conditions. Experiment 6, finally, indicated that with prior suboptimal presentation, happy and angry faces could be discriminated in a 'two-alternative-forced-choice' recognition task, whereas male and female faces could not be discriminated.

Stronger suboptimal than optimal effects have also been reported in several other experimental paradigms involving affective material. An affective variant of the Stroop paradigm, for instance, showed indications of stronger interference from subliminally than from supraliminally presented threat words with anxious participants (MacLeod & Hagan, 1992; MacLeod & Rutherford, 1992), as well as higher correlations of interference with state anxiety. A negative correlation has also been obtained in our laboratory between the amount of priming by sex pictures (on reaction times of deciding whether target pictures were sex or plant pictures) and recognition performance afterwards of the sex primes (Janssen, Everaerd, Spiering & Janssen, 2000). Priming by non-affective plant pictures was, however, largest for those participants who had the highest recognition of the plant pictures afterwards. A comparable pattern of results was also obtained in a pronunciation task (Bargh, Chaiken, Raymond, & Hymes, 1996). An affectively valent prime influenced (i.e., facilitation with congruent values, and interference with incongruent values) the time of pronunciation of the affectively valent adjective target. It was shown that with removing conscious processing aspects from the paradigm the influence of affective primes increased.

Stronger suboptimal than optimal effects also emerged from a meta-analysis of the mere-exposure effect (Bornstein, 1989), which was supported by a direct experimental comparison of the effects of subliminal and supraliminal prior exposure on preference ratings (Bornstein & d'Agostino, 1992). Mere exposure is sometimes considered an implicit memory effect where the enhanced processing fluency due to prior exposure is misattributed to an intrinsic liking of the stimuli, particularly when prior exposure cannot be consciously remembered (Seamon, Marsh, & Brody, 1984; Bornstein & d'Agostino, 1994). The emergence of a stronger suboptimal than optimal pattern of results, however, seems to point in the direction of an affective phenomenon.

Recently (Reber, Winkielman, & Schwarz, 1998; Winkielman & Cacioppo, 2001; Chapter 6), it has been suggested, however, that there may be a fundamental correspondence between some affective and memory processes at a nonconscious level. Recognition performance of affectively neutral words from a previously studied list, for instance, was influenced by positively and negatively valenced prime words preceding the test words (Phaf et al., Submitted). Suboptimally presented positive primes led to more 'old' responses to both old and new (i.e., 'false recognition') test words than suboptimally presented negative primes. With optimal presentation this priming effect was merely reduced, but did not reverse. This may, thus, be a further effect complying with the stronger suboptimal than optimal pattern. If familiarity of neutral material can be influenced by affective priming, it may be hypothesized that processing on the positive-negative dimension and the familiarity-novelty dimension, at least in part, correspond, and that the occurrence of the greater suboptimal than optimal pattern may be used as a marker for processing on both dimensions.

The stronger suboptimal than optimal pattern of results has considerable theoretical relevance because it contradicts two types of theoretical positions on the relationship between conscious and nonconscious processes. The first position (for a number of different conceptions of "nonconscious" see Kihlstrom, 1987) would argue that only a few peripheral processes are nonconscious and that all 'cognitive' processes performed by a central processor are conscious. Suboptimal effects result, according to this position, from conscious effects leaking through in some trials due to the incomplete exclusion of such effects. An example of this position can be found with Shanks and St. John (1994) when they argue that the positive results on information processing during general anesthesia may be due to inadequate anesthesia that left some of the patients partially conscious. Similarly, inadequate masking may leave some of the suboptimal trials conscious (Holender, 1986). The occurrence of stronger, instead of weaker suboptimal than optimal effects, however, directly opposes this idea.

The second position acknowledges both conscious and nonconscious processes, but assumes that their effects are similar. They adhere to what has been called by Mandler (1985) the 'identity position'. This position is implicit in many 'cognitive' approaches of emotion, which assume that subjective report may be a sufficient means for probing the underlying structure of emotions (Frijda, 1986; Lazarus, 1991). If priming conditions available to subjective report reveal weaker, or even an absence of effects than less conscious conditions, than much of the underlying structure of emotions may be obscured by the choice of this method. If one accepts the marginally significant reversal of affective priming in optimal conditions, one may even argue that subjective report yields a distorted picture of the nonconscious processes involved in emotion.

In spite of its potential theoretical importance and, although, it is often cited in the literature, not all attempts to replicate the affective priming results of Murphy and Zajonc (1993) have been successful. Kemps, Erauw, and Vandierendonck (1996), for instance, only obtained a congruent affective priming effect with 30 ms presentation of the emotional faces, which actually increased with longer presentation times.

Rotteveel and Phaf (Unpublished results) obtained also stronger optimal than suboptimal affective priming in a study which differed in many respects (i.e., computer screen stimulus presentation) from the Murphy and Zajonc (1993, Experiment 2) study. Participants, for instance, had to wait for the target ideograph to disappear (2000 ms) before the affective rating could be made on the subsequent Likert-scale. In other studies, only suboptimal but not optimal affective priming conditions were investigated (Winkielman, Zajonc, & Schwarz, 1997; Kemp-Wheeler & Hill, 1992), so that the occurrence of stronger suboptimal than optimal affective priming could not be assessed. The priming effect on affectively valenced targets was, moreover, found to be as large in subliminal as in supraliminal priming conditions by affective words (Greenwald, Klinger & Liu, 1989) and faces (Raccuglia & Phaf, 1997). We have also been told informally of a number of other unsuccessful replications, which, probably due to the null results, have not reached the publication stage. The incomplete and inconsistent findings raise the question whether and under which conditions the stronger suboptimal than optimal affective priming effects can be obtained. Before far-reaching conclusions about the distinction between conscious and nonconscious emotional processes can be drawn with any confidence much more needs to be known about the generality of the phenomenon.

An alternative interpretation for the stronger suboptimal than optimal affective priming found by Murphy and Zajonc (1993) is that participants treated the primes differently because they received different instructions in the two conditions. Only with optimal presentation were they instructed to ignore the primes, whereas, they could incorporate these primes in their ratings with suboptimal presentation. When participants are explicitly instructed to ignore the primes also in suboptimal conditions, as in our Experiment 1, the usual stronger optimal than suboptimal pattern may return.

