Psicothema 2005. Vol. 17, nº 2, pp. 332-337
www.psicothema.com
ISSN 0214 - 9915 CODEN PSOTEG

Facilitation and interference of the automatic information processing on a reaction time task to threat-relevant stimuli

José L. Marcos and Jaime Redondo*
Universidad de La Coruña and * Universidad de Santiago de Compostela

The purpose of this experiment was to study if the threat-relevant stimuli receive automatic processing when presented effectively masked in a priming paradigm. The prime consisted of an angry face (A) as threat-relevant stimulus and a face with neutral expression (N) as threat-irrelevant stimulus. The same stimuli (A and N) were used as target (or mask), giving four masking conditions (A/A, N/N, A/N and N/A). Furthermore, the target was considered an imperative stimulus for a reaction time (RT) task. Thirty-two subjects were exposed to 10 trials of each masking conditions with a stimulus-onset asynchrony (SOA) of 34 milliseconds (ms). The same number of subjects received the same trials, but with a SOA of 51 ms, this being an unmasking presentation of the stimulus. The results demonstrate that an effective masking presentation of a threat-relevant stimulus produces either facilitation or interference with the RT task, depending on whether the target (mask) is a threat-relevant or a threat-irrelevant stimulus.

Facilitación e interferencia del procesamiento automático de la información sobre una tarea de tiempo de reacción ante estímulos amenazantes. El objetivo de este experimento era estudiar si los estímulos amenazantes reciben procesamiento automático cuando son presentados eficazmente enmascarados en un paradigma de *priming*. El *prime* consistió en un rostro con expresión amenazante (A) y una cara con expresión neutra como estímulo irrelevante de amenaza (N). Los mismos estímulos fueron utilizados como *target* (o máscara), dando lugar a cuatro condiciones de enmascaramiento (A/A, N/N, A/N y N/A). Además, el *target* fue utilizado como un estímulo imperativo para una tarea de tiempo de reacción (TR). Treinta y dos sujetos fueron expuestos a 10 ensayos de cada condición de enmascaramiento con una asincronía del estímulo (SOA) de 34 milisegundos (ms). Otros tantos sujetos recibieron los mismos ensayos, pero con un SOA de 51 ms. Los resultados demuestran que la presentación eficazmente enmascarada de los estímulos amenazantes produce facilitación o interferencia con la tarea de TR, dependiendo de si el *target* (máscara) consiste en un estímulo relevante o irrelevante de amenaza.

One of the most influential models used to study the orienting reaction (OR) has been that proposed by Öhman (1979) for information processing. This model makes two basic assumptions. First, it assumes the existence of two types of memory systems, one short-term (STM) and one long-term (LTM). Secondly, it distinguishes between automatic and controlled information processing (Schneider, Dumais and Shiffrin, 1984; Shiffrin, 1988; Shiffrin and Schneider, 1977). It is also assumed that there are preattentive mechanisms that automatically process input information in relation to the content of the STM. When a significant stimulus —or a stimulus failing to find a match in the STM— is encountered, control over processing must be handed over to the central channel, which works in the controlled processing mode. When control is switched between the two modes of information processing, an OR is elicited and the stimulus enters the focus of attention. The OR was associated with «a call for processing resources» in the central channel (Öhman, Hamm and Hugdahl, 2000, p. 546). In the original model, the call and the associated OR were assumed to have a preattentive origin (Öhman, 1979).

However, this assumption was later modified (Öhman, 1992, 1993a, 1997, 2000) using the results obtained in a series of experiments with masked stimuli that could only be processed at the preattentive level. In accordance with the new formulation, only the ORs to biologically significant stimuli have a preattentive origin, while ORs to neutral stimuli, that do not imply any degree of biological threat, require central processing for its elicitation.

