Automatic Processes and the Appraisal of Sexual Stimuli: Toward an Information Processing Model of Sexual Arousal

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A model of sexual arousal is presented that highlights the interaction between automatic and controlled cognitive processes and proposes that different levels of cognitive processing can differentially affect subjective and physiological sexual arousal. In addition, two studies are presented in which the role of automatic processes was explored using a priming paradigm. Subjects were sexually functional men. In the first study an effect of priming was found on penile erection. Unexpectedly, responses were lower in sexual than in neutral trials. In the second study support was found, using a behavioral measure (reaction time), for the notion that the meaning of sexual stimuli can be perceived in a fast, automatic manner. Priming was most successful at lower levels of stimulus accessibility. The model and experimental approach presented in this article render starting points for new research on response discordance, gender differences in the processing of sexual stimuli, and inhibition of sexual response.

Sexual arousal can be conceptualized as a complex triad involving physiological, psychological (cognitive and affective), and behavioral components (Rosen & Beck, 1988). Instances of discordance between the components highlight the complexity of the mechanisms involved. Psycho-physiological studies have shown that correlations between genital responses and subjective sexual arousal are variable, both between and within subjects (Janssen & Everaerd, 1993). Genital responses have been found to be easily elicited in sexually functional men and women, even under ostensibly unfavorable experimental conditions such as performance demand and anxiety, and when sexual stimuli induce negative affect (Cranston-Cuevas & Barlow, 1990; Heiman & Rowland, 1983; Laan & Everaerd, 1995; Sakheim, Barlow, Abrahamson, & Beck, 1987). This suggests a strong link between sexual stimuli and the activation of genital responses. In contrast, subjective responses seem to be more variable, the levels reported more strongly dependent upon situational factors, and the levels can be low even in the presence of strong genital responses (e.g., Janssen Everaerd, van Lunsen, & Oerlemans, 1994a; Laan, Everaerd, Bellan, & Hanewald, 1994; Meston & Gorzalka, 1995, 1996; Meston & Heiman, 1998; Palace & Gorzalka, 1990: see Laan & Everaerd, 1995, for a review). These findings suggest that the components of sexual arousal are, at least to a certain degree, under the control of different mechanisms (cf. Bancroft, 1989). Although existing models of sexual arousal (e.g., Bancroft, 1989; Barlow, 1986; Byrne, 1977; Palace, 1995) have contributed considerably to our understanding of the determinants of sexual arousal, and while some recognize the complexity of the interrelationships among response components, they essentially treat sexual arousal as a unified construct and thus fail to explain and predict differential patterns of sexual arousal.

In an attempt to stimulate the conception of experimental hypotheses on the mechanisms involved in the regulation of the different components of sexual arousal, Janssen and Everaerd (1993) discussed some basic concepts that have proven useful in cognitive psychology and contemporary emotion research. Two of these concepts, or principles of emotional processing as we might call them, are of particular relevance to the study of sexual arousal. The first could be labeled the multiplicity of meaning and refers to the notion that sexual stimuli may have more than one (i.e., sexual) meaning. The second may be identified as the interaction of automatic and controlled processes, or the notion that different levels of cognitive processing can differentially affect subjective and physiological components of sexual arousal.

The notion that sexual stimuli or situations may have multiple meanings is supported by findings of several studies. For example, Everaerd and Kirst (1989) assessed the agreement, between and within individuals, on what constitutes sexual arousal, and measured the possible overlap of this emotion with other emotions. Using a computer program based on Frijda's (1986) emotion theory they found that sexual arousal overlaps with many positive emotions. However, the emotion profile of sexual arousal also showed overlap with negative emotions. Similarly, psychophysiological studies have shown that sexual arousal may co-occur with negative emotional responses to sexual stimuli (Heiman & Hatch, 1980; Janssen et al., 1994b; Laan et al., 1994) and with emotional states such as anxiety and anger.

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The distinction between automatic and controlled (or attentional) cognitive processes was originally introduced in the study of human memory (Posner & Snyder, 1975; Schneider & Shiffrin, 1977). Automatic processes, as opposed to attentional processes, are thought to be fast, unconscious processes which consume little or no attentional capacity. They are so named because they are engaged inevitably by the presentation of stimuli, regardless of a person's intentions (Williams, Watts, Macleod, & Mathews, 1997). Whereas a large number of studies have been conducted on the role of attentional processes in sexual arousal (e.g., Abrahamson, Barlow, Beck, Sakheim, & Kelly, 1985; Farkas, Sine, & Evans, 1979; Geer & Fuhr, 1976: see Barlow, 1986 for a theoretical integration), automatic processes have, as yet, received little attention.

Many contemporary emotion theorists acknowledge, and emphasize, the importance of unconscious or automatic processes in the appraisal of emotional events (e.g., Frijda, 1993; Leventhal, 1984; Öhman, 1986; Zajonc, 1984; but see also LeDoux, 1995). Appraisal occupies a central role in present-day emotion theory. It refers to the mechanisms that give a stimulus event emotional meaning and involves the analysis of an event's affective valence and its relevance for some concern (Frijda, 1993). Although appraisal may lead to the conscious awareness of the appraisal outcome, it does not have to (LeDoux, 1996). Also, while it has been argued that appraisal may involve noncognitive processes (e.g., Zajonc, 1984), it is now widely agreed that this should be reformulated to appraisal potentially being independent of conscious cognitive processes (Williams et al., 1997). In this context it should perhaps be emphasized that unconscious cognitive processes are part of what Kihlstrom (1987) called the cognitive unconscious; they should not be confused with psychodynamic notions of the unconscious. The term cognitive unconscious merely implies that a lot of what the mind does goes on outside consciousness. The dynamic ("hot and wet"; see Kihlstrom, 1992) unconscious can be conceived in terms of cognitive processes, but the terms automatic and unconscious do not imply dynamic operations (LeDoux, 1996).

Starting from considerations of the biological functions of fear, Öhman (1986; Öhman, Dimberg, & Esteves, 1989) outlined a theoretical perspective on aversive emotions which explicitly stresses the significance of unconscious information processing mechanisms in their elicitation. According to Öhman, automatic processing mechanisms can detect emotionally significant stimuli in a preattentive analysis, which activates physiological responses. The functional-biological basis of his model is relevant to our understanding of the mechanisms of sexual arousal. Clearly, species survival requires that genital responses occur in the presence of appropriate stimuli (Geer, Lapour, & Jackson, 1993). This view implies that there must be a strong link between sexual stimuli and genital responses, and that this link is likely to be highly prepared (in a biological sense) and automatic (in a cognitive sense).

In the present discussion, sexual arousal is considered the outcome of a process involving several cognitive actions. To elaborate on the concepts introduced above, we propose a conceptual model of sexual arousal that divides the process of sexual arousal into two main information processing stages: an appraisal stage and a response generation stage (cf. Frijda, 1986: see Figure 1). Appraisal, as noted above, refers to the mechanisms which give a stimulus event emotional meaning, and involves processes of encoding and linking of stimuli in memory. Response generation can be conceptualized as an integrative stage, integrating meaning with response or motor plans, which may lead to subjective experience of sexual arousal and genital response. The two stages, which form the central pathway in this model, mediate between stimuli and responses and are proposed to operate primarily on an automatic or preattentive level. As a third ingredient of the model, controlled or attentional processes (involving higher level regulation processes) both affect and are affected by central pathway operations.