Experiment 1

The first experiment had a similar design to Murphy and Zajonc's (1993) Experiment 2. Participants had to affectively evaluate ideographs when primed by optimally and suboptimally presented happy and angry facial expressions. Similar to their experiments stimuli were presented with a tachistoscope which was, however, fitted with electronically controlled LCD-shutters. LCD-shutters allow for finer control of prime timing than mechanical shutters, so that suboptimal presentation could be set at exactly 10 ms (with a 0.01 ms accuracy) which probably corresponds with the effective suboptimal presentation duration in the Murphy and Zajonc (1993) experiments (see Winkielman et al., 1997). Prime presentation (i.e., suboptimal vs. optimal) was similar to Murphy and Zajonc (1993) varied between participants. A 'two-alternative-forced-choice' recognition task was omitted in this experiment because we think the establishment of nonconscious conditions by this task is largely illusory. The exclusion of conscious processing in these conditions could only be guaranteed when the 'two-alternative-forced-choice' recognition task would measure all conscious processes exhaustively (Cheesman & Merikle, 1984). Our research strategy is not to show that there is no conscious processing of the prime in suboptimal conditions but to contrast conscious (i.e., optimal) and less conscious (i.e., suboptimal) conditions (Merikle, 1992). If we find differential results or even only a stronger suboptimal than optimal pattern, the importance and the meaningfulness of the distinction between conscious and nonconscious affective processes would be emphasized and it can no longer be concluded that suboptimal conditions represent only a diluted form of conscious processing, or that both types of processing are essentially identical (Mandler, 1985).

There were, however, also some additions and improvements to the experimental design of Murphy and Zajonc (1993, Experiment 2). Most importantly, participants in both prime presentations conditions (i.e., optimal and suboptimal) were instructed to ignore the facial expressions. In this respect, prime presentation and instruction were not confounded as in Murphy and Zajonc (1993) where participants were only instructed to ignore the primes in optimal conditions, and no instruction concerning the primes was given in suboptimal conditions. The stronger suboptimal than optimal pattern could disappear when participants also actively tried to ignore the faces in suboptimal conditions. In addition, we compared two kinds of ignore instruction as a between-participant variable to investigate whether the results of Murphy and Zajonc (1993) could be due to a particular interpretation of the ignore instruction by the participants. Participants in the 'passive-ignore' condition (as in Murphy and Zajonc, 1993) were instructed to just ignore the prime and it was also stressed that only the ideograph had to be evaluated (i.e., indirect instruction). In the 'active-ignore' condition participants were explicitly instructed to compensate for any possible influence of the prime on their affective ratings. It was simultaneously emphasized, however, that only the ideographs had to be evaluated.

If the instruction is the critical factor in the Murphy and Zajonc (1993) findings the stronger suboptimal than optimal pattern should disappear in Experiment 1. From the assumption that this pattern of results is characteristic for affective processing we expected, however, stronger congruent affective priming effects for the ratings in suboptimal conditions than in optimal conditions. If the instruction has an effect, it is, moreover, expected that the priming effect in optimal conditions might decrease or even reverse with active-ignore instruction.

Method

Participants. One-hundred-and-sixty first-year psychology students (99 females average age 20.6 year, *SD*=1.62, and 61 males average age 21.8 year, *SD*=2.56) from the University of Amsterdam participated in the experiment for course credit. All participants had normal or corrected-to-normal vision and none of them were familiar with Japanese ideographs. The experiment was announced as "Intuitive knowledge of the Japanese language". All participants were randomly assigned to one of four groups.

Design. The priming task had a 2 (Instruction: passive-ignore, active-ignore) x 2 (Prime-presentation: 10 ms, 1000 ms) x 4 (Prime-valence: negative, neutral, positive and empty) mixed factorial design. Instruction and prime-presentation were between-participant factors. Prime was the only within-participant variable. Nine positive, nine negative, nine neutral and nine empty primes were randomly presented once within all of the four between-participants conditions which resulted in 36 experimental trials for each participant. Every ideograph was only presented once to a participant. Coupling of primes with the ideographs and their sequence was varied randomly for each participant separately.

Affective rating responses were measured with a two-button response box. Only responses given in the 200 ms – 2000 ms time window after the beginning of prime presentation were included in further analyses. Only one missing trial per valence condition per participant was allowed. 'Negative' responses were labeled '1' and 'positive' responses '2'. These responses were averaged over conditions. Participants with more than one missing trial per valence condition were excluded from the analyses.

Material and apparatus. Fifteen slides of sport events and landscapes served as adaptation pictures and were presented for 30 s each at the beginning of the experiment. Twenty-seven pictures (Ekman & Friesen, 1976) of faces were selected as primes. Each was photographed against a black background. Nine had a happy expression, nine had an angry expression, and nine had a neutral expression. Model gender was not fully balanced (of each affective valence 3 models were male and 6 were female). Nine empty slides, which were matched on average grayscales to the faces, also served as primes. Forty-one Japanese ideographs, which were matched on complexity (10-12 strokes), served both as backward mask and as target. All ideographs were digitized and edited in Adobe PhotoShop 4.0 after which they were printed on slides. The ideographs were matched on average grayscales to the faces.

The central fixation-point was presented for 600 ms on the midline between the eyes of the prime faces which was to follow. The primes were presented for 10 ms (suboptimally) or 1000ms (optimally). The primes were immediately followed by the ideographs. On all trials the ideographs appeared for 2000 ms.

The experiment was conducted in two adjacent, dimly lit, sound-attenuated, rooms, which were connected by an intercom, and which had a milk-colored projection screen in the wall between them. Participants were seated at a table facing the backlit projection screen. The size of the projected images was 17 cm x 26 cm. Viewing distance was approximately 130 cm, resulting in a 7.5° horizontal and 11.3° vertical visual angle. The two-button box was placed in front of the participant. One button was labeled with a schematized smiling face (two eyes and a smiling mouth) and the other one with a similar sad face (two eyes and a reversed smile). The position of both labels (left/right) was counterbalanced across participants.

All equipment required for slide presentation and data collection was located in the other room. Three Kodak slide projectors, each fitted with a Displaytech ferro-electric liquid crystal shutter, were used to project the images on the screen. A Bull Z433D microcomputer controlled the slide carousels, the sequencing and timing of the shutters, and registered the response.

Procedure. Participants were first instructed to study the fifteen adaptation slides carefully and were told that they would later be asked questions about them. They were subsequently asked to describe three of the slides. In the instruction for the evaluation-test, participants were told that the ideographs had either a positive or negative meaning. They should intuitively guess this meaning, and respond by pressing one of two buttons on the response box. They were instructed to rely on their intuition and to respond as quickly as possible. They should avoid extensive reasoning about the ideograph. In both suboptimal and optimal conditions, participants were warned that the ideographs could be preceded by slides of faces. It was emphasized that the valence of the ideograph should be rated and not of the prime. They were told that the faces only played a role in another condition of the experiment. With the active-ignore instruction the participant should try to counteract any possible influence of the prime on the target. In the passive-ignore instruction the participant should simply ignore any preceding slide. The participants first practiced for five trials in their presentation condition and then completed thirty-six experimental trials.