A scientific examination of this hypothesis requires the dissociation of the physiological responses from the conscious perception of the stimulus. A procedure used to achieve this goal is backward masking. This procedure is used to disrupt processing of a target stimulus by an immediately following masking stimulus. When the stimulus-onset asynchrony (SOA) between the target stimulus (masked stimulus) and the mask is short (about 30 ms), conscious recognition of target facial (Esteves and Öhman, 1993; Esteves, Dimberg and Öhman, 1994) and small animal (snakes

Fecha recepción: 23-4-04 • Fecha aceptación: 16-11-04
Correspondencia: José L. Marcos
Departamento de Psicología
Universidad de La Coruña
15071 La Coruña (Spain)
E-mail: jlmarc@udc.es

and spiders; Öhman and Soares, 1993) pictorial stimuli is effectively prevented (see Öhman, 1999, for a discussion of the conceptual and methodological implications of perceptual masking). This procedure seems to allow quite complete analysis of the target stimulus, but prevents its conscious representation; that is, it allows the dissociation of the automatic processing of the controlled process, since it does not allow the subject to be conscious of the presence of the stimulus (Marcel, 1983a; 1983b; for a review, see Holender, 1986; Merike and Reingold, 1992).

Several works on classical conditioning have demonstrated that the masked presentation of a stimulus that has been previously conditioned (CS+) can elicit an electrodermal conditioned response (CR), even when complete processing is disrupted by masking. This effect, however, only occurred when the masked CS+ was a fear-relevant stimulus. These results indicate that only an automatic processing of the fear-relevant stimuli is necessary for a previously acquired electrodermal CR to be produced (Esteves, Dimberg and Öhman, 1994; Öhman, 1986, 1992; Öhman and Soares, 1993, 1994; Parra, Esteves, Flykt and Öhman, 1997; Saban and Hugdahl, 1999).

The idea that there are perceptual systems geared to pick up potential threats from the environment at a very early stage of information processing has also been tested by procedures involving reaction time (RT) tasks (see Hansen and Hansen, 1988; Öhman, 1997). As Öhman (1997) indicates, «these results are consistent with the notion that there is a perceptual system that automatically and preattentively focuses attention on potentially threatening stimuli, where the threat has a likely origin in biological evolution» (p. 176).

The assumption of automatic and controlled processes places the reformulated model of Öhman (1997) within the contemporary theories of attention. Among these theories, of special importance is the formulation of Schneider and Shiffrin (Schneider, Dumais and Shiffrin, 1984; Shiffrin, 1988; Shiffrin and Schneider, 1977), mentioned above. After reviewing the corresponding empirical evidence, Shiffrin (1988) points out two characteristics of the automatic and controlled processes that are especially interesting for our purposes: 1) some automatic processes may trigger attentive processes (such as automatic calls to the attention system) (p. 772), and 2) when a process produces interference with attentive processes despite the subject's attempts to eliminate the interference, then the process in question is surely automatic (p. 765), as occurs, for example in the Stroop phenomenon (Stroop, 1935).

These characteristics suggest that it is possible to determine if a stimulus has received automatic processing by considering its effects on the processing of a subsequent stimulus, presented immediately after.

Hence, the objective of this investigation is to demonstrate if only biological and emotionally significant stimuli (such as threatening stimuli) receive automatic processing, evaluating its effects of facilitation or interference on a task requiring controlled processing of a second stimulus (priming).

For this, a procedure will be used that combines backward masking with a reaction time secondary task in a priming paradigm (Shiffrin, 1988, pp. 770, 771). The backward masking procedure is used to assure the automatic processing of a prime. The prime will consist of a picture of an angry face (as threat-relevant stimulus) or a picture of the same face, but with a neutral expression (as threat-irrelevant stimulus). Then, with a 34-ms SOA the target will be presented for 2.000 ms, acting as a mask of the prime. The target constitutes the imperative stimulus for an RT task. The same two pictures of the angry and neutral faces will be used as target. The task of the subject consists in pressing the white key as quickly as possible when the target consists of the angry face, or the red key for the neutral face. The correct performance of this task requires a controlled processing of the target.