In what way may we conceptualize the activation of sexual responses in terms of this rudimentary information processing model of sexual arousal? Clearly, the process starts with a relevant stimulus or stimulus event. The stimulus is encoded and matched with memory elements. A match with sexual elements in memory primes genital responses and this primary appraisal triggers attentional processing (cf. Öhman, 1986). When a stimulus event predominantly provokes sexual meaning in the memory system, attentional processes and the central pathway will operate in harmony. In this situation, attention enhances the processing of sexual meaning. In other words, attention is directed toward task-relevant, sexual cues (cf. Barlow, 1986). Central to our theoretical perspective is the notion that the central pathway is an automatic one, and that when sexual meaning prevails, this automatic process triggers the attentional system and directs it toward the sexual content of the stimulus event. Thus, a sexual stimulus may be viewed to attract attention to its sexual content in an auto-

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Figure 1. An Information Processing Model of Sexual Arousal

![Figure 1. An Information Processing Model of Sexual Arousal](image-url)
The foregoing account accentuates the role of a specific class of nonsexual meaning in the inhibition of genital responses, namely threat- or worry-related nonsexual meaning. This specification is relevant because not all processing of nonsexual meaning leads to inhibition of genital responses. Instances of discordant response patterns demonstrate that some classes of nonsexual meaning can be processed which influence subjective responses more strongly than genital responses. It seems that in many of these cases, nonsexual meaning is primarily related to the (conscious) evaluation of the stimulus itself (Laan & Everaerd, 1995). Apparently, this kind of processing does not draw attention away from the sexual content of a stimulus and, thus, does not interfere with further development of genital responses. Worry-related nonsexual meaning, in contrast, does seem to trigger inhibitory processes and attracts attention away from the sexual content of a stimulus. How is this difference to be understood? First, worry-related nonsexual meaning pertains to evaluations (and expectations) regarding one’s own performance rather than to the mere evaluation of a stimulus event. Inasmuch as the stimulus is involved, its role is that it triggers off “personal and emotional threats to self” (Mathews, 1990). Second, in the same way that fear has been described as an alarm state preparing the organism for escape (Barlow, 1988), worry may be seen as a state of the cognitive system adapted to anticipate possible future danger or threat (Mathews, 1990). For this reason, the activation of worry-relevant meaning in memory is supposed to be associated with the assignment of high priority to those processes involved in the detection and encoding of danger- or threat-related information, and a corresponding reduction in the cognitive resources available for the processing of other information. It appears that this assignment involves some automatic process, which is initiated preattentively, that serves to attract attention to off-task or nonsexual performance-related cues, and minimizes further acquisition of sexual information.

There are a number of relationships among the elements of the model presented, some more and some less explicitly described, that could be tested. The gist of the model, however, is that unconscious processes are relevant to explaining the “automaticity” of the genital response, whereas subjective report of sexual arousal is assumed to be under control of higher level, conscious cognitive processing. For the latter notion evidence exists, and is growing (cf. Laan & Everaerd, 1995). In contrast, the role of automatic processes has not been the subject of empirical investigation until now. As a starting point, we tested the assumption that sexual stimuli (pictures) presented under conditions of limited access to consciousness, are nevertheless sufficient to activate genital responses and sexual meaning. Related studies will be reported elsewhere (e.g., Spiering, Everaerd, & Janssen, 2000).

To explore the role of automatic processes it is necessary to demonstrate that stimuli presented under conditions limiting access to consciousness are nevertheless suf-
efficient to activate sexual meaning. The experimental paradigm of preattentive priming, in which the presentation of one stimulus, or prime, alters subjects' responses to a second (target) stimulus, may provide the tools for such a demonstration (Greenwald, Drainie, & Abrams, 1996; Holender, 1986). Regardless of the nature of a stimulus (e.g., whether word or picture), it is generally assumed that its affective meaning is represented in memory within a semantic network (e.g., De Houwer & Hermans, 1994). The findings of several studies suggest that semantic representations are more easily activated by pictures than by words (Carr, McCauley, Sperber, & Parmelee, 1982; De Houwer & Hermans, 1994; Sperber, McCauley, Ragain, & Weil, 1979). Furthermore, a number of studies using non-sexual stimuli have shown that the significance of pictures can be processed without the need for conscious perception (e.g., Morris, Ohman, & Dolan, 1998; Murphy & Zajonc, 1993), and that unconsciously presented pictures can facilitate identification of related pictures (e.g., Sperber et al., 1979) and even trigger physiological responses (Borgeat, Boissonneault, & Chaloup, 1989; Ohman, 1986).

Typically, a pattern-masking procedure is employed in this paradigm to prevent awareness of the priming stimuli (e.g., Marcel, 1983), and appropriate prime exposure durations are established by assessing each subject’s awareness threshold prior to the experiment (e.g., Cheesman & Merikle, 1984). In pattern-masking, the processing of the prime is impaired by the presentation of another visual stimulus, the mask, which usually consists of a randomly arranged visual pattern (e.g., pieces of letters or pictures). According to Marcel (1983), pattern-masking blocks the recovery process by which sensory information is entered into awareness. Effects produced by masked primes would thus reflect in pure form the properties of the perceptual encoding mechanisms in the "cognitive unconscious" (Kihlstrom, 1987). While this contention has not been without controversy (Holender, 1986), it is probably safe to state that masking effectively limits the opportunity for intentional, consciously-controlled processing.

In the experiments presented in this paper we used a preattentive priming paradigm in conjunction with pattern-masking. The subjects in both studies were sexually functional men. Prime exposure durations were established by assessing each subject’s subjective threshold (Cheesman & Merikle 1986; Kihlstrom, Barnhardt, & Tataryn, 1992; Merikle, 1992). In addition, at the end of each experiment subjects performed a forced-choice recognition task. This task was added to allow for a post-experimental test of awareness (Cheesman & Merikle, 1986). The rationale underlying this task is that if subjects truly cannot identify the prime, they should do no better than chance at recognizing it.

**Experiment 1**

The first experiment was a pilot study designed to provide a direct test of the assumption that genital responses may be activated as a result of automatic processing of a sexual stimulus. A group of sexually functional heterosexual men was presented with a series of sexual (target) slides. Each slide was preceded by either a neutral (e.g., a picture of a plant) or a sexual (e.g., a nude female model) priming stimulus. Exposure duration of half of each of the neutral and sexual primes was set at the subject’s threshold level, and the other half was set at 20 ms below threshold. The exposure duration of the priming stimuli was varied to allow for a post hoc assessment of the robustness of the effects of priming. It was expected that, in comparison with the neutral primes, the presentation of a sexual prime would facilitate responses to the sexual target slides. If our theoretical view is correct, sexual priming stimuli should activate early components of the genital response, and this activation should be reflected in higher initial response levels to the sexual target stimuli.