Results

Twenty-five of the one-hundred-and-sixty participants were excluded from further analysis because of equipment failure (n=15) or because exit-interviews revealed that participants in suboptimal conditions reported awareness of 'flashes' or even of the primes (n=8). Two participants were excluded from analyses because they had too many late responses. As a consequence, 37 participants (14 male, 23 female) were included in the optimal passive-ignore condition, 31 participants (14 male, 17 female) were included in the optimal active-ignore condition, 35 participants (13 male, 22 female) were included in the suboptimal passive-ignore condition and 32 participants (10 male, 22 female) were included in the suboptimal active-ignore condition.

Stronger suboptimal than optimal congruent affective priming, irrespective of instruction, (see Table 1) occurred in this experiment, as was evidenced by the significant interaction between prime-duration and prime-valence ($F(3, 384)=3.32$, $p<0.05$) in the 2 (Prime-presentation) x 2 (Instruction) x 4 (Prime-valence) ANOVA.

Table 1. *Means (SD) of the Affective ratings of the ideographs (1= negative, 2= positive) for the optimal and subtoptimal and for both instruction-conditions conditions (Passive Ignore and Active Ignore) with the affective primes.*

	Suboptimal			Optimal		
	PI	AI	Average	PI	AI	Average
Positive	1.61	1.62	1.62	1.52	1.52	1.52
	(0.17)	(0.14)	(0.16)	(0.17)	(0.19)	(0.18)
Neutral	1.56	1.54	1.54	1.54	1.53	1.53
	(0.15)	(0.17)	(0.16)	(0.20)	(0.16)	(01.8)
Empty	1.50	1.51	1.50	1.54	1.55	1.54
	(0.16)	(0.14)	(0.15)	(0.16)	(0.19)	(0.17)
Negative	1.48	1.54	1.50	1.56	1.46	1.51
	(0.22)	(0.21)	(0.21)	(0.17)	(0.18)	(0.18)

Planned comparisons revealed that in suboptimal conditions priming by positive faces differed reliably from all other priming conditions (happy vs. angry, one-tailed, $t(65)=3.44$, $p<0.001$; happy vs. control, one-tailed, $t(65)=4.8$, $p<0.0001$; happy vs. neutral, one-tailed, $t(65)=2,3$, $p<0.05$). One-tailed comparisons for negative primes in suboptimal conditions with other prime conditions revealed a reliable difference with positive primes and a marginally significant difference with neutral primes ($t(64)=1.47$, $p=0.07$). For optimal conditions no reliable differences were revealed by planned comparisons (all t's<1).

In absolute terms, congruent priming was found in optimal conditions with active-ignore instruction, whereas the passive-ignore seemed to result in incongruent priming (see also Experiment 1, Murphy & Zajonc, 1993). This interaction between prime-presentation, instruction and prime-valence, however, did not reach significance ($F(3,384)=1.9$, $p=0.13$). The passive-ignore instruction condition with optimal presentation also revealed no reliable priming effects. For the optimal active-ignore instruction condition, however, only the priming effects of the negative primes differed reliably from the priming effects of the empty-primes ($t(30)=2.1$, two-tailed, $p<0.05$). No further main or interaction effects were significant in these analyses.

Discussion

Stronger suboptimal than optimal affective priming was obtained in this first experiment and the Murphy and Zajonc (1993, Experiment 2) findings were, therefore, replicated. This is the first replication that we know of in which presentation time of the prime and instruction was not confounded. The stronger suboptimal than optimal affective priming does not seem to be due to the participants actively trying to ignore the primes only in the optimal conditions. Evidently, ignoring the primes seems to entail a conscious strategy which cannot be engaged when the primes are not available for such conscious processing. The active- and passive-ignore instructions, however, also did not clearly influence this pattern of results. Although it could be argued that the difference in wording of instructions was too small to have an impact it seems more likely that the pattern of results is relatively robust and insensitive to the precise instructions.

A paradoxical feature of these results, if they serve as a criticism on emotion research using only subjective reports, is that both in optimal and suboptimal priming conditions the affective value of the target ideograph is reported subjectively. The pattern of results would be much more meaningful if it could be extended to affective measures that do not rely, however indirectly, on conscious dependent measures (i.e., implicit measures). Moreover, it is important to extend the affective priming paradigm with an additional dependent measure of affect because then the affective nature of the stronger suboptimal than optimal pattern could be underlined.

It has been claimed by Clore and Colcombe (2001; see also Clore & Ortony, 2000), for instance, that the stronger suboptimal than optimal pattern of results does not concern emotional processing but only reflects 'cognitive' information processing. Clore and Colcombe (2001) argue that Murphy and Zajonc (1993) only investigated semantic priming and not emotions at all. They further claimed that a similar pattern of results could be obtained in non-affective priming studies. Murphy and Zajonc (1993), however, already showed (Murphy & Zajonc, 1993; Experiment 3, 4, & 5) that in a similar set-up the opposite pattern of results (i.e., stronger optimal than suboptimal priming) is obtained when targets are primed by 'cognitive' (i.e., non-affective such as symmetry and gender) stimulus attributes on a corresponding response dimension. If we would find evidence for the stronger suboptimal than optimal pattern with another dependent measure, which also reflects affective but not, for instance, semantic activation, the argument for the specificity of this pattern of results for affective information processing would be strengthened.

Experiment 2

A very sensitive and valence specific measure of affect (Fridlund & Izard, 1983; Dimberg, 1988; Lang, 1995) is the electrical activity of the spontaneous movements of specific facial muscles (facial EMG). Spontaneous emotional facial expressions also seem to be evoked by the extrapyramidal system which mostly involves subcortical nuclei (Rinn, 1984). Facial Electromyography (EMG) of the musculus zygomaticus major for smiling and the musculus corrugator supercilii for frowning, has proved to be a useful tool in the measurement of valenced states (Cacioppo, Petty, Losch, & Sook Kim, 1986; Lang, Greenwald, Bradley, & Hamm, 1993; Lang, 1995). Facial EMG, moreover, appears to be a very sensitive measure that can detect minimal differences in the activity of a specific muscle, even when there is no overtly visible expression (Dimberg, 1988; Cacioppo, Bush, & Tassinary, 1992). In addition, also suboptimally presented facial expressions can evoke differential facial EMG activity (Dimberg, Thunberg, & Elmehed, 2000) at least when they served as targets (i.e., direct instructions).