From these objectives, the following hypotheses are formulated:

1) When the prime and the target are the same stimulus, the RT to the target will be shorter when this stimulus (the target) is threat-relevant than when it is threat-irrelevant. At the base of this hypothesis is the assumption that the automatic processing of the threat-relevant stimulus will prime the controlled processing of this same stimulus when it is presented immediately, unmasked.
2) If the masked prime and the target (mask) are different stimuli (angry or neutral faces), the RT will be shorter when the prime is threat-irrelevant (neutral face) than when this stimulus is threat-relevant (angry face). Indeed, if the masked prime is threat-irrelevant it will not receive automatic processing, so, it will not affect the controlled processing of the target (angry face), that constitutes the imperative stimulus for the RT task. However, if the prime is threat-relevant, it will quickly be detected and processed by preattentive mechanisms; this processing will produce interference with the controlled processing of the target that consists of the neutral stimulus. The interference will be reflected in a slowing down of the RT.

Method

Participants

Subjects were 64 undergraduate volunteers, ages 20-30. All received class credit for their participation in the experiment. An additional 3 subjects were rejected for giving RTs in anticipation of the imperative stimulus.

Stimuli, materials and apparatus

The prime and target stimuli consisted of the image on a computer screen of a female face showing either an angry or neutral expression. Both stimuli were used indistinctively as prime and target. These pictures were taken from the book of Ekman and Friesen (1975). The pictures were processed using «IrfanView» software to equate their visual properties of resolution, size and color. The size of each image on the computer screen was 75 × 105 mm (millimeters).

Stimulus onset and offset, SOA, and inter-trial intervals were controlled by an IBM-compatible microcomputer, with MEL Professional software (Rodgers, Schneider, Pitcher and Zuccolotto, 1996; Schneider, 1996).

The RT task consisted in pressing a red key when the neutral face appeared and a white key when the angry face was presented. The keys were connected to the MEL Professional system, which allowed for the computerized register of the RTs, with a precision of 1 ms.

Variables and design

The prime and target were an angry face and a neutral face. Each of the two stimuli could be presented as prime or as target.

This meant that in some assays of backward masking the same stimulus used as prime could appear as target, while in other assays the prime and the target were different stimuli. Hence, the *correspondence between the prime and target* was a first independent variable, with two levels: *congruent*, when the prime and target are the same stimuli, and *incongruent*, if they are different stimuli. The biological and emotional *relevance of the prime* was another independent variable, with two levels: *angry face (A)*, as threat-relevant stimulus, and *neutral face (N)*, as threat-irrelevant stimulus. Therefore, the backward masking can be achieve by four possible combinations of the prime and target (A/A, N/N, A/N, and N/A).

All subjects received 10 trials of each masking condition in random order. Thus, *correspondence, relevance of prime,* and *trials* were three within-subjects factors with repeated measures.

To adequately isolate the effects of facilitation or interference of the automatic processing of the prime, the subjects were divided into two groups of 32 subjects in each, that differed according to the SOA used (34 ms and 51 ms) during the backward masking. The choice of the SOAs was established as a function of two criteria: the characteristics of the hardware used and previous research on this topic.

Regarding the hardware, the 'refresh rate' of the color monitor used to display the stimuli determined that the minimum SOA was 17 ms. To coordinate the timing of the prime and target displays with each other and also with the start of the response timing, the guidelines of Mogg and Bradley (1995) were followed. Consequently, the SOAs used (34 and 51 ms) were whole multiples of the minimum SOA.

Furthermore, there is abundant empirical evidence suggesting that the use of SOAs near 34 ms prevents the conscious recognition of the prime. Most of this research was developed in the theoretical framework of the Öhman model using the backward masking procedure with angry and neutral faces as prime and target stimuli (Esteves and Öhman, 1993; Esteves, Dimberg and Öhman, 1994; Öhman, 1999). However, it seems clear that a SOA near 50 ms does not prevent the conscious recognition of the prime (Öhman, 1997; Öhman and Soares, 1993; Stone, Valentine and Davis, 1991).