Of the two most widely used measures of penile circumference erection, the mercury-in-rubber strain gauge (Bancroft, Jones, & Pullan, 1966) and the electromechanical strain gauge (Barlow, Becker, Leitenberg, & Agras, 1970), the latter was used in this study because of its greater sensitivity to changes in penile circumference during initial stages of erection (Janssen, Vissening, Visser, & Everaerd, 1997). Because the lifetime of priming effects is believed to be limited (Greenwald et al., 1996), according to some studies to a few seconds (Deacon et al., 1999), and given that genital measurements are more reliable at later intervals, we decided to focus on some intermediate interval between stimulus presentation and measurement. It was predicted that maximum penile responses as measured during the first 5 seconds of the sexual target presentations would be higher when these stimuli are preceded by a sexual prime than when they are preceded by a neutral prime.

**Method**

**Subjects**

Eighteen sexually functional male subjects participated in the first experiment. All subjects were psychology students and received course credit for their participation. The mean age was 23, ranging from 19 to 42 years (SD = 6). Seventeen subjects had a heterosexual orientation, and one subject considered himself to be bisexual. Seventeen subjects (94%) had seen erotic pictures before participation.

**Setting and Apparatus**

The experiment was conducted in two adjoining rooms. In a semi-lit room (cf. Holender, 1986), the subject was seated in a comfortable recliner chair facing a back-lit projection screen. The experimenter and all technical equipment needed for slide presentations and data collection were stationed in an adjoining room.

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1 Some preliminary analyses on the data of this experiment have been reported by Janssen and Everaerd (1993).
Three Kodak slide projectors, each outfitted with a Displaytech Ferroelectric Liquid Crystal shutter, were used to project 17 x 26 cm images onto the screen. Viewing distance was approximately 130 cm, resulting in a 4° horizontal and 6° vertical visual angle. An IBM AT microcomputer was used to control the slide carousels as well as the sequencing and timing of the shutters. The program also employed trigger signals to initiate sampling of the physiological measurement, and marked change-over between trials and experimental phases.

Materials and Design

Eighteen sexual and six sexually-neutral color slides served as stimuli during the experimental trials. The sexual slides depicted nude female models and heterosexual couples engaged in oral or genital sexual activity. The neutral slides depicted pictures of flowers and plants. The luminances of the two sets of stimuli, measured during projection, were comparable in range (2.10 to 2.45 lm/m² for the sexual slides; 2.20 to 2.40 lm/m² for the neutral slides). Twelve of the 18 sexual slides were used as target stimuli. These stimuli were presented for 1 minute each. The remaining six sexual slides and the six neutral slides served as priming stimuli. The masking stimulus was constructed by arranging pieces of photographs of neutral objects in random orientations. The size and shape of these pieces were carefully chosen to prevent recognition of any of the objects represented. The luminance of the mask was 2.90 lm/m². The mask was presented for 500 ms.

A prime presentation consisted of five repeated exposures of the prime using a forward and backward masking procedure (cf. Forster & Davis, 1984; de Groot & Nas, 1991). Primes were presented more than once in an attempt to maximize exposure effects (cf. Bornstein, 1989; Kunst-Wilson & Zajonc, 1980). Moreover, because the experimental phase comprised only a relatively small number of trials it was important to ensure that all prime presentations were attended to. The present procedure reduced the probability of a priming stimulus being missed (e.g., as a result of eye-blinking).

The experimental design of this study was a 2 (prime-target relationship: congruent, incongruent) x 2 (prime exposure duration: T1, T2) within-subjects factorial. Two different relationships existed between primes and targets: For congruent trials, the sexual target was preceded by a sexual prime, whereas on incongruent trials the sexual target was preceded by a neutral prime. Prime exposure duration was determined using an identification threshold procedure (Cheesman & Merkle, 1984). Exposure duration of half the neutral and sexual primes was set at threshold level (T1) and of the other half at 20 ms below threshold (T2). The order of presentation of the primes and exposure durations was determined through the use of Latin squares (Kirk, 1968).

The stimuli used for the assessment of the identification threshold (threshold setting trials) were emotionally neutral slides. These slides depicted various kinds of objects (e.g., a pie or a boat) and animals (e.g., a cat or a monkey) as well as men and women, all in different neutral contexts. Sexual stimuli were not included in the threshold procedure because they may negatively affect the reliability of the resulting identification threshold. That is, subjects may be more reluctant to verbalize in detail anything they saw when confronted with degraded sexual stimuli than when presented with neutral stimuli (cf. Loftus & Klinger, 1992). The present procedure may thus be considered to yield a more conservative estimate of identification threshold. Stimuli in the threshold setting trials were presented using the same masking procedure as specified for the experimental trials. Furthermore, in an attempt to keep levels of dark adaptation during threshold and experimental trials comparable (Holender, 1986), a target slide was shown following each stimulus presentation. This slide depicted a male professor in academic dress (luminance: 2.40 lm/m²) and was presented for 3 seconds.

In a forced-choice recognition test presented to the subjects following the 12 experimental trials, the complete set of 24 experimental slides (primes and targets) was presented again, randomly intermixed with 24 distractor stimuli. The distractor stimuli consisted of 18 sexual and 6 neutral slides, and were matched for content, composition, and luminance. Each slide was presented for 3 seconds.

Measures

A mechanical penile strain gauge (Barlow et al., 1970) was used to measure penile circumference during all conditions. A continuous DC signal recorded changes in electrical output caused by expansion of the strain gauge. Before each session, calibration was accomplished using a 26-step plastic cone with steps ranging from 85 to 160 mm circumference. To ensure maximum privacy, subjects placed the strain gauge on the penis themselves. After careful instruction they positioned the strain gauge two-thirds of the way down the shaft of the penis toward the base. The genital device was sterilized in a solution of Cidex activated Glutaraldehyde before use (Geer & Janssen, in press).

Procedure

To help subjects make an informed decision about whether to participate in this experiment, the procedures were first explained in an introductory session. Confidentiality, privacy, and the opportunity to withdraw at any time were assured to the subjects. All subjects attending the introductory session decided to participate. Subjects were tested individually in the experimental session, which lasted about 2 hours. On arrival at the laboratory an informed consent form was read. Subjects were told that the general purpose of this experiment was to examine the effects of attention on the processing of sexual stimuli and the activation of sexual responses. After the informed consent had been signed the experimenter instructed the subject on how to attach the genital device to the penis. When the subject signaled (using a one-way intercom system) that the device had been attached, a 5-minute adaptation period
was varied during which the subject listened to music. After this period the threshold procedure began.

Phase 1: Threshold setting trials. Subjects were told that the purpose of this part of the experiment was to examine the effects of attention on the perception of stimuli presented under varying conditions of illumination. It was explained that a series of trials would be given and that all trials included the repeated presentation of a slide depicting fragments of photographs (the mask) and a slide depicting a professor. It was further explained to the subjects that a third stimulus would be shown in addition to these two slides, and that they might or might not be able to see this stimulus clearly. Subjects were told that they would be asked about this stimulus.

