Central activation of the sexual system

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Chapter 2

Priming the Sexual System: Implicit versus Explicit Activation

We investigated implicit versus explicit activation of the sexual system using a priming paradigm in which sexual slides were preceded by either sexual or neutral primes. In the first experiment, primes were made inaccessible to conscious cognitive elaboration. Identification of sexual targets was facilitated by sexual primes, indicating that sexual representations in memory can be activated automatically. In the second experiment, in which primes were presented at a conscious level, identification of sexual targets was decelerated by sexual primes. Primes elicited subjective sexual arousal in Experiment 2 only, demonstrating that the activation of subjective experience requires conscious cognitive elaboration. With the addition of a sexually specific physiological measure, to be constructed to measure initial genital responses, this paradigm may help elucidate activational mechanisms of sexual response.

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Introduction

The development of a full-blown emotional response can be understood as the result of two independent processes (LeDoux, 1996, 2000). The core of the emotional system involves a mechanism for computing the affective significance of stimuli (cf. Zajonc, 1984). This mechanism operates automatically, outside of conscious awareness, and depends on implicit memory. Studies have found that autonomic responses can be directly activated through this mechanism and these responses are part of the precursers for the conscious emotional experience. Subjective experience is the outcome of the second process, involving the conscious elaboration of emotional information, and is dependent on explicit or declarative memory.

Empirical support for this model stems mostly from negative emotions, in particular fear (e.g., Bechera et al., 1995; LeDoux, 1996; Morris, Öhman, & Dolan, 1998). However, there is growing evidence that these pathways are also relevant to positive emotions (e.g., Adolphs, Tranel, & Damasio, 1998; Hamann, Ely, Grafton, & Kilts, 1999; Morris et al., 1996; Whalen et al., 1998). Sex can be thought of as among the emotions (Everaerd, 1988; Geer et al., 1993), and the sexual emotions can be taken as prototypical in the domain of positive emotions. The studies presented in this chapter are an attempt to investigate the contribution of implicit versus explicit central activation of sexual response.

Erotic situations may elicit a great variety of emotional responses. In addition to sexual excitement, other emotions can be experienced: for example, those connected with a tendency to approach the partner, desires, and expectations (Janssen & Everaerd, 1993). We do not know to what degree a preference for sexual stimuli is determined at birth; what we do know is that we are born with a sensitivity to what we call sexual stimuli. This sensitivity develops and becomes prominent around puberty and, although attenuated, remains manifest into old age (Everaerd, Laan, & Spiering, 2000).

Sexual arousal is activated in response to a relevant stimulus. In the production of a sexual response, stimuli that are ascribed sexual meaning by the brain are transformed into specific efferent messages. Relevant stimuli activate approach behavior; that is, they may function as an incentive (Ågmo, 1999; Everaerd et al., 2001). The subjective experience of sexual

arousal ultimately depends on the individual's awareness and definition of the response as sexual (Everaerd, 1993). The physiological component of sexual response, however, seems connected with implicit memory and can be activated automatically (Bancroft, 1989; Everaerd, Laan, & Spiering, 2000; Geer et al., 1993; Janssen & Everaerd, 1993).

This theoretical view is supported by a number of phenomena, including a frequently observed discordance between subjective and physiological sexual response. Genital response can occur without a concurrent subjective sexual experience. This can be interpreted to involve an automatic activation of physiological responses with a concomitant conscious appraisal of the stimulus or stimulus situation as nonsexual (Everaerd & Laan, 1994; Janssen & Everaerd, 1993). An extreme example of response discordance can be found in studies with hypogonadal men. Because of low androgen (testosterone) levels, sexual appetite in these men is absent. Erections in response to erotic films, however, are largely intact (Bancroft, 1989, 1995). This suggests a strong link between visual sexual stimuli and genital responses that does not depend on the presence of sexual desire.

Janssen et al. (2000) first proposed a conceptual model in which sexual arousal is viewed as dependent on the interaction between automatic and attentional processes. In this model, different levels of cognitive processing can differentially affect subjective and physiological components of sexual arousal: Physiological sexual arousal can be activated automatically, after which strategic or attentional processes may lead to the subjective experience of sexual arousal. To test this model, Janssen et al. (2000) conducted two studies using a priming paradigm.