Hence, it is assumed that the group with the 34-ms SOA carries out an automatic processing of the prime only when the stimulus is threat-relevant (A/N and A/A conditions), whereas the 51-ms SOA is sufficiently long to allow for the identification or processing in the central channel of the prime, when it is a threat-relevant stimulus as well as when it is a threat-irrelevant stimulus. The controlled processing will produce an interference effect, both under the A/N condition and the N/A condition. That is, the use of an SOA of 51 ms constitutes an unmasking condition. Therefore, SOA was a between-subjects factor with two levels: 34 and 51 ms.

The dependent variable was the time (RT) it took the subject to press the key when shown the neutral face or the angry face. The experiment was thus designed according to a 2 (SOA) × 2 (correspondence between the prime and target) × 2 (relevance of prime) × 10 (trials) factorial model with repeated measures on the last three factors.

Procedure

For the experiment, the subject would sit in front of a computer screen placing his/her dominant hand on the response box. Then, the instructions would appear on the computer screen, informing the subject to press as quickly as possible, the white key when the face of a threatening woman appeared on the screen, and the red key when the same face was presented but with a neutral expression. To help the subject become familiarized with the task, two practice trials, one with each image, were done.

Then, if the subject had no doubts about the task, the backward masking trials would begin. The sequence of trials was run randomly, with the restriction that none of the four masking conditions could be presented more than two consecutive times. The interval between trials was 10 seconds.

When the experiment was finished, the subjects from both groups were asked questions to confirm whether the backward masking procedure had avoided the processing of the prime in the central channel. The questions were general and avoided giving any type of information about the prime/target combinations used in the experiment. So, first, the subjects were asked to describe what they had seen on the screen. If they indicated having seen something before the target, they were asked to describe it. In cases where they commented having seen another face before the target, they were asked to specify what the face was like.

Scoring and analysis

Reaction times were scored automatically using a MEL Professional system. To evaluate the reliability of effects on the RTs, ANOVAs were calculated. Greenhouse-Geisser epsilon corrections were used to adjust probabilities for repeated measures effects (Jennings, 1987). Test of multiple mean differences were calculated by a priori t-test formula, corrected for degrees of freedom (Kirk, 1968). A rejection region of $p<0.05$ was used for all main effects and interactions.

Results

The subjects' answers to the questions asked at the end of the experimental session revealed that in the 34-ms SOA group none of the subjects adverted that before the imperative stimulus of the RT task another image was presented during a brief period of time. However, in the 51-ms SOA group, 84% of the subjects stated they had seen (or thought they had seen) the prime.

Reaction time data were subject to a mixed-model ANOVA. The factors included in the analysis were *SOA × correspondence between the prime and target × relevance of prime × trials*. This ANOVA yielded a significant main effect of *correspondence* between the prime/target, [$F(1/62)= 22.41$, $p<0.01$], the A/A condition being where the subjects responded more quickly (M= 623), and the A/N condition showing slower RTs (M= 682). There was a general diminution of RTs over trials, [$F(9/558)= 41.86$, $p<0.01$, $e= 0.67$].

The interaction between *correspondence* of prime/target and *relevance of prime* was highly significant, [$F(1/62)= 26.56$, $p<0.01$]. The a priori tests showed significant differences in all the possible prime/target combinations, except between the N/N and N/A conditions. The interaction between SOA, *correspondence* of prime/target, and *threat-relevance* of prime was also significant [$F(1/62)= 6.98$, $p<.05$]. The post-hoc test to analyze this interaction revealed that the 34 SOA group exhibited a faster RT in the N/A masking condition than the 51 SOA group [$F(1/62)= 7.08$, $p<0.01$, $\varepsilon= 0.62$]. The groups did not differ significantly in responding to the other three masking conditions. In Table 1 the means and standard deviations of the two groups in the four masking conditions are seen.