The sequence of events for each trial in the threshold procedure was as follows. First, a 1000 ms black fixation dot signaled the start of a trial. Then, after a delay of 1000 ms, the mask was presented for 500 ms, directly followed by the stimulus. This sequence (mask-stimulus) was repeated four times. The last presentation of the stimulus was directly followed by the slide depicting the picture of the professor. After this slide had been presented, subjects were asked to report anything they saw of the third slide (i.e., the slide shown between the presentations of the mask and the professor). When a subject reported having seen nothing he was encouraged to try to report on any "irrelevant" feature of the stimulus that he might have perceived (e.g., shapes, colors). A stimulus was classified as identified when the subject was able to accurately describe the stimulus, or when he correctly identified relevant features of the stimulus (e.g., the most prominent colors, the shape of an object, an item in the background). A stimulus was classified as not-identified when the subject failed to give any verbal description of the stimulus (e.g., "I think nothing was presented") or when a description was erroneous beyond doubt (e.g., describing the picture of an animal as "maybe a large triangle").

Identification thresholds were determined by a combination of the descending (Marcel, 1983) and ascending (e.g., Carr et al., 1982) method of limits. The first threshold setting trial started with an exposure of 120 ms. If the stimulus was correctly identified, exposure of the next stimulus was decreased with 10 ms. This was repeated until the subject failed to identify a stimulus for the first time. All following stimuli were presented in blocks of five. Thus, after the first time the subject failed to identify a stimulus, exposure duration was held constant for the next four presentations. Completion of this first block of five presentations yielded two outcomes. First, the subject identified one or more of the remaining four stimuli of the first block correctly. In this case, exposure of the next block of five trials was decreased by 5 ms. This was repeated until the subject failed to identify all five stimuli in a block. The threshold estimate equaled the exposure duration of this last block of trials. The second possibility was that the subject failed to identify any of the remaining four stimuli of the first block. In this case, exposure dura-

Phase 2: Experimental trials. After the identification threshold had been established, subjects were informed about the second phase of the experiment. It was explained that 12 sexual slides would be shown for 1 minute each. Subjects were told that each slide presentation would be preceded by the fixation dot and a repeated presentation of the slide with the fragments of photographs (the mask) for the purpose of manipulating attention. After this instruction a 5-minute resting period was started during which subjects listened to music. The resting period included a 1-minute baseline measurement for the strain gauge. The resting period was followed by the presentation of the 12 sexual slides. Each slide presentation was followed by 1-minute return-to-baseline periods in which the subjects were asked to complete a puzzle or listen to music. The experimenter announced all slide presentations and asked subjects to direct their attention to the screen.

Phase 3: Forced-choice recognition test. Immediately following the experimental phase, an old/new recognition task was started. This test was employed to control for the availability of the primes for conscious identification during experimental trials. Subjects were told they would be given a series of forty-eight 3-second slide presentations. After each slide presentation subjects were asked whether they believed they had seen this slide before, that is, at any time during the experimental phase of the study. They were asked to guess whenever they were uncertain. After this instruction, all 12 primes and 12 targets were presented again, randomly intermixed with the 24 distractor stimuli.

Data Reduction, Scoring and Data Analysis

All data from the strain gauge output were recorded on a WEKA OEM 821060 thermo writer and simultaneously sampled (10 Hz) by the microcomputer for off-line analysis. Data were entered into a computer program that enabled visual inspection and deletion of movement artifacts. A second program was used to transform the sampled data of the strain gauge from mVolts to millimeters circumference, based on the results of precession calibration. This program calculated means and maxima on both the total data of each condition and on 5-second intervals. Differences between baseline measures and evoked measures (with negative values set to zero) provided indices of penile responding.

Accuracy of the old-new decisions obtained during the recognition task was determined by calculating hit-rates (true positive rates), false-alarm rates (false positive rates), and predictive values positive and negative (Weinstein & Fineberg, 1980). Hit- and false-alarm rates provided information about accuracy in terms of detection (the proportion
of stimuli that is correctly or incorrectly identified as prime. Predictive values positive and negative provided information about accuracy in terms of discrimination (i.e., the proportion of seen before and not seen before responses that correspond to primes and distractors). Predictive values positive were calculated as the number of times a subject decided seen before given that the stimulus was a prime. This measure reflects the probability of a correct response when a subject indicates to have seen a slide before. Predictive values negative were calculated as the proportion of correct decisions given the response not seen before.

The BMDP 4V program (Dixon, 1990) was used for analyses of variance (ANOVAs). Greenhouse-Geisser probability levels are reported for repeated measures ANOVAs to control for possible violations of the homogeneity of variance (Vasey & Thayer, 1987). When required, post hoc contrast analyses (simple mean comparisons) were performed. The BMDP 3D and 6D programs were used for one-group t tests and Pearson product-moment correlations, respectively.

RESULTS

Identification Thresholds and Recognition Test

Identification thresholds ranged from 30 to 45 milliseconds (M = 38, SD = 5). The recognition data of two subjects were missing due to a computer failure. Thirteen of the remaining 16 subjects (81%) recognized all 12 target slides during the recognition task. Three subjects correctly identified only 10 target slides.

Eight subjects (50%) believed they had seen none of the 24 priming (experimental and distractor) stimuli before. Ten subjects (63%) believed they had seen none of the 12 sexual (experimental and distractor) stimuli before, and 13 subjects (81%) believed they had seen none of the 12 neutral (experimental and distractor) stimuli before. Table 1 shows the mean numbers of old-new decisions for primes and distractors, and the accuracy of these decisions in terms of hit-rate (true positive rate), false-alarm rate (false positive rate), and predictive values positive and negative.

The low hit rates indicate that the subjects were not accurate in detecting priming stimuli. False-alarm rates were also low, suggesting that the subjects accurately detected distractors. However, the combined results indicate that the decision not seen before prevailed regardless of the true nature of the presented stimuli. Predictive values negative were all about .50, indicating that the response not seen before was given equally as often for primes as for distractors. The mean predictive value positive, which was based on the data of only 6 subjects, was high for the sexual stimuli. This suggests that these subjects were reasonably accurate in discriminating between sexual primes and distractors. This was confirmed by a one-group t test, which showed that the predictive values positive deviated significantly from chance (t(6) = 7.47, p < .001). The low mean predictive value positive for the neutral stimuli, which was based on the data of only 3 subjects, indicates that for these stimuli the response seen before was given more often for distractors than for primes. While the predictive values positive were high for the sexual stimuli, the accompanying hit rates were low. This means that the 6 subjects were found to be "accurately discriminating" based on one or two decisions only. For this reason, it was decided not to exclude these subjects from analyses but to create an exploratory grouping factor (Recognition group: high recognizers, n = 6; low recognizers, n = 10). The 2 subjects of whom the recognition data were missing were excluded from further analyses.

Genital Responses

A 2 x 2 x 2 (recognition group x prime-target relationship x prime exposure duration) repeated measures ANOVA with recognition group as the between-factor was performed on the maximum circumference data obtained during the first 5 seconds of the 12 sexual slide presentations. This analysis revealed a marginally significant main effect of prime-target relationship (F(1,14) = 4.25, p < .06). No other significant main effects were found. The main effect of prime-target relationship was conditioned by a marginally significant interaction between exposure duration and prime-target relationship (F(1,14) = 3.70, p < .07) and a marginally significant interaction between recognition group and prime-target relationship (F(1,14) = 4.25, p < .06; see Figure 2). Follow-up tests revealed a significant

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<th>Table 1. Mean Number and Accuracy of Old-New Decisions in Recognition Task (Experiment 1)</th>
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Note. The values represent mean numbers of old-new decisions. For the accuracy measures, mean proportions and standard deviations (in parentheses) are provided.