Not only facial EMG but also affective ratings were determined in Experiment 2. To assess the affect-specificity of the stronger suboptimal than optimal pattern, we contrasted affective rating conditions with gender rating conditions (see Experiment 5, Murphy & Zajonc, 1993). Facial EMG was measured in an experimental room which was equipped for this purpose but which did not allow for tachistoscopic presentation. All stimuli, therefore, had to be presented on a computer screen, which also entailed some restrictions on the memory load of the computer by the pictures. Fast single-frame presentation on a computer screen, moreover, can only be achieved reliably when a picture has a relatively small memory size. Stimuli were degraded from full-color (grayscales) pictures to black-and-white pictures. To ensure that we would still get a suboptimal effect digitized stimuli were selected that had the most extreme ratings under minimal presentation (i.e., suboptimal) conditions. In the selection experiment, participants rated facial expressions (i.e., with direct instructions), which were all presented suboptimally and masked by an ideograph, both with respect to affective valence and gender. If, moreover, affect is more liable to nonconscious processing than gender, it would be expected that more extremely rated expressions can be selected than male/female faces. The selection experiment may, therefore, already reveal an effect supporting the affect specificity of the stronger suboptimal than optimal pattern. We included also a 'two-alternative-forced-choice' recognition task in this experiment to check for suboptimal presentation afterwards. It should be noted, however, that at chance performance in the latter task is no guarantee for the absence of conscious processing in suboptimal conditions (Cheesman & Merikle, 1984). Although our research strategy is to contrast conscious (i.e., optimal) with less conscious (i.e., suboptimal) conditions (Merikle, 1992) the 'two-alternative-forced-choice' recognition task could support the assumption that most conscious processing has disappeared in less conscious conditions.

In accordance with the Murphy and Zajonc (1993, Experiment 2) results, we expected in the main experiment stronger congruent affective priming effects for both affective ratings and facial EMG in suboptimal than in optimal conditions. In contrast to the previous experiment, affective primes (i.e., faces with happy and angry expressions) were presented in a blocked fashion. It was expected that there would be considerable transfer of affect and facial muscle activity between trials, which would reduce effect-size in a randomized design. This is, for instance, supported by findings of stronger interference in an emotional Stroop task when affective stimuli were presented in a blocked instead of a randomized fashion (Richards, French, Johnson, Naparstek, & Williams, 1992). We expected to have more chance of finding the greater suboptimal than optimal pattern in the facial EMG results than in the affective ratings due to the blocked design. For the non-affective gender ratings we expected stronger optimal than optimal priming effects with the ratings but no clear effect on facial EMG.

Selection Experiment

Method

Participants. Eighteen first-year psychology students (8 males and 10 females, average 22.6 years, SD=3.6 years) from the University of Amsterdam participated for course credit. All participants had normal or corrected-to-normal vision. The experiment was announced as a "Facial-Recognition" experiment.

Material and apparatus. All target stimuli (6.3 cm by 9.3 cm) were presented for 15 ms on the screen of a Macintosh LC 475 personal computer. Viewed at a distance of approximately 60-cm the presentation resulted in a visual angle of 6.2° horizontally and of 8.8° vertically. The same Chinese ideograph served as masking stimulus in all trials. The ideograph was drawn in black against an irregular random background pattern, had the same size as the target stimulus, and was rated as effectively bland in a pilot study. The stimuli were digitized black-and-white versions of photographs of facial expressions by Ekman and Friesen (1976) and Raccuglia and Phaf (1996) and new photographs prepared for this study. They consisted of fourteen pictures of male and fourteen pictures of female faces, fourteen pictures expressing happiness, fourteen pictures expressing anger and 28 pictures of fruits and vegetables which served as neutral stimuli in both rating tasks. From these pictures, the seven pictures rated as most positive, negative, male, female and the fourteen pictures rated as most neutral on both dimensions would be selected. Each trial started with a fixation point for 900 ms and was followed by the target stimulus for one frame (15 ms, but with a phosphor persistence of about 4 ms, see Bridgeman, 1998). The ideograph was presented for 2000 ms. The (inter-trial) interval between the offset of the response and the onset of the following fixation-point was 900 ms.

Procedure. The affective stimuli and half of the neutral stimuli had to be rated on a five-point Likert scale, ranging from "1" (labeled positive) to "5" (labeled negative). The non-affective stimuli and the other half of the neutral stimuli had to be judged on a scale which ranged from "1" (labeled male) to "5" (labeled female). Affective and non-affective stimuli were rated in two separate blocks. In the affective condition one smiling and one angry face were presented three times as practice trials. In the non-affective condition a male and a female face with neutral expression were presented for practice. The practice stimuli were not used again in the experiment. The order of the affective and non-affective rating tasks was counterbalanced. Two different stimulus orders were counterbalanced over participants. They were instructed that all stimuli would be shown under barely visible conditions, that all categories were represented equally, and that they had to choose using their intuition.

Results

With affective evaluation (see Table 2), the 14 positive faces were rated overall more positively than the 14 negative faces ($t(17)=3.79$, $p<0.001$). For the main experiment the pictures which received the most extreme ratings were selected, resulting in seven positive faces and seven negative faces ($t(17)=11.4$, $p<0.001$). For the non-affective condition the fourteen male faces were rated as being more masculine than the fourteen female faces ($t(17)=2.8$, $p<0.001$). Again the seven stimuli per category that received the most extreme ratings were selected for the main experiment ($t(17)=11.8$, $p<0.001$). The neutral pictures received intermediate ratings and the 14 pictures that were most intermediate were selected as neutral stimuli. In absolute terms, the range of ratings was larger for the emotional faces than for the male/female faces, thus providing some support for the affect specificity of the stronger suboptimal than optimal pattern.

Table 2. *Means (SD) for the overall Ratings of the faces (affective: 5= negative; 1= positive; non-affective: 1= male; 5= female) and means (SD) for the selected faces in the selection experiment.*

	Positive	Neutral	Negative	Male	Neutral	Female
Overall	2.33	2.89	2.86	2.86	2.94	3.14
	(0.40)	(0.31)	(0.45)	(0.36)	(0.34)	(0.25)
Selected	2.07	2.98	3.21	2.60	3.00	3.34
	(0.29)	(0.14)	(0.33)	(0.24)	(0.23)	(0.13)

Main Experiment

Method

Participants. Forty-eight students (21 males and 27 females, average 23 years, *SD*=5.9 years) from the University of Amsterdam participated for course credit. All participants had not participated in the selection experiment, had normal or corrected-to-normal vision, and no understanding of the ideographs. The experiment was announced as an experiment investigating "Intuition".

Design. The priming task had a 2 x (Prime-presentation: 15 ms, 1000 ms) x 3 (Prime-valence: negative, positive, and neutral, or Prime-gender: male, female, and neutral) factorial within-participants design. Gender of the participant served as an exploratory factor. The ratings of the ideographs, the facial EMG measurements of the m. zygomaticus major and m. corrugator supercilii served as dependent variables. Primes were presented in four blocks: affective suboptimal, affective optimal, non-affective suboptimal, and non-affective optimal. The order of these four blocks was counterbalanced among participants, but affective and non-affective conditions were kept together (resulting in four combinations). The suboptimal and optimal affective conditions each consisted of three sub-blocks (positive, negative, and neutral). The order of the sub-blocks within a particular condition was counterbalanced across participants (resulting in six combinations) but remained the same over all presentation conditions. Seven positive, seven negative, and seven neutral primes, were repeated twice within a respective block. In the non-affective conditions, male, female, and neutral primes were also presented in three separate blocks (seven male, seven female, and seven neutral primes, presented twice within a block). This resulted in 84 affective trials (21 different primes shown twice and presented subsequently for one frame and for 1000 ms) and 84 non-affective trials (21 primes shown twice and presented subsequently for one frame and for 1000 ms). For the primes within a block two different sequences were constructed, and the order of these sequences was also counterbalanced. The ideographs were presented in the same order for all participants, so that they would be combined with different primes across participants. The 84 ideographs were repeated in the long and short presentation conditions, so that a particular ideograph would be coupled to the same prime in the short and long presentation conditions for a particular participant. Both affective and non-affective conditions started with the presentation of twelve practice trials.