Separate analyses for each of the SOA groups with *correspondence* of prime/target, *threat relevance* of prime, and *trials* as the factors were carried out. Results of ANOVA for the 34 SOA group showed that the main effect of *correspondence* between the prime and target was significant [F(1/31)= 6.76, p<.05], but the *prime relevance* effect was not. However, the interaction between these factors was highly significant, [F(1 /31)= 25.91, p<0.01]. As seen in Table 2, comparisons using a priori tests revealed highly significant differences between N/N and A/A [(F(1/31)= 12.35, p<0.01)], A/N and N/A [(F(1/31)= 13.57, p<0.01)], and A/N and A/A [(F(1/31)= 28.29, p<0.01)] masking conditions. In addition, a significant trials factor effect was observed, [F(9/279)= 35.79, p<0.01, ε= 0.54], which was caused by a diminution in RT with trials.

The 2 × 2 × 10 ANOVA (prime/target *correspondence* × *threat-relevance* of prime × *trials*) with RT data from subjects of the 51 SOA group showed that the main effect of *correspondence* between the prime/target was significant [F(1/31)= 15.93, p<0.01. However, a significant effect was not detected for prime *relevance*. The a priori tests indicated that all comparisons were significant, except for the comparison between A/N and N/A masking conditions. As in the previous ANOVAs, a main effect of *trials* was also observed. None of the interactions were significant.

Discussion

The experimental results show that the previous presentation of the masked prime (34 ms SOA) affects the RT task to a target stimulus that serves as mask. This effect can be seen as either as a diminution or an increase in the RT to target, depending on two interrelated factors: 1) The biological and emotional relevance of the prime (an angry face as threat-relevant stimulus versus a face with a neutral expression as threat-irrelevant stimulus) and 2) the correspondence between the prime and the target, that is, if dealing with the same stimulus, or with two stimuli of different biological and emotional significance. The two possibilities will be discussed separately.

Correspondence between the prime and the target . When a 34-ms SOA is used the RT is shorter when the target stimulus is threat-relevant (A/A condition) than when it is threat-irrelevant (N/N condition). This indicates that the prime is processed preattentively, but only when this stimulus is threat-relevant. The automatic processing of this stimulus primes the emission of a faster RT to this same stimulus when it is presented immediately after as imperative stimulus (target).

In the 51-ms SOA group the same effect is observed, although more attenuated, since in this group the prime receives controlled processing, when it is threat-relevant, as well as when it is threat-irrelevant. Nonetheless, the fact that the subjects respond faster to the A/A than to the N/N masking condition seems to indicate that the relevant biological and emotional stimuli are processed more quickly, as the experiments of Hansen and Hansen (1988) and of Öhman (1997) show. Therefore, the big difference between these two conditions, in the 34-ms SOA group, could be due to the additional facilitation effect of the automatic processing of the prime in the A/A masking condition.

The prime and target have different biological and emotional relevance. When the prime and the target are different, various effects are observed in the 34-ms SOA group.

First, a clear slowing down of the RT is observed when the prime is threat-relevant (A/N masking condition), in relation to what occurs when the prime and the target are the two threat-relevant stimuli (A/A masking condition). This result is consistent with the idea that the prime has been processed preattentively, creating a response disposition to this stimulus. If the target is the same stimulus, the RT will be shorter because it has previously been processed. However, if the target is different, the response disposition produced by the automatic processing of the prime interferes with the adequate response to the new imperative stimulus (the target), which is reflected by a slowing down of the RT.