* These values are based on 8, 6, and 3 subjects respectively. The remaining subjects could not be included in the calculations because they reported to have seen none of the (prime and distractor) slides before.
Figure 2: Penile Responses to Congruent and Incongruent Trials as Measured During the First Five Seconds of the Sexual Target Presentations, by Prime Exposure Duration and Recognition Group

PRIME EXPOSURE DURATION

RECOGNITION GROUP

Note. Left panel: Responses during congruent trials were smaller than responses during incongruent trials for the shorter exposure duration (T2). No effects were found for the longer exposure duration (T1). Right panel: Responses during congruent trials were smaller than responses during incongruent trials for the low-recognition group. No effects were found for the high-recognition group.

Effect for the shorter exposure duration (T2), indicating that responses during congruent trials ($M = 0.73, SD = 1.72$) were smaller than responses during incongruent trials ($M = 1.56, SD = 2.27; F(1,14) = 6.60, p < .02$). No significant effects were found for the longer exposure duration. Follow-up tests for the Prime-Target Relationship x Recognition Group interaction revealed a significant effect for the low-recognition group, indicating that responses of these subjects during congruent trials ($M = 0.95, SD = 1.69$) were smaller than responses during incongruent trials ($M = 1.77, SD = 2.39; F(1,9) = 10.15, p < .01$). No differences were found for the high-recognition group.

To evaluate the duration of the reported effects, a second ANOVA was performed using the maximum circumference data obtained during the first 10 seconds of the 12 slide presentations. This ANOVA revealed no significant main and interaction effects, indicating that after an additional 5 seconds the difference between congruent and incongruent trials had disappeared (Exposure Duration x Prime-Target Relationship: $F(1,14) = 2.66, p > .13$; Recognition Group x Prime-Target Relationship: $F(1,14) = 1.77, p > .20$).

Discussion

As expected, maximum responses during the first 5 seconds of the sexual target presentations were different for sexually and neutrally primed target presentations. Surprisingly, the direction of this effect was opposite to the one predicted; that is, genital responses to sexually primed targets were lower than responses to neutrally primed targets. Although main and interaction effects were only marginally significant, this reversed priming effect was found to be significant for the short exposure duration (T2) and low-recognition subject group. While these latter findings are consistent with the results of other priming studies (e.g., Murphy & Zajonc, 1993; Smith, Spence, & Klein, 1959; see also Bornstein, 1989) demonstrating that affective priming effects are stronger with lower levels of prime exposure, the reversal in the direction of the priming effect was unexpected.

A first, forthright interpretation of the reversed priming effect would be that the neutral prime presentations facilitated genital responses. Theoretically, however, this interpretation has little appeal. It implies that representations of sexual meaning and response activation in semantic memory are more strongly associated with neutral than with sexual stimuli (Collins & Loftus, 1975). An alternative interpretation would be that, relative to neutral prime presentations, sexual primes exercised an initial inhibitory effect on genital responses to the target stimuli. This points to the possibility that sexual prime presentations resulted in the activation of some antagonistic process.

There is, however, a third and more parsimonious explanation for the lower initial responses to the sexually primed targets. This interpretation involves the physiology of penile erection. Several investigators (e.g., Earls & Marshall, 1982; McConaghy, 1974) have observed that during initial stages of erection the penis undergoes an increase in length, which is associated with a simultaneous decrease in circumference. Recently, Kuban (1997), in a comparison between volumetric and circumferential measures, found a negative correlation between the two measures for approximately 25% of his subjects, and indicated that in many of these cases an initial increase of penile volume coincided with a decrease
in penile circumference. Unfortunately, the software used in the present study set all negative responses to zero circumference change, thus eliminating the opportunity for checking this phenomenon in our own data. However, the findings of other studies suggest, in contrast to the interpretations provided above, that the present experiment did yield evidence for early activation of the genital response. If sexual prime presentations activated early components of the genital response, and if this activation was reflected, at least in some subjects, in an initial decrease in penile circumference (resulting in a zero response in the present study) a relatively low mean response for the total group of subjects is to be expected.

In conclusion, while the interpretation of the direction of the priming effects found in this study is problematic, the finding that penile circumference was affected by the presentation of sexual primes does indicate that stimuli presented under conditions limiting access to consciousness are nevertheless capable of activating processes relevant to sexual response. The success of future research in confirming our findings will probably prove dependent upon further validation of penile circumference measures at initial stages of erection, or will have to rely on the further development of new measures of early components of genital response (e.g., penile EMG).

**EXPERIMENT 2**

In view of the uncertainties surrounding the interpretation of the current findings, a second experiment was designed in an attempt to tap the effects of automatic processing at an earlier stage (i.e., at a central level), using a behavioral measure (decision time). Although this type of measure is clearly inappropriate to probe genital activation effects, it allows for a test of the underlying and necessary assumption that sexual meaning is processed in a fast, automatic manner.

The second experiment was designed to test the assumption that the meaning of sexual stimuli is processed in an automatic manner. Subjects in this experiment were presented with a number of neutral and sexual target stimuli. Their task was to indicate as fast as possible whether the target was neutral or sexual. As in the first experiment, two different relationships between primes and targets were created. For congruent trials the target was preceded by a related prime (e.g., sexual-sexual), whereas for incongruent trials the target was preceded by an unrelated prime (e.g., neutral-sexual). Based on our assumption that the meaning of sexual stimuli can be activated without the need for a high (i.e., conscious) level of processing, it was predicted that response times to sexual targets would be shorter for congruent than for incongruent trials.

The old-new recognition task in the first experiment revealed that some subjects were fairly accurate in discriminating between primes and distractors. This result suggests that we failed, at least for these subjects, to establish exposure durations that effectively limit conscious awareness of the primes. One explanation for this failure involves the possibility that dark adaptation levels in threshold and experimental trials differed too much. We attempted to keep levels of dark adaptation as equal as possible by including "target" presentations in the threshold procedure. However, this precaution may not have been sufficient. While targets in the threshold trials were presented for 3 seconds, targets in the experimental phase were presented for 1 minute. There was, therefore, more light involved in the experimental phase than in the threshold phase, and this may have increased the probability of primes being identified in the experimental phase (cf. Holender, 1986). However, in the present experiment a decision-time task was used, and since decision times normally are shorter than 1 second (Ratcliff, 1993), this change in experimental design can be expected to eliminate the problem of differences in dark adaptation between threshold and experimental trials.

**METHOD**

**Subjects**

A new group of 20 sexually functional male subjects participated in this experiment. All subjects were psychology students and received course credit for their participation. Nineteen subjects had a heterosexual orientation. One subject considered himself to be bisexual. The subjects were between 19 and 27 years old ($M = 22, SD = 2$). All subjects had seen erotic pictures before participation. All subjects submitted written informed consent prior to participation.