Priming involves a change in the ability to identify a stimulus as a consequence of a prior encounter with a related stimulus. This type of paradigm can be used to study the independent contributions of implicit and explicit processes (Schacter & Badgaiyan, 2001; Schacter & Buckner, 1998). An accepted operational definition of implicit processes is evidence for indirect effects of a stimulus in the absence of direct effects (e.g., Greenwald, Klinger, & Schuh, 1995): in other words, when priming stimuli produce a response without being consciously elaborated. In the studies of Janssen et al. (2000), sexual stimuli were presented subliminally. Pictures (instead of words) were used because they might produce stronger connections with sexual memory (Carr, McCaulley, Sperber, & Parmelee,

1982; De Houwer & Hermans, 1994; but for the contrary see Van Den Hout, De Jong, & Kindt, 2000).

The hypothesis of the first study of Janssen et al. (2000) was straightforward: Can subliminally presented sexual slides activate genital responses in men? Subliminally presented sexual or neutral pictures (i.e., primes) preceded consciously perceived sexual pictures (i.e., targets). Genital responses were evaluated by measuring penile circumference changes. Although the researchers found a small effect, it was difficult to interpret because erectile responses to sexually primed targets were smaller than responses to neutrally primed targets. Therefore, in a second study they decided to test a related hypothesis: Can subliminally presented sexual slides activate sexual meaning in memory?

In this study, Janssen et al. (2000) chose decision time as the behavioral measure and asked participants to categorize sexual and neutral targets as quickly as possible. Subliminally presented sexual or neutral primes preceded the targets. Results showed that categorization of sexual pictures was facilitated by sexual primes. This can be interpreted as evidence for the implicit activation of sexual memory. However, interpretation of the results was hindered because a postexperimental recognition test revealed that some participants had consciously perceived some of the primes.

The goal of the studies presented here is to further improve our understanding of the role of implicit and explicit processes in the activation of sexual meaning. To that end, we included a subjective measure of sexual arousal in the design. When processing of sexual information is implicit and does not activate declarative memory, subjective arousal should not be elicited. In addition, we made three substantial changes regarding the operationalisation of subliminal presentation of primes. First, Janssen et al. (2000) established individually subjective perceptual thresholds (Cheesman & Merikle, 1984, 1986). They did not include sexual pictures in this procedure because it was believed that participants might be reluctant to verbalize what they saw when confronted with degraded sexual stimuli. However, as emotional stimuli may have a lower threshold compared to neutral stimuli (e.g., Murphy & Zajonc, 1993), we did include emotional stimuli in the threshold determination task in the present study. Second, prime presentation time was reduced to 80% of the participants' threshold. Third, in the Janssen et al. (2000) study, one prime presentation consisted of five repeated exposures of the prime using a forward and backward masking

procedure (cf. De Groot & Nas, 1991; Foster & Davis, 1984). Since there were four exposures of a mask for 500 ms in between the prime exposures, stimulus onset asynchrony (SOA) was over 2,000 ms. Since controlled processes are assumed to start 300 ms after stimulus presentation, this could be too long (Fazio, Sanbonmatsu, Powell, & Kardens, 1986; Hermans, De Houwer, & Eelen, 1994; Posner & Snyder, 1975; Neely, 1977). In the current study primes were presented only once in each trial, thus substantionally reducing SOAs.

In this study, as in Janssen et al. (2000), only men were tested to maximize priming effects. Men as compared to women have been found to be more easily aroused by visual stimuli (Geer et al., 1993). Also, emotional responses to sexual stimuli are more blended in women than in men (Everaerd, Laan, Both, & Van Der Velde, 2000).

Experiment 1

The purpose of this experiment was to test the hypothesis that sexual meaning can be activated implicitly. Participants were asked to respond to consciously perceived sexual and neutral targets that were preceded by subliminally presented sexual and neutral primes. The experiment consisted of two series of trials, Series 1 and Series 2. In the first series, we assessed whether sexual primes can activate implicit sexual memory and thus facilitate the recognition of sexual targets. In the second series, we tested whether sexual primes, when rendered inaccessible to conscious awareness, will fail to elicit subjective sexual arousal.