On the other hand, when the prime is threat-irrelevant a significant difference in responding to the target is not detected, independently of whether the target be the same stimulus (N/N masking condition) or a threat-relevant stimulus (N/A masking condition). This result suggests that the prime has not received automatic processing, since it does not produce an interference or a slowing

Table 1
Mean and standard deviation of the RT data for each masking condition in the 34-ms SOA and 51-ms SOA groups

SOA	MASKING CONDITIONS							
	N/N		A/A		N/A		A/N	
	M	S.D.	M	S.D.	M	S.D.	M	S.D.
34 ms	655	112	612	79	632	115	677	122
51 ms	660	129	634	105	684	134	687	119

Table 2
F-Values obtained in the comparisons of masking conditions in the 34-ms SOA group (in bold) and in the 51-ms SOA group (in italics). *p<.05; ** p<.01

	N/N	A/A	N/A	A/N
N/N	–	**12.35****	**3.53**	**3.25**
A/A	*6.33**	–	**2.67**	**28.29****
N/A	*5.85**	*24.36***	–	**13.57****
A/N	*7.08**	*26.82***	*0.06*	–

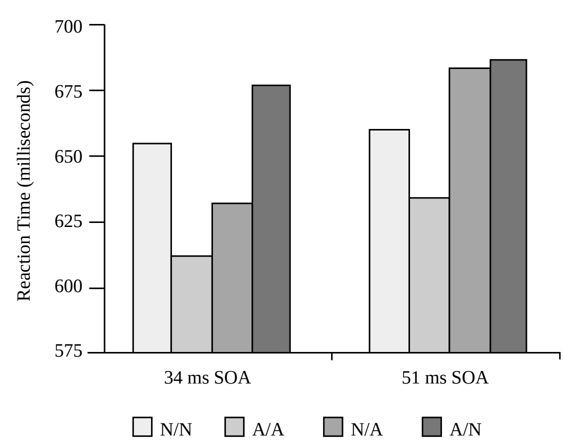

Figure 1. *Mean reaction times for each masking condition in the 34-ms SOA and 51-ms SOA groups*

down of the RT in the N/A condition compared with the N/N condition. This result constitutes further proof that only the relevant biological and emotional stimuli receive automatic processing when they are effectively masked.

In total agreement with the previous explanations, the results also show that when the prime and the target are both of different biological relevance, the subjects take longer in responding when the prime is threat-relevant (A/N masking condition) than when it is a threat-irrelevant stimulus (N/A masking condition). Again the results are consistent with the explanation that only the threat-relevant stimuli are processed preattentively when they are masked, producing interference in the response (slowing down of the RT) when the imperative stimulus (the target) has different biological and emotional significance. However, when the masked primes are neutral, automatic processing is not received, and therefore they do not interfere with the RT task to the target, even if this stimulus is of different biological significance.

The results obtained in the 51-ms SOA group support this interpretation of the results. As observed in Table 2, the subjects take longer in responding when the prime and the target are of different biological and emotional relevance, with respect to what occurs when they are the same stimulus, independently of whether the prime is a threat-relevant or a threat-irrelevant stimulus. The explanation is very simple: a 51-ms SOA is sufficiently long to allow for controlled processing of the prime, independently of its biological and emotional significance. In agreement with the considerations of Shiffrin (1988), the controlled processing of the prime will produce interference with the processing, also controlled, of the imperative stimulus (target). This interference is reflected in a slowing down of the RT. Moreover, the fact that a difference is not detected between N/A and A/N conditions supports this same interpretation, since it is assumed that in both cases the prime receives controlled processing, in the central channel, such that interference with the RT task in both conditions will be produced.

Other considerations. Finally, the results of the general ANOVA (SOA × correspondence of prime/target × relevance of prime × trials) show that the subjects exhibit the fastest RT to the A/A condition, which could be explained as being a result of the addition of the two effects: the facilitation effect of the prior processing of the prime and the effect of a faster processing of the target, since it is a biologically relevant stimulus (Hansen and Hansen, 1988). On the other hand, the slowest RT is produced in the A/N condition, which can easily be explained as being a result of the interference of the prior processing of the prime to the controlled processing of the target. Moreover, the post-hoc test to analyse the interaction between SOA and masking condition showed that the 34-ms SOA group exhibited a faster RT in the N/A condition than the 51-ms SOA group. This result can adequately be explained by recurring once more to the fact that in the 34-ms SOA group the prime has not received any type of processing, since it is a threat-irrelevant stimulus, hence, it will not interfere with the later processing of the target. However, in the 51-ms SOA group, the prime receives controlled processing that interferes with the later processing of the target, since it is a stimulus with different biological and emotional significance.