**Materials and Design**

The setting and apparatus were the same as in the first experiment. The experimental design of this study was a 2 (prime-target relationship: congruent, incongruent) x 2 (target: sexual, neutral) within-subjects factorial. Forty sexual and 40 neutral (pictures of plants) color slides served as stimuli during the experimental trials. The luminances of the two sets were comparable in range (2.10 to 2.45 lm/m² for the sexual; 2.20 to 2.40 lm/m² for the neutral slides).

Half of the sexual and neutral slides were used as target stimuli. The remaining 20 sexual and 20 neutral slides served as priming stimuli. Thus, as in the first experiment, two different relationships between primes and targets were created. For congruent trials the (e.g., sexual) target was preceded by a related (sexual) prime, whereas on incongruent trials the (sexual) target was preceded by an unrelated (neutral) prime. In contrast with the first experiment, the priming stimuli in this experiment were all presented at threshold level (i.e., T1 in the first experiment). The order of presentation of congruent and incongruent (sexual/neutral) trials was random. The masking procedures used in the threshold and experimental phase of this experiment, as well as the stimuli used for assessing the threshold, were identical to the ones used in the previous study.

In a forced-choice recognition test, 10 sexual and 10 neutral prime slides and 5 neutral and 5 sexual target slides were presented again. These slides were randomly select-
eu and intermixed with 20 distractor stimuli. The distractors consisted of 10 sexual and 10 neutral slides and were matched with the experimental primes for content, composition, and luminance. As in the first experiment, each slide was presented for 3 seconds.

Measures

For the registration of responses two button boxes were placed in front of the subject on a small movable table. One button was labeled "sexual," the other button was labeled "neutral." Software routines incorporated in the experimental programs were used to register button responses and to time response latency with millisecond accuracy. Latency was measured from onset of the target to the pressing of a button.

Procedure

In this experiment subjects did not attend an introductory session but were informed about the experimental procedures at the beginning of the experimental session, which lasted about 1.5 hours. Subjects were told they would be presented with slides of an explicit sexual nature. Confidentiality, privacy, and the opportunity to withdraw were assured to the subjects. Again, all subjects decided to participate.

The subjects were told that the general purpose of this experiment was to examine the effects of attention on the processing of sexual stimuli. As in the first experiment, subjects were presented with threshold trials, experimental trials, and recognition trials. After the threshold had been assessed, subjects were informed that in the next phase of the experiment they would be presented with a series of 40 (target) slide presentations. They were told that each slide presentation would be preceded by the fixation dot and a repeated presentation of the slide with the fragments of photographs (the mask) for the purpose of manipulating attention. Subjects were asked to decide on each trial whether the target slide was neutral or sexual. They had to press the button under their dominant (writing) hand when the target was sexual and to press the button under their nondominant hand when the target was neutral. They were instructed to respond as quickly and as accurately as possible.

After a 5-minute resting period in which subjects listened to music, 10 practice stimuli were presented for 100 ms each to acquaint the subject with the task. Following the last experimental trial the old/new recognition task was presented. The procedure used for this task was identical to the one used in the first experiment.

Data Reduction, Scoring and Data Analysis

As in the first experiment, accuracy of old-new decisions obtained during the recognition test was determined by calculating hit-rates, false-alarm rates, and predictive values positive and negative.

Outlier decision times were eliminated as follows. First, decision times of more than 1000 ms were excluded. Second, decision times of three standard deviations above a subject's mean, in which the standard deviation was calculated over all experimental conditions, were removed (cf. Mogg, Mathews, & Eysenck, 1992; Ratchiff, 1993).

The BMDP 4V program (Dixon, 1990) was used for analyses of variance (ANOVA). Greenhouse-Geisser probability levels are reported for repeated measures ANOVAs to control for possible violations of the homogeneity of variance (Vasey & Thayer, 1987). When required, post hoc contrast analyses (simple mean comparisons) were performed. The BMDP 3D and 6D programs were used for one-group t tests and Pearson product-moment correlations, respectively.

Results

Identification Thresholds and Recognition Test

Identification thresholds ranged from 30 to 50 ms (M = 37, SD = 5). In the recognition task, 10 subjects correctly identified more than 7 of the 10 target slides. Of the remaining subjects, 4 correctly identified 6 slides, 3 correctly identified 5 slides, and 3 correctly identified only 4 target slides.

The results of the recognition task for the priming stimuli are presented in Table 2. Only 1 subject reported not to have seen any of the 40 priming (experimental and distractor) stimuli before. Three subjects believed they had seen none of the sexual (experimental and distractor) stimuli before, and 1 subject believed he had seen none of the neutral (experimental and distractor) stimuli before.

<table>
<thead>
<tr>
<th>Decision</th>
<th>Sexual &amp; Neutral</th>
<th>Sexual</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primes (n = 20)</td>
<td>Distractors (n = 20)</td>
<td>Primes (n = 10)</td>
</tr>
<tr>
<td>&quot;Seen before&quot;</td>
<td>5.1</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>&quot;Not seen before&quot;</td>
<td>14.9</td>
<td>18.4</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Note. The values represent mean numbers of old-new decisions. For the accuracy measures, mean proportions and standard deviations (in parentheses) are provided.

*These values are based on 19, 17, and 19 subjects respectively. The remaining subjects could not be included in the calculations because they reported to have seen none of the (prime and distractor) slides before.
The hit rates were relatively low, indicating that the subjects were not very accurate in detecting priming stimuli. As in the first two studies, false-alarm rates were low. The combined results again indicate that the decision not seen before prevailed regardless of the true nature of the presented stimuli. Predictive values were reasonably close to .5, indicating that the response not seen before was given equally often for primes as for distractors. The mean predictive value positive for the sexual stimuli, which was based on the data of 17 subjects, was high. The mean predictive value positive for the neutral stimuli, based on the data of 19 subjects, was also relatively high. One-group t tests showed that the two predictive values deviated significantly from chance (t(16) = 6.72, p < .0001; t(18) = 5.38, p < .0001, respectively).

Because the predictive values positive were based on the data of the majority of subjects, the relationship between the results of the recognition test and the effects of priming could first be explored using correlational analyses. Pearson product-moment correlations were calculated between an index of recognition and an index of effect of priming. The index of recognition was created by multiplying predictive values positive (which were generally between .7 and 1) by the associated hit rates. Thus, this index consisted of weighted predictive values positive. The effect of priming index was created by subtracting decision times obtained in the incongruent trials from decision times obtained in the congruent trials. The correlation between the two indices for the sexual stimuli was significant (r = -.39, p < .05), indicating that priming effects increased with decreasing levels of recognition. The correlation between the two indices for the neutral stimuli was not significant (r = -.06, p > .39).

For further analyses an explorative grouping factor (Recognition group: high-recognizers, low-recognizers) was created to allow for a comparison of the results of this experiment with the findings of Experiment 1. The grouping factor was created using the following cut-off criterion. Subjects with a predictive value positive of 1 and a hit rate equal to or higher than .4 were assigned to the high-recognition group (i.e., when the recognition index was equal to or higher than .4; n = 4). Subjects with a predictive value positive lower than 1 and a hit rate lower than .4 were assigned to the low-recognition group (i.e. when the recognition index was lower than .4; n = 16).