Material and apparatus. The apparatus for presenting the stimuli was the same as in the selection experiment. The Macintosh LC 475 personal computer was placed in a well-lit, sound attenuated room. In the adjacent dimly lit room the apparatus for facial registration was mounted. A one-way screen and an intercom connected the two rooms.

The 42 stimuli from the selection experiment served as primes. Also 84 Chinese ideographs, which in pilot research proved to be affectively neutral, served as targets. They were presented against an irregular random pattern, which improved their masking function. A trial started with a 900 ms presentation of a central fixation point followed by a prime (either for one frame or 1000 ms) which was masked directly by the ideograph (for 2000 ms). A five-point Likert scale appeared on the screen after the ideograph. In the affective condition the scale ranged from "1" (labeled positive) to "5" (labeled negative). In the non-affective condition the scale ranged from "1" (labeled male) to "5" (labeled female). The participants were instructed to rate their beliefs about the meaning of the ideographs on the Likert scale, by pressing the mouse-button on a particular position of the scale after the target had disappeared. The affective and non-affective conditions were preceded by twelve practice trials in which non-selected facial primes were presented (affective: three angry and three sad faces; non-affective: three male and three female faces; all presented optimally and suboptimally).

The 'two-alternative-forced-choice' recognition task consisted of 28 trials. Fourteen not previously used affective stimuli (seven positive and seven negative) and fourteen new non-affective stimuli (seven male and seven female) were presented for one frame, immediately masked by an ideograph, and followed by a five-point rating scale. Participants were then presented with two faces for 2000 ms: an image of the actual face presented (target) on one side of the screen and a foil on the other side of the screen. Each face always served once as a foil and once as target. Targets and foils were matched for valence and gender. Targets and foils were equally distributed at the left and the right side of the screen.

Participants had to decide whether the left or the right face corresponded to the target.

Facial EMG. Left corrugator and zygomaticus muscle activity was recorded with pairs of miniature Ag/AgCl surface electrodes (Sensor Medics) filled with Electrolyte gel. The electrode placement was in accordance with the guidelines of Fridlund and Cacioppo (1986), except that both bipolar measurements were referenced to two independent electrodes to ensure equal impedance. Inter-electrode impedance was reduced to 6000 ohms or less by briskly rubbing Omniprep paste on the electrode sites. The signal was pre-amplified (2000 x) using a band-pass filter (80-1000 Hz), and processed through a RMS-integrator with a 25 ms time constant and further amplified (5-50 x). The integrated signal was led through a Krohn-Hite band-pass filter (2-1000 Hz) to eliminate possible direct current and was sampled at 1000 samples/s by an Keithly System 570 A/D converter and recorded by a Compaq Prolinea 4/505 personal computer. A pulse from the Macintosh computer, starting 500 ms prior to the onset of the fixation point, triggered recordings of the facial EMG. Average EMG was calculated online and stored over the first 500 ms (baseline) and over 3 s following the onset of the prime. EMG averages that deviated by more than three standard deviations from the baseline-mean of that participant in that particular condition were excluded from further analysis. All facial EMG values were transformed to Z-scores for each participant and muscle separately. Finally, due to the complementary nature of both facial muscle responses we calculated an EMG difference-score between both facial muscles as was proposed by Greenwald, Cook, and Lang (1989).

Procedure. Before arrival of the participant, the electrodes were filled with Electrolyte gel. Participants were first informed and reassured about the procedure of the electrode placement. It was emphasized that the physiological measurement was of a general nature. The terminology of facial activity and EMG measurement was avoided. After electrode placement, participants were seated in front of the computer screen, were asked to relax and to refrain from talking during the task. The experimenter started the Macintosh computer and gave task-specific instructions. A second experimenter started the facial registration program in the adjacent room.

The affective and non-affective conditions were each preceded by twelve practice trials. Participants were told in the affective condition that the ideographs represented something with a positive or negative valence and participants were explicitly instructed to rate the ideographs on this dimension, or to guess its valence if they felt they could not adequately do so. In the non-affective conditions it was told that the ideographs represented something with either a male or a female connotation and participants were explicitly instructed to rate the ideographs on this dimension, or to guess if they felt they could not adequately do so. They were asked to use the whole rating-scale. For the 'two-alternative-forced-choice' recognition task participants could indicate whether the previously presented stimulus appeared on the left or the right side of the screen, using only the extremes of the five-point scale. After the electrodes were removed, participants received an exit interview. They were asked about strategies and beliefs when performing the experimental tasks.

Results

From the 48 participants the results of 40 participants (17 males and 23 females) were retained for analysis. Due to equipment failure, the data of six persons were lost. Two participants were familiar with the meaning of some of the ideographs and consequently had to be excluded from the analyses.

The results of the exit interview indicated that twelve participants had no clear assumptions about the experimental set-up, twenty-eight participants thought it was about the effect of the primes on the rating of the ideographs. Eighteen participants reported that although they could not recognize the suboptimal primes, they had sensed "something flashing by". The other participants reported not to be able to notice the suboptimal primes at all. Thirty-five participants indicated that they used some sort of strategy to rate the ideographs, the remaining five participants did not. Round, open, symmetrical forms were often associated with femininity and positive attributes. Heavy, asymmetric, angular forms on the other hand were associated with masculinity or negative attributes.