In conclusion, the results confirm the two hypotheses formulated in this experiment and are consistent with the assumption of the model of Öhman (1992, 1993a, 1997) that only the biologically significant stimuli receive automatic processing. Also, in accordance with the predictions derived from the model of Schneider and Shiffrin (Schneider, Dumais and Shiffirn, 1984; Shiffrin, 1988; Shiffrin and Schneider, 1977), it was possible to prove that the automatic processing of the stimulus can prime the controlled processing of the same stimulus when it is presented right after, or it can interfere with the processing of other stimuli of different biological significance.

Lastly, it is worth noting the importance of the experimental technique used in this investigation. As described before, this technique derives from the combination of the procedure of backward masking of the prime with a task of RT to the target. The results show that this technique is highly effective in isolating the automatic processing from the controlled processing, and also exhibits an elevated sensitivity to the effects of facilitation and interference of the processing to RT tasks. Due to these characteristics, its use in future investigations is recommended.

References

Ekman, P. and Friesen, W.V. (1975). *Unmasking the face. A guide to recognizing emotions from facial cues*. Englewood Cliffs, New Jersey: Prentice-Hall.

Esteves, F., Dimberg, U. and Öhman, A. (1994). Automatically elicited fear: conditioned skin conductance responses to masked facial expressions. *Cognition and Emotion*, *8*, 393-413.

Esteves, F. and Öhman, A. (1993). Masking the face: recognition of emotional facial expressions as a function of the parameters of backward masking. *Scandinavian Journal of Psychology, 34*, 1-18.

Hansen, C.H. and Hansen, R.D. (1988). Finding the face in the crowd: an anger superiority effect. *Journal of Personality and Social Psychology, 54*, 917-924.

Hansen, C.H. and Hansen, R.D. (1994). Automatic emotion: attention and the facial efference. In P.M. Niederthal and S. Kitayama (Eds.): *The heart's eye: emotional influences in perception and attention* (pp. 217-243). San Diego, CA: Academic Press.

Holender, D. (1986). Semantic activation without conscious identification in dichotic listening, parafoveal vision, and visual masking: a survey and appraisal. *Behavioral and Brain Sciences*, *9*, 1-66.

Jennings, J.R. (1987). Editorial policy on analysis of variance with repeated measures. *Psychophysiology, 24*, 474-475.

Kirk, R.E. (1968). *Experimental design: procedures for the behavioral sciences*. Belmont: Brooks/Cole.

Marcel, A.J. (1983a). Conscious and unconscious perception: experiments on visual masking and word recognition. *Cognitive Psychology, 15*, 197-237.

Marcel, A.J. (1983b). Conscious and unconscious perception: an approach to the relations between phenomenal experience and perceptual processes. *Cognitive Psychology*, *15*, 238-300.

Merike, P.M. and Reingold, E.M. (1992). Measuring unconscious perceptual processes. In R.F. Bornstein and T.S. Pittman (Eds.): *Perception without awareness* (pp. 55-80). New York: Guilford Press.

Mogg, K. and Bradley, B. (1995). Tachistoscopic applications of Micro Experimental Laboratory (MEL) used with IBM PC compatibles: stimulus and response timing issues. *Behavior Research Methods, Instruments & Computers, 4*, 512-515.

Öhman, A. (1979). The orienting response, attention and learning: an information-processing perspective. In H.D. Kimmel, E.H. Van Olst and

J.F. Orlebeke (Eds.): *The orienting reflex in human* (pp. 55-80). Hillsdale, N.J.: Erlbaum.