Decision Times
A total of 17 response errors were made during the decision task, constituting 2% of 800 trials (20 subjects x 40 trials). Of the remaining 783 trials, 15 decision times (2%) were eliminated using the 1000 ms cutoff and the cutoff based on each subject's standard deviation. While the proportion of responses eliminated is relatively small, it approximates proportions indicated in the literature. According to Ratcliff (1993), cutoffs should, in fact, be selected as a function of the proportion of responses eliminated. When experimental manipulations affect the tail of a distribution, which occurs more often in decision time studies than that a distribution shifts, cutoffs are recommended that eliminate approximately 5% of the observations (Ratcliff, 1993).

Figure 3. Decision Times of Responses to Congruent and Incongruent Trials, by Prime-Target Relationship, Target, and Recognition group

<table>
<thead>
<tr>
<th>SEXUAL TARGETS</th>
<th>NEUTRAL TARGETS</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

**Note.** Left panel: Decision times during congruent trials were shorter than decision times during incongruent trials for the low recognition group. For the high recognition group, decision times were longer during congruent than during incongruent trials.

Right panel: For both the low and the high recognition group, decision times during congruent trials were not different from decision times during incongruent trials.
A 2 x 2 x 2 recognition group, target, prime-target relationship repeated measures ANOVA with recognition group as the between-factor was performed on the decision time data. The ANOVA revealed a significant interaction involving all three factors (F(1,18) = 6.17, p < .02, see Figure 3). No other (main or interaction) effects were found.

Follow-up tests on the data of the low-recognition group revealed a significant main effect of prime-target relationship (F(1,15) = 6.71, p < .01), indicating that decision times during congruent trials were shorter than decision times during incongruent trials. Further post-hoc tests revealed that this effect was primarily caused by the trials in which sexual targets were used (congruent trials: M = 449, SD = 82; incongruent trials: M = 472, SD = 95; F(1,15) = 8.83, p < .009). No significant effect was found for the neutral targets (congruent: M = 453, SD = 69; incongruent: M = 463, SD = 75; F(1,15) = 1.59, p > .23). For the high-recognition group, only a marginally significant interaction between target and prime-target relationship was found (F(1,3) = 6.08, p < .09). Contrasts showed a significant effect for the sexual targets, indicating that for these targets decision times during congruent trials (M = 526, SD = 47) were longer than decision times during incongruent trials (M = 503, SD = 43; F(1,3) = 17.33, p < .03). Again, no significant effect was found for the neutral targets (congruent: M = 477, SD = 47; incongruent: M = 489, SD = 59; F(1,3) = 1.57, p > .29).

**Discussion**

The results of the last experiment provide evidence for the idea that the meaning of sexual stimuli can be perceived in a fast, automatic manner. For the low-recognition group a significant effect of prime-target relationship was found, indicating that decision times during congruent trials were shorter than decision times during incongruent trials. This effect was significant for trials with sexual targets only. The difference between congruent and incongruent neutral trials did not reach statistical significance.

Interestingly, a negative correlation was found for the sexual trials between the effect of priming and recognition accuracy, indicating that priming of sexual targets was more successful at lower levels of stimulus accessibility. In fact, the results for the high-recognition group show that at high levels of recognition the priming effect significantly reversed. Sexual primes, as compared to neutral primes, occasioned longer decision times to sexual targets in the high-recognition group. No significant correlation was found for trials with neutral targets. How may this pattern of results be explained?

As was noted in the discussion of the first experiment, the finding that priming of sexual stimuli is more successful at lower levels of prime exposure is consistent with the results of some earlier affective priming studies (e.g., Murphy & Zajonc, 1993; Smith, Spence, & Klein, 1959). For example, Murphy and Zajonc found that very brief presentations of affective primes produced significant shifts in subjects' judgments of novel stimuli, but had no effects on exposures allowing conscious identification of the primes. In explaining their results, the authors referred to the model of Öhman et al. (1989) which proposes that affect is processed early in the information-processing chain that is, before more complex perceptual stimulus features are encoded. According to Murphy and Zajonc, it follows from this model that at degraded exposure levels stimuli elicit affective decisions that are unencumbered by other, more complex information. At longer exposures, they further propose, affective stimuli are likely to activate more complex networks of associations. If the outcome of this more elaborate appraisal contradicts or dilutes the primary affective decision, the two sources of information may nullify each other, thus canceling priming effects. Clearly, the findings of the present experiment support the notion that different processes are involved at different levels of stimulus accessibility. However, if we apply Murphy and Zajonc's interpretation to the present results, we still need to explain why the supposedly more elaborate appraisal processes nullified, and even reversed, the priming effect. It may be speculated that the early appraisal of sexual stimuli mainly activates sexual associations, while later appraisal processes may lead to an additional activation of other, apparently more negative (cf. Geer, 1991) and response-inhibiting associations. It should be emphasized, however, that in the present study these later appraisal processes took place at still some intermediate level of stimulus accessibility. As for the low recognition group, stimulus exposures in the high recognition group were extremely low (about 50 milliseconds). It would be interesting to learn what the results would have looked like if we had included exposures well above threshold level (e.g., exposures of 1000 ms).

For both the low and high recognition group no significant priming effects were found during neutral trials. A positive aspect of this finding is that it reduces the likelihood that the sexual priming effect in the low recognition group can be explained in terms of feature overlap (Sperber et al., 1979a). According to this interpretation, facilitation effects may occur between pictures as a function of overlap in stimulus characteristics (e.g., shape, colors). Clearly, if feature overlap played a role, a priming effect should also have been found for the neutral targets. Still, this leaves the question unanswered of why no priming effect was found for the neutral targets. Although Figure 3 reveals that decision times were shorter during congruent neutral trials, this difference did not reach statistical significance. Moreover, as opposed to the sexual trials, no significant correlation was found for neutral trials between the effect of priming and recognition accuracy. If any correlation should have been expected for the neutral trials, it probably would have been a positive one. In contrast with affective primes, neutral primes have most often been found to produce stronger effects at higher levels of prime exposure (e.g., Carr et al., 1982; Cheesman & Merikle, 1984). This frequently reported finding suggests the absence of priming effects for the neutral targets in the
high recognition group may have been the result of low statistical power. That is, if affective (e.g., sexual) stimuli at short exposures occasion stronger priming effects than neutral stimuli, we may have needed a larger number of subjects or trials to obtain significant effects for both sexual and neutral stimuli.

An alternative explanation for the discrepant findings for the sexual and neutral trials deserves attention. Holender (1992) suggested that differences between congruent and incongruent priming trials may be caused by a congruity effect. This effect may occur whenever there is dimensional overlap between relevant and irrelevant aspects of the task. Although in the present study the button for sexual targets was always under the dominant hand—suggesting that a congruity effect may have played a role—there is one convincing argument against it. According to Holender (1992), congruity effects can only influence decisions when the participant is aware of the relations between the task attributes. Thus, if our findings had been the result of a congruity effect, we should have found a positive correlation between recognition accuracy (an index of awareness) and priming effects for the sexual trials rather than a negative correlation.