Table 3. *Normalized means (SD) of Corrugator, Zygomatic (Z-scores), and Affective ratings (1= positive, 5= negative), of the ideographs for the suboptimal and optimal presentation conditions with the affective primes.*

	Corrugator	Zygomaticus	Rating
Suboptimal			
Positive	-0.51	-0.34	2.93
	(3.36)	(2.71)	(0.44)
Neutral	1.0	-0.42	2.84
	(2.67)	(1.39)	(0.41)
Negative	0.53	-0.74	2.97
	(3.2)	(2.1)	(0.40)
Optimal			
Positive	0.40	-0.89	2.91
	(2.7)	(2.89)	(0.45)
Neutral	0.25	-0.47	2.83
	(3.4)	(4.05)	(0.36)
Negative	0.23	-0.23	3.07
	(3.9)	(1.93)	(0.48)

For the ratings (see Table 3) the ideographs preceded by negative primes were rated overall more negatively than the ideographs preceded by positive primes. The 2 x (Prime-presentation: suboptimal, optimal) 3 x (Prime-valence: negative, positive, neutral) ANOVA yielded a main effect for prime-valence ($F(2,39)=5.05$, $p<0.05$). No significant main effect was found for prime-presentation ($F(1,39)<1$). Also the interaction between prime-valence and prime-presentation did not reach significance ($F(2,78)<1$). Unexpectedly, the ideographs preceded by neutral primes were rated as most positive in both presentation conditions. The presentation of close-up faces may have led to more overall negative affect than pictures of fruits. In a follow-up ANOVA the neutral primes were excluded. The effect for prime-valence was now only marginally significant ($F(1,39)=2.91$, $p=0.09$). Again no significant effects were found for prime-presentation ($F(1,39)<1$) and prime-presentation x valence ($F(1,39)=1.02$, n.s.).

The expectation that optimally presented non-affective primes (see Table 4) would have a stronger influence on the gender rating of the ideographs than suboptimal non-affective primes was not corroborated. No differences in rating were found for the non-affective primes (Prime-presentation: $F<1$.; Prime-gender: $F(2,39)=1.49$, n.s. Prime-presentation x Prime-gender: ($F(2,78)<1$). Exclusion of neutral primes also revealed no further main or interaction effects.

Table 4. *Normalized means (SD) of Corrugator, Zygomaticus (in Z-scores), and Gender ratings (1= male, 5= female) of the ideographs for the suboptimal and optimal presentation conditions with the non-affective primes.*

	Corrugator	Zygomaticus	Rating
Suboptimal			
Male	0.64	-0.58	2.94
	(2.67)	(2.89)	(0.32)
Neutral	0.94	-0.49	3.06
	(3.9)	(2.36)	(0.34)
Female	0.13	-0.47	3.05
	(2.8)	(3.6)	(0.33)
Optimal			
Male	1.33	-1.39	2.96
	(3.9)	(3.6)	(0.46)
Neutral	0.58	-0.95	3.0
	(2.9)	(2.9)	(0.34)
Female	1.0	-0.61	3.07
	(4.2)	(2.2)	(0.42)

Normalized means (baseline subtracted) and standarddeviations of corrugator responses, and zygomaticus responses for the affective, and non-affective conditions are presented in Tables 3 and 4, respectively. Also the facial EMG scores of the fruit stimuli deviated sharply from the scores for the face stimuli. The neutral condition (fruit) was excluded from all further analyses because the fruit stimuli apparently cannot be seen as a neutral condition for face stimuli. All ANOVAs were conducted with participant-gender as a between-participant factor because there are some indications for sex differences in facial EMG responses (Dimberg, 1990; Thunberg & Dimberg, 2000).

The interaction between prime-valence and prime-presentation ($F(1,38)=4.38$, $p<0.05$) showed a larger corrugator response in suboptimal negative priming conditions than in suboptimal positive priming conditions (planned comparison: $t(39)=1.8$, one-tailed, $p<0.05$), but this difference did not occur in optimal conditions ($t(39)<1$, n.s.). No further main or interaction effects were found in the analyses of the corrugator response.

As expected, no fully significant main (Prime-presentation: $F(1,38)=3.83$, $p=0.06$; Prime-gender: $F(2,39)=1.52$, n.s.) or interaction effects (Prime-presentation x Prime-gender: $F(2,38)<1$) were found in the non-affective conditions with respect to the corrugator response. There was, however, some indication of overall frowning in optimal conditions, which could implicate that close-up faces, regardless of their expression, may be experienced as threatening, particularly when fully visible.

The mean zygomaticus response was larger for the suboptimal positive priming conditions than for suboptimal negative priming conditions but not in optimal conditions, as was evidenced by the interaction between prime-valence and prime-presentation ($F(1,38)=4.75$, $p<0.05$). With optimal presentation condition even a reversal occurred. The optimal negative priming condition evoked a larger zygomaticus response than the optimal positive priming condition (planned comparison, $t(39)=2.23$, two-tailed, $p<0.05$). In the suboptimal conditions the congruent valence effect was, however, not significant (planned comparison: $t(39)=1.08$, n.s.).

Female models evoked overall a slightly stronger zygomatic response ($M=-0.54$, $SD=2.97$) than male models ($M=-0.98$, $SD=3.24$), as was evidenced by a marginally significant effect of prime-gender ($F(1,38)=3.97$, $p=0.054$) in the 2 x (prime-presentation: suboptimal, optimal) x 2 (prime-gender: male, female) x 2 (participant-gender: male, female) ANOVA. Moreover, women responded more with smiling ($M=-0.05$, $SD=1.5$) than men ($M=-1.73$, $SD=4.26$) to male as well as to female primes, as was evidenced by a main effect of participant-gender ($F(1,38)=4.24$, $p<0.05$). This effect was previously found (Hall, 1984) and is probably absent in affective conditions because it is drowned out by the affective priming. No further main or interaction effects were found in these analyses.

Because in preceding analyses the interaction between prime-valence and prime-presentation seemed to be unaffected by participant gender, results were collapsed over participant gender in the following EMG-difference analyses. For the EMG difference-score (see Figure 1) the overall priming effect was again larger in suboptimal conditions than in optimal conditions for which even a reversal seemed to appear. The 2 x (Prime-presentation: suboptimal, optimal) x 3 (Prime-valence: negative, positive) ANOVA on difference scores indicated a significant interaction of prime-presentation and prime-valence ($F(39,1)=5.82$, $p<0.05$), but a planned comparison showed that only the suboptimal priming effect was significant ($t(39)=2.04$, one-tailed, $p<0.05$). The reversal for the optimal conditions did not reach significance (planned comparison: $t(39)=1.23$, one-tailed, $p=0.11$). We also calculated an EMG difference score for the non-affective conditions. Analysis of these scores revealed significantly more negative facial activity in optimal (M=-2.17, SD=5.68) than in suboptimal (M=-0.91, SD=4,77) conditions, irrespective of prime-gender ($F(1,39)=4.14$, $p<0.05$), again indicating that close-up faces appear to be associated with negative valence. Furthermore, a significant difference in facial response as a function of prime-gender was revealed by the same analysis. The difference-score was more negative (M=-1.97, SD=5.34) in response to male models than to female (M=-1.11, SD=5.18) models ($F(39,1)=4.35$, $p<0.05$).