Öhman, A. (1986). Face the beast and fear the face: animal and social fears as prototypes for evolutionary analyses of emotion. *Psychophysiology, 23,* 123-145.

Öhman, A. (1992). Orienting and attention: preferred preattentive processing of potentially phobic stimuli. In B.A. Campbell, H. Hayne and R. Richardson (Eds.): *Attention and information processing in infants and adults: perspectives from human and animal research* (pp. 263-295). Hillsdale, NJ: Erlbaum.

Öhman, A. (1993). Fear and anxiety as emotional phenomena: clinical phenomenology, evolutionary perspectives and information processing mechanisms. In M. Lewis and J.M. Haviland (Eds.): *Handbook of emotions* (pp. 511-536). New York: Guilford.

Öhman, A. (1997). As fast as the blink of an eye: evolutionary preparedness for preattentive processing of threat. In P.J. Lang, R.F. Simons and M. Balaban (Eds.): *Attention and orienting: sensory and motivational processes* (pp. 165-184). Mahwah, NJ: Erlbaum.

Öhman, A. (1999). Distinguishing unconscious from conscious emotional processes. Methodological considerations and theoretical implications. In T. Dalgleish and M. Power (Eds.): *Handbook of cognition and emotion* (pp. 321-352). Chichester, U. K.: Wiley.

Öhman, A., Hamm, A. and Hugdahl, K. (2000). Cognition and the autonomic nervous system: orienting, anticipation and conditioning. In J.T. Cacioppo, L.G. Tassinary and G.G. Berntson (Eds.): *Handbook of psychophysiology* (pp. 533-575). New York: Cambridge University Press.

Öhman, A. and Soares, J.J.F. (1993). On the automaticity of phobic fear: conditioned skin conductance responses to masked phobic stimuli. *Journal of Abnormal Psychology, 102,* 121-132.

Öhman, A. and Soares, J.J.F. (1994). Unconscious anxiety: phobic responses to masked stimuli. *Journal of Abnormal Psychology, 103*, 231-240.

Parra, C., Esteves, F., Flykt, A. and Öhman, A. (1997). Pavlovian conditioning to social stimuli: backward masking and the dissociation of implicit and explicit cognitive processes. *European Psychologist, 2,* 106-117.

Rodgers, K., Schneider, W., Pitcher, E. and Zuccoloto, A. (1996). *MEL proffesional: language reference guide*. Pittsburgh: Psychology Software Tools.

Ruiz-Padial, E., Sánchez, M.B., Thayer, J.F. and Vila, J. (2002). Modulación no consciente de la respuesta cardiaca de defensa por imágenes fóbicas. *Psicothema, 14*, 739-745.

Saban, S. and Hugdahl, K. (1999). Nonaware classical conditioning to pictorial facial stimuli in a between-groups paradigm. *Integrative Physiological and Behavioral Science, 34*, 19-29.

Schneider, W. (1996). *MEL professional: user guide*. Pittsburgh: Psychology Software Tools.

Schneider, W., Dumais, S.T. and Shiffrin, R.M. (1984). Automatic and control processing and attention. In R. Parasuraman and D.R. Davis (Eds.): *Varieties of attention* (pp. 1-27). New York: Academic Press.

Shiffrin, R.M. (1988). Attention. In R.C. Atkinson, R.J. Herrnstein, G. Lindzey and R.D. Luce (Eds.): *Stevens´handbook of experimental psychology, vol. 2: Learning and cognition* (pp. 739-811). New York: Wiley.

Shiffrin, R.M. and Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review, 84,* 127-190.

Stone A., Valentine T. and Davis R. (1991). Face recognition and emotional valence: processing without awareness by neurologically intact participants does not simulate covert recognition in prosopagnosia. *Cognitive, Affective and Behavioral Neuroscience*, *1*, 183-191.

Stroop, J.R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643-662.