Method

Participants

Thirty male university students (M = 24.8 years, SD = 5.6) participated in this study. As only heterosexual stimulus materials were used, only heterosexual men were recruited. All participants had normal or corrected-to-normal vision. All completed written informed consent prior to participation, and were offered course credits for collaboration.

After the experiment was finished the participants were asked to complete the Questionnaire for Screening Sexual Dysfunctions (Vroege, 1994). This was done to enable the selection of participants for a related

study with patients. All participants reported being sexually active and relatively satisfied with their current sexual life (M = 3.6, SD = 1.1, on a 5-point scale from *highly dissatisfied* to *highly satisfied)*. All participants had seen erotic pictures prior to participation.

Setting and Apparatus

The experiment was conducted in two adjacent rooms. As in Janssen et al. (2000), participants were seated at a table facing a backlit milk colored projection screen. The size of the projected images was 13 cm x 26 cm. Viewing distance was approximately 130 cm, resulting in a 6° horizontal and 11° vertical visual angle. For the registration of responses, three button boxes were placed in front of the participant. The first button box was placed in the middle of the table. This box had seven buttons and was used to measure subjective responses on a 7-point scale. Two boxes with one button each were used to measure decision times. They were placed on the left and right side of the table. One was labeled with the word *sex*, the other with the word *plant*. The positions (left or right) of these buttons were randomized across participants.

The experimenter and all technical equipment needed for slide presentations and data collection were stationed in the other room. The experimenter communicated with the participant using an intercom system. Three Kodak slide projectors, each outfitted with a Displaytech ferroelectric liquid crystal shutter, were used to project the images on the screen. We used a Bull Z433D microcomputer to control the slide carousels as well as the sequencing and timing of the shutters.

Materials and Design

The neutral or *plant* slides depicted flowers, plants, and bushes. Slides with sexual content were made of photographs taken from erotic magazines. We created two subsets of sexual stimuli, named *explicit* and *models*. Slides in the explicit subset portrayed heterosexual couples engaging in oral sex or sexual intercourse. Slides in the models subset depicted nude or nearly nude women, looking into the camera. To ensure that these slides were comparable in arousal value, and to enable us to attribute small differences in subjective arousal to the different primecategories, we conducted a pilot study in which 23 men rated an initial set of 80 slides. The question "To what degree did you find the last slide sexually arousing?" could be

answered on a 7-point scale, varying from *not at all* to *extremely*. We selected 20 slides with a mean of 2.9 (SD = 1.2) to form the models subset. The slides with the models were used as targets in Series 2, in which participants rated their subjective sexual arousal and the arousability of the slides. To avoid having the effect of the targets overrule the effect of the primes, no explicit slides were used as targets in this series.

All pictures were carefully selected to match on stimulus dimensions such as complexity, contrast, and luminance. For example, the number of main elements of a picture was not allowed to exceed two, excessively dark or light pictures were omitted, and an attempt was made to arrive at a broad range of colors for all sets. The luminances of the two sets of stimuli measured during projection were comparable in range: 0.25 to 0.35 lx for the sexual slides, 0.20 to 0.35 lx for the plant slides.

Each of the two stimulus series consisted of 40 trials. In each trial a consciously perceived sex or plant target was preceded by a subliminally presented sex or plant prime. In the first series, decision time was the dependent variable. We asked participants to categorize the targets as quickly as possible by pushing either the sex or plant button. We measured decision time from onset of the target to the pressing of a button. In the second series, the variable of interest was subjective sexual arousal. Each target was followed by two questions. The first asked participants to indicate how sexually aroused they felt ("To what degree do you feel sexually aroused at this moment?"). Participants could press one of the seven buttons, reflecting a 7-point scale with *not at all* and *extremely* as its anchors. As we generally expected low levels of sexual arousal, and as the possibility of carry-over effects existed (i.e., participants still experiencing arousal from a previous slide), a second, more indirect and evaluative assessment of sexual arousal was added. This involved a rating of the arousal value of the slide and required participants, using the same 7-point scale, to answer the question "To what degree did you find the last slide sexually arousing?"