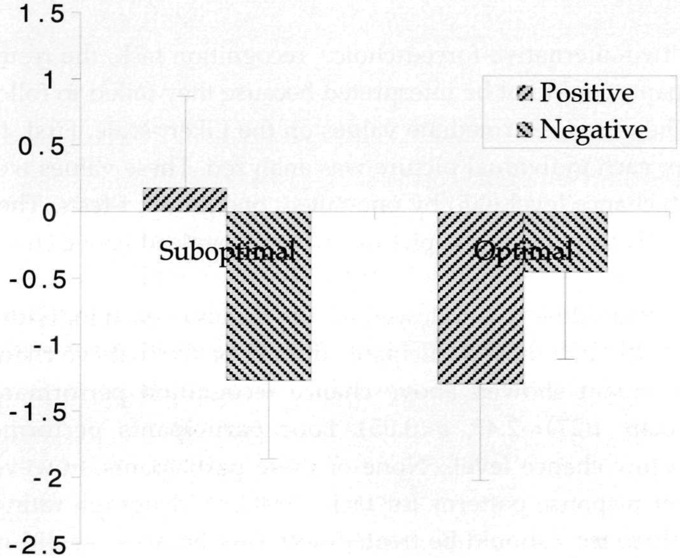

Figure 1. *Difference-score (SE) between the Zygomatic and Corrugator muscle (Z-scores) activity as a function of affective valence and exposure time in the affective conditions.*

To test the alternative explanation that priming effects could be attributed to physical stimulus properties, the percentage of black pixels was calculated for all primes, separately. A possible assumption would be that relatively dark pictures have a more negative priming effect than light pictures. The highest percentage of black pixels was found for the neutral primes, and the lowest percentage was found for the positive primes. Corrugator and zygomaticus activity indeed appeared to correspond to prime brightness, though not significantly (Proportion black/corrugator $r=0.36$, n.s., Proportion black/zygomaticus $r=-0.16$, n.s.). In a subsequent analysis the primes were divided into three groups, based on the percentage of black pixels, and 3 (Proportion black: low, medium, high) ANOVAs were conducted with corrugator, zygomaticus and ideograph ratings as dependent variables for the suboptimal presentation condition only. These analyses yielded no significant effects suggesting that in this experiment the priming results could not be explained by systematic differences in prime brightness (main effect of proportion black in the rating scores: $F(2,78)=1.18$, n.s.; in the corrugator response: $F(2,78)=0.45$, n.s.; in the zygomaticus response: $F(2,78)=0.99$, n.s.).

For the 'two-alternative-forced-choice' recognition task, the results of two participants could not be interpreted because they failed to follow instructions. They used intermediate values on the Likert-scale. First, the mean scores for each individual picture was analyzed. These values were compared with chance level (0.5) by one-tailed, one group, t-tests. These analyses revealed that none of the pictures were recognized above chance level.

The same procedure was followed for the means of each individual participant and although most participants did not perform above chance level, one participant showed above chance recognition performance (M=071, $SD=0.46$, $t(27)=-2.47$, $p<0.05$). Four participants performed significantly below chance level., None of these participants, however, showed deviant response patterns for facial EMG or ideograph ratings. Furthermore, these tests should be treated with care because we did not correct for multiple testing.

To further test the alternative interpretation that our results could be explained by differences in prime recognition, a median split was executed for forced-choice-performance of the participants. ANOVAs, conducted for the affective conditions, did not yield any significant main or interaction effect with group on any dependent variable.

Discussion

The expectation that affective primes would evoke larger affective responses in suboptimal conditions than in optimal conditions was supported by the facial EMG data, but not by the affective ratings. Particularly the m. corrugator showed strong affect-congruent responses in suboptimal conditions. For the m. zygomaticus we even obtained an incongruent affective priming effect in optimal conditions (as in Experiment 1 of Murphy & Zajonc, 1993). Though there was a trend towards an overall priming effect of affective valence of the primes in the affective rating data, there was no indication of a stronger suboptimal than optimal effect, and in absolute terms optimal priming appeared to be larger than suboptimal priming. No reliable effects of male and female faces showed up in the gender ratings of the ideographs and, most notably, even in absolute terms there was no larger optimal than suboptimal influence as would be expected with non-affective priming.

It seems that participants in this experiment were less biased overall in their subjective ratings by the primes than the participants of Murphy and Zajonc (1993), or in our Experiment 1. This may be due to the blocked prime presentation time. Fox (1993), for instance, showed in an experiment in which numbers had to be classified as odd or even that spatially separate presented masked threat words (distractors) only had their influence, with high trait anxious participants, when they were intermixed with unmasked threat words. If prime presentation time was also randomized in Experiment 2 stronger effects could probably have been obtained in the ratings, but the EMG effects would, most likely, have decreased. Participants could also have developed a strategy with respect to the blocked presentation of affective primes. It could be that repeating the same response over and over again within a block of affective primes was avoided. Moreover, according to the exit-interview, participants seemed to rely predominantly on analytical strategies in the ratings of the ideographs. In sum, participants may well have developed strategies during the experiment that may have rendered them less open to the priming influences in their subjective ratings of the ideographs.

The dissociation we seem to have obtained between affective rating and facial EMG supports, moreover, the notion that facial EMG is not simply a derivative of the expressed affective rating. Such a dissociation would support the notion of a 'primacy' of an implicit measure, such as facial EMG, over subjective rating as an affective response and would argue against the notion that affective priming is merely a 'cognitive' phenomenon (Clore & Colcombe, 2001; Clore & Ortony, 2000). Concluding in favor of a dissociation would, however, require that the ratings have sufficient statistical power and that other processes are not confounded with these variables. Facial EMG, for instance, may have measured some other process such as effort or even facial mimicry (Hatfield, Cacioppo, & Rapson, 1994; Hess, Philippot, & Blairy, 1998; Lundqvist & Dimberg, 1995). On the other hand, the affective ratings may also have been distorted by strategical considerations.

An alternative explanation for the facial EMG findings in terms of effort may be supported by the finding of more overall frowning in optimal conditions than in suboptimal conditions. Participants, probably, had to put more effort (Rinn, 1984; Hess, Philippot, Blairy, 1998) into ignoring the primes as instructed when the faces were fully visible. The larger suboptimal than optimal pattern of congruent influences on the corrugator activity could, consequently, be the result of overwhelming interference from the effort spent in ignoring the faces in optimal conditions. A ceiling effect in the optimal conditions may have disguised these congruent effects. Although such an explanation could possibly account for the corrugator results, it fails to account, however, for the optimal incongruent affective priming results with the m. zygomaticus major.

Although there is much evidence that facial EMG is useful for the measurement of valenced states (Cacioppo et al., 1986; Lang et al., 1993; Lang, 1995), a second alternative explanation could be that participants only imitated the facial expressions of the primes (Hess, et al., 1998; Chartrand, & Bargh, 1999). The stronger suboptimal than optimal affective priming pattern could then be due to the (conscious) inhibition in optimal conditions of this mimicry. It could, however, be argued that this initial facial mimicry plays a role in evoking affective states. In this respect, the mimicry hypothesis may not be distinguishable from an affective hypothesis.