Before turning to the general discussion, one last issue deserves some attention. The results of the recognition task indicated that, as in the first experiment, some subjects were fairly accurate in discriminating between priming and distractor stimuli. In the introduction of this experiment, it was argued that whereas differences in dark adaptation levels between threshold and experimental trials may have been responsible for the finding in the first experiment, due to changes in experimental design (i.e., targets now being presented for approximately one second instead of 60 seconds) this problem should not play a role in the second experiment. There are, however, other possible explanations for the fact that we found it again in the present study. One is related to the fact that subjects in the second experiment were presented with more than three times as many trials than subjects in the first experiment (i.e., 40 versus 12 trials). Thus, this may have occasioned some perceptual learning effect, with subjects gradually picking up more information from the primes over trials. In any case, as exposure durations were found to have been on the high side in both experiments, it probably is safe to conclude that future studies would benefit from the implementation of more restrictive threshold criteria.

**GENERAL DISCUSSION**

The two studies described in this paper represent the first experimental attempt to investigate the role of automatic cognitive processes in sexual arousal. Further research is needed to improve our understanding of the role of these processes in the activation and regulation of sexual responses. Although the findings of the first experiment provide some preliminary evidence for the role of automatic processes in the activation of the genital response, the success of future research in confirming our findings will depend on the further validation of penile circumference measures at initial stages of erection or on continuing efforts in the development of alternative measures of early components of genital response (e.g., penile EMG). Meanwhile, much can be learned from studies using the preattentive priming paradigm in conjunction with nonphysiological measures (i.e., decision time).

For example, a next step could involve the application of the preattentive priming paradigm to the study of response discordance. From the conceptual model described in this article, it could be predicted that discordant response patterns are most likely to be found in subjects in whom, more than in others, sexual priming stimuli activate multiple meanings. In operational terms, this could be explored by assessing whether sexual primes lead to shorter decision times to both sexual and other affective (positive and negative) targets, as compared to neutral primes. Inclusion of trials with nonsexual affective targets would thus allow for the evaluation of the notion that sexual stimuli have the potential of activating both sexual and nonsexual affective meanings in memory. This approach would be equally applicable to the study of gender differences in response discordance. On the whole, correlations between physiological and subjective indices of sexual arousal seem to be lower in women than in men (e.g., Rosen & Beck, 1988). A priming paradigm using both sexual and nonsexual affective stimuli would permit the exploration of the idea that while sexual stimuli may be "doubly coded" in both men and women, this may be especially true for women.

The priming paradigm may also prove fruitful in the study of sexual dysfunction. For instance, it allows for the exploration of the question of whether inhibition is related to the automatic processing of specific classes of negative meaning. Inclusion of trials with threat- or worry-relevant targets would allow for the exploration of the notion that a sexual stimulus has the potential of activating threat-related meanings in memory. In people with sexual dysfunction, for example, sexual primes could be expected to facilitate responses to negative, threat-relevant targets.

Central to our view on inhibition of genital responses is the idea that it is initiated at an automatic cognitive level and starts with the processing of threat- or worry-relevant meaning. Controlled or attentional processes are considered important in that the actual process of inhibition appears, to a large degree, to be effectuated at an attentional level. A number of studies have shown that distracting sexually functional subjects from attending to the sexual content of stimuli is sufficient and very efficient, a method for reducing sexual arousal (e.g., Abrahamson et al., 1985; Farkas et al., 1979; Geer & Fuhr, 1976). In contrast, sexually dysfunctional subjects have been found to sometimes show stronger genital responses to visual stimuli when under conditions of distraction or divided attention (Janssen, Everaerd, van Lunsen, & Oerlemans, 1994a; Sakheim et al., 1987). It seems that the elicitation of responses under these conditions is mediated by an alleviation of the effects of negative
attentional processing (reflected in distracting worries or negative thoughts). In line with our theoretical perspective, we believe that this reduction of the influence of attentional processing gave way to the workings of the "central pathway," or in other words, that the resultant genital responses were dependent upon an essentially automatic processing of sexual meaning.

Bancroft (1997, 1998) has expressed doubts about the explanatory power of attentional processes in inhibition. He believes that distraction from erotic cues is inadequate to explain the often complete failure of erectile response. In his discussion of studies reported by Cranston-Cuebas and Barlow (1990) and Janssen and Everaerd (1993) he comments:

My interpretation of these interesting experiments, whilst recognizing the fundamental role of information processing, also requires some other mediating mechanism to explain the occurrence of erectile failure. The most likely candidate is a central inhibitory mechanism which reduces or impairs genital response.

(Bancroft, 1997, p. 252)

As a basis for this notion of central inhibition, Bancroft (1997) discusses the phenomenon of REM-related erections, the fact that inhibition can occur in the absence of a sexual stimulus (e.g., to the injection of smooth-muscle relaxants in the penis), and relevant animal and pharmacological studies. The neurophysiological mechanism proposed by Bancroft might be related to chronically higher (i.e., tonic) levels of inhibition, occasioning relatively high thresholds for genital response. However, considering the findings of studies showing that inhibition could be reduced through cognitive manipulations (e.g., Janssen et al., 1994a; Sakheim et al., 1987) it is not unlikely that central inhibition (also) would involve phasic processes, and can be invoked by cognitive mechanisms that are activated in response to sexual stimuli. This interface between information processing and central inhibition (Bancroft, 1998) may well be built upon automatic cognitive processes, with its output, inhibition, provoked by the activation of threat- or worry-related meanings in memory.

The idea that inhibition of a more direct physiological nature may be involved in situations where genital responses do not occur in the presence of relevant stimuli does not exclude an important role for attentional processes. First, strictly speaking, even though inhibition can occur without the involvement of attentional processes in certain situations (e.g., to the injection of smooth-muscle relaxants in the penis), this does not preclude the possibility that attentional processes can be sufficient in explaining the absence of sexual responses in other (sexual) contexts. Clearly, studies on distraction (e.g., Farkas et al., 1979; Geer & Fuhr, 1976) have shown the powerful modulating effects of attentional processes on sexual arousal, and in some cases distraction-like processes may be all that is needed to explain a failure to become sexually aroused. Still, even if future research shows that inhibition is, indeed, essentially a cognitively triggered and neurophysiologically mediated process, attentional factors may be found to have an amplifying effect. The allocation of attention to off-task nonsexual cues, which in our model is assumed to result from the processing of threat- or worry-related meaning, may prove to be some collateral cognitive process secondary to inhibitory processes of a more direct, neurophysiological nature. But its effects seem to contribute considerably to the nonappearance of sexual responses in the presence of sexual stimuli (cf. Abrahamson et al., 1985; Beck et al., 1983).

In view of the preliminary nature of the data presented and the absence of any direct measures of the relative contribution of automatic and attentional processes in the appraisal of sexual stimuli, the ideas and interpretations presented in this article clearly are tentative. We do believe, however, that the theoretical perspective presented here is both sensible and fruitful. It offers an interpretative framework incorporating emotion and information processing concepts, which have proven valuable in the understanding of various other psychological phenomena (Janssen & Everaerd, 1993). Furthermore, it elaborates on existing models of sexual arousal (e.g., Barlow, 1986). Both the model of Barlow (1986) and the present model emphasize the role of attentional processes and feedback. We believe that our perspective has additional heuristic value, however, in that it introduces and emphasizes the role of automatic processes in the appraisal of sexual stimuli and the activation (and inhibition) of sexual arousal. The findings of the two studies presented here underscore the importance of these processes.

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