In addition to the sex and plant slides we used four other slides. First, a black fixation dot signaled the start of each trial. Second, before each prime presentation, we presented a mask. The mask was constructed by arranging pieces of photographs of neutral objects (e.g., trees, musical instruments) and parts of the human body (e.g., hands, ears) in random orientations. We carefully chose the size and shape of these pieces, approximately 60 in number, to prevent recognition of any of the objects

presented. The mask was comparable with sex and plant slides in contrast, color, and luminance (0.35 lx). Finally, the two questions following the targets in Series 2 were also presented on slides.

Experimental trials proceeded as follows (see Figure 2.1). First, we presented the fixation dot for 1,000 ms. Then, after a delay of 1,000 ms, we presented the mask for 500 ms, directly followed by the prime. We determined prime exposure duration with an identification threshold procedure (cf. Cheesman & Merikle, 1984, 1986). Backward masking of the prime (Holender, 1986) was accomplished by immediately presenting the target (cf. Murphy & Zajonc, 1993). Since there was no pause between prime and target, the SOA was equal to the prime presentation time. In Series 1, we ended target presentations as soon as the participant pressed a button. In Series 2, we presented targets for 1,000 ms, followed by the slide with the first question. After the participant responded, we presented the second question.

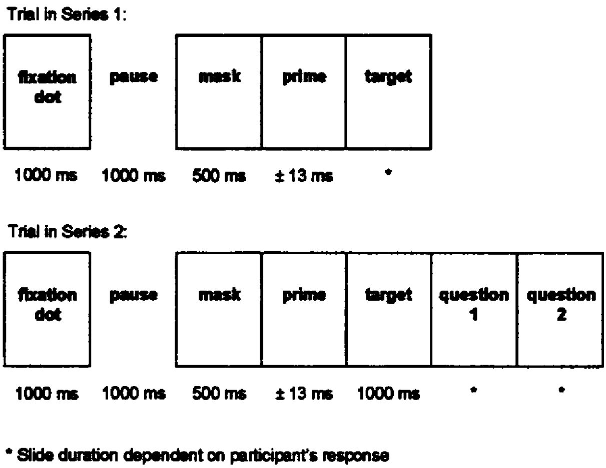

Figure 2.1. Proceedings of experimental trials. Duration of the target in Series 1 and the questions in Series 2 is dependent on participant's response.

The experimental design of the study was a 2 (Prime: sex, plant) X 2 (Target: sex, plant) within-subjects factorial. Randomization of conditions was limited for both methodological and technical reasons. We created one sequence that consisted of 80 trials. This sequence was randomly determined with one restriction: within each block of 20 trials, the four conditions were equally represented (i.e., each block contained five trials of each of four conditions: sex-sex, sex-plant, plant-sex, plant-plant). We created a mirror of this sequence by changing prime content so that whenever a target was preceded by a sexual prime in the original sequence, it would be preceded by a plant prime in the mirror sequence, and vice versa. These two sequences were randomly distributed among the participants.

Regarding randomization of slides (i.e., the specific slides that fill in the conditions), we used a random selection of 40 out of a total of 80 plant slides as primes; the other 40 were used as targets. We used 20 of the 60 explicit sexual slides as targets in Series 1; the other 40 were used as primes (20 in Series 1, 20 in Series 2). We selected the set of 20 models slides to function as targets in Series 2. We made one random sequence of the targets used for all participants; the sequence of the primes was randomized afresh for each participant.

Procedure

The experiment, which took about 75 minutes to complete, consisted of five phases total: (a) adaptation, (b) threshold determination, (c) Series 1: measurement of decision times, (d) Series 2: measurement of subjective sexual arousal, and (e) a forced-choice recognition test (see Table 2.1). At the end of the experimental session, we asked participants to complete the Questionnaire for Screening Sexual Dysfunctions (Vroege, 1994). We also conducted an exit interview and provided participants with information about the theoretical background of the study.