General Discussion

Without confounding instruction and presentation time of the primes stronger suboptimal than optimal affective priming was obtained in the ratings of Experiment 1 and the facial EMG results of Experiment 2. This pattern of results seem to be characteristic of genuine affective information processing if one accepts the facial EMG to be a reflection of affective activation. In this respect, the claim that affective priming is just some form of 'cognitive' priming that has nothing to do with emotion (Clore & Colcombe, 2001; Clore & Ortony, 2000) seems to be weakened. This pattern of results can, moreover, be seen as a kind of existence proof of nonconscious affective processes. Stronger suboptimal than optimal effects seem to exclude the possibility of only conscious processes leaking through to suboptimal conditions. If one accepts the reversal to incongruent priming in optimal conditions, even a qualitative difference (Merikle, 1992) has been obtained, indicating that conscious and nonconscious affective processes can be dissociated. In both cases, however, the identity position (Mandler, 1985) seems to be violated and subjective report alone does not represent an adequate measure for determining the full structure of emotions.

Stronger suboptimal than optimal affective priming is, however, not always easily obtained. This is evidenced by the absence of clear effects in the affective ratings of Experiment 2 (see also Kemps et al., 1996; Rotteveel & Phaf, Unpublished results). Although the absence of clear effects in the ratings of the second experiment is probably mostly due to the blocked affective prime presentation the lack of congruent affective priming in suboptimal conditions could also be due to relatively ineffective suboptimal conditions. Other reasons for ineffective suboptimal conditions, however, seem to be twofold. First, a tachistoscope, as in Experiment 1, may be more suited for suboptimal presentation than a computer screen, as in Experiment 2. Clear advantages of tachistoscopic stimulus presentation with high-speed shutters are a fine control over timing and the continuous availability of the full picture even with very short stimulus durations. With single-frame presentation on a computer screen, however, the picture is built up pixel by pixel and line by line. The visibility of a single pixel corresponds to the persistence of the specific phosphor used in the screen (about 4 ms, Bridgeman, 1998), and the result is incomplete prime presentation for a shorter period (less than 10 ms) than a single frame.

The second problem with suboptimal presentation is inherent to the affective priming paradigm and consists of the participants missing a number of suboptimally presented primes due to eye-blinks or saccades. Suboptimal, but not optimal, affective priming effects are, therefore, diluted by missed trials, which evidently counteracts the stronger suboptimal than optimal pattern. This argument not only strengthens the finding of stronger suboptimal than optimal affective priming when it occurs but also necessitates attempts to create suboptimal conditions with longer presentations. Merikle and Joordens (1997) have, for instance, suggested that dividing attention during presentation has parallel effects to masked presentation. In preliminary research (Rotteveel & Phaf, Unpublished results) we have indeed found indications for stronger suboptimal than optimal affective priming when suboptimally was achieved by dividing attention.

In sum, we think that stronger suboptimal than optimal affective priming is an important finding with strong theoretical implications. The pattern of results may, however, be rather brittle due to the dependence on specific experimental conditions, such as mode of presentation and specific experimental design. A similar brittleness of the stronger suboptimal than optimal pattern could be observed in neural network simulations of the affective priming results in our laboratory (Capalbo, Den Dulk, & Phaf, 2000). Murphy and Zajonc (1993) already suggested that their results could be understood in terms of the dual-pathway model of LeDoux (1986, 1996), but did not present a computational model that actually produced these results. The dual-pathway model distinguishes a short, direct, pathway responsible for 'quick and dirty' processing and a longer, indirect pathway which leads to affective responses through slower, more elaborate, and detailed processing. It is assumed that evolutionary relevant (see also Öhman, 1986) stimuli (such as presumably facial expressions) especially can also follow this direct pathway to address affective effector systems (for recent evidence from neuroimaging studies see: Morris, Öhman & Dolan, 1998; Morris, Öhman & Dolan, 1999). Direct processing leads to a strong tendency to respond congruently to the faces, but the opportunity to process the faces more extensively provides the opportunity to place them in the proper context (i.e., the laboratory context where these emotional faces are irrelevant) and the affective response will be inhibited. Because LeDoux' neurobiological model is well specified, it can be implemented quite readily in a computational neural network model. Only a few additions, such as nodes representing direct (i.e., evaluating the faces) and indirect (i.e., evaluating the ideographs) instructions are needed (see Capalbo et al., 2000). With activation of the direct instruction the model produces stronger optimal than suboptimal effects, but with an indirect instruction the reverse pattern is observed. When no instruction is activated in the model, which may correspond to participants being unsure what to do, mostly the stronger optimal than suboptimal pattern occurs.

The connectionist model even predicts further conditions when it will be difficult to obtain the stronger suboptimal than optimal priming effect. LeDoux (1996) already suggested within the framework of fear conditioning that extinction due to the indirect pathway may be disabled by unrelated fear stimuli or stress, and that the conditioned fear response preserved in the direct pathway may return under these circumstances. Similarly, it was expected that the inhibition due to the indirect pathway would disappear in stressful or arousing circumstances. The stress was postulated to correspond with increased neuromodulator levels (e.g., norepinephrine) which may raise global levels of lateral inhibition in the network. The stronger suboptimal than optimal pattern indeed reversed in the model when lateral inhibition was raised (Capalbo et al., 2000). Experimentally, these simulations lead to the prediction that relaxed participants will show the stronger suboptimal than optimal pattern more easily than stressed participants. Extensive processing through the indirect pathway, entailing a regulation of affective responses, can be profited from most when arousal mechanisms, preparing the organism for vigorous action, do not seem to be activated.

LeDoux' dual-pathway model may be more than a neurobiological model for fear conditioning. It may also provide a global framework for the relation between conscious and nonconscious processes. This may be illustrated by the fact that it can also account for the Murphy and Zajonc (1993) results, which do not represent a form of fear conditioning. The model does not neglect the role of conscious processes, as may be the case in the affective primacy hypothesis (see also Murphy & Zajonc, 1993), but assigns different functions to conscious and nonconscious processes which contribute in a parallel fashion to affect. Due to their (implicit) adherence to the computer metaphor, many theories of emotion distinguish sequential stages of nonconscious and conscious processing. Arguably, the most important progress made by the LeDoux model is that conscious and nonconscious processes work in parallel and may differ in their effects. When nonconscious processes are assumed to precede conscious processes, for instance, by crossing some consciousness threshold, there is little room for qualitative differences. The ensuing correspondence between conscious and nonconscious processes would allow for subjective report, or even introspection, to be taken as the primary reflection of emotional processes. The stronger suboptimal than optimal affective priming, however, violates this identity assumption (see Mandler, 1985). These findings, thus, support the notion that emotion consists of both the direct nonconscious activation of affect and the more elaborate construction (Phaf & Wolters, 1997) of conscious content.