Phase 1: adaptation. The adaptation phase was included to permit habituation to room illumination level and to the light emitted by the slide presentations, and to familiarize participants with the slide presentation procedure. We informed participants about the experimental procedures in the dimly lit experimental room. After this, the experimenter went to the adjacent room and from that moment on all communication took place via the intercom system. As part of the adaptation phase, participants were presented with 15 slides (including both sex and plant slides), each lasting

30 seconds. They were instructed to simply watch the slides and were told that later in the experiment some questions might be asked about the slides.

Table 2.1 *Experimental Design of Study 1*

	Phase 1: adaptation	Phase 2: threshold	Phase 3: Series 1	Phase 4: Series 2	Phase 5: recognition
Goal	Adaptation to setting, light, slides, etc.	To establish perceptual thresholds	To measure implicit activation of sexual memory	To measure if explicit memory is bypassed	To check if primes were presented subliminally
Task	Just watch the slides	What is on the slide?	Is it a sexual or a plant slide?	(1) How aroused are you? (2) Is the slide arousing?	Did you see this slide before?
Slides	Sexual & other affective, plants & other neutral	Fixation dot, mask, sexual & other affective, plants & other neutral	Fixation dot, mask, sex - explicit, plants	Fixation dot, mask, sex - explicit (primes), sex - models (targets), plants, Question 1 & 2	Sex - primes, sex - distractors, plant - primes, plant - distractors, fillers
Dependent variable	None	Individual threshold	Decision time	Subjective sexual arousal	Hit rate

Phase 2: threshold determination. The longest stimulus (or prime) duration at which a participant was not able to correctly identify or guess the content of slides was considered to be his perceptual threshold (cf. Cheesman & Merikle, 1984, 1986; Kihlstrom, Barnhardt, & Tataryn, 1992). In addition to sex and plant slides, we used stimuli with other affective (e.g., snakes, babies) or neutral (e.g., houses, utensils) content (selected from the International Affective Picture System; Lang, Bradley, & Cuthbert, 1995). We took care to meet the same criteria of complexity, contrast, and luminance that were met by the sex and plant slides.

The sequence of events for a trial in the threshold determination procedure differed in one aspect from an experimental trial: The presentation of the target was now replaced by a second presentation of the mask. After each trial, we asked participants to report anything they saw on the slide between the repeated presentations of the mask. When the participant 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). We classified a stimulus as identified when the participant correctly mentioned relevant features of the stimulus. We classified a stimulus as not identified when the participant failed to give any verbal description of the stimulus or when a description was erroneous beyond doubt.

We determined identification thresholds with a combination of the descending (Marcel, 1983) and ascending (e.g., Carr et al., 1982) method of limits (cf. Janssen et al., 2000). In the first trial, we set the SOA to 100 ms. If the participant correctly identified the stimulus, the SOA of the next trial was decreased by 10 ms. This was repeated until the participant failed to identify a stimulus for the first time. After this procedure, we held exposure duration constant for the next presentation. If the participant identified the stimulus correctly, the SOA in the next trial was again decreased by 10 ms. If the participant failed to identify the stimulus, we held exposure duration constant. This procedure was repeated until the participant failed to identify five stimuli at the same duration in succession. Then we increased the SOA by 5 ms. If the participant failed to identify five stimuli at this duration in succession, this SOA was considered to be his personal threshold. If, however, the participant did identify a stimulus at this SOA, his personal threshold estimate equaled the exposure duration of the previous block of trials (i.e., 5 ms lower). The SOA in the experimental series was set on 80% of the personal threshold.

Phase 3: Series 1, measurement of decision times. We explained to participants that in this phase only sex and plant slides would be presented, and that they would be preceded by the fixation dot and the presentation of "the slide with the fragments of photographs" (i.e., the mask). We asked participants to decide in each trial whether the target was a sex or plant slide and to press the corresponding button with their right or left forefingers. They were instructed to respond as quickly and accurately as possible. During a block of 12 practice trials, participants became familiar with the task. After these trials, they were told that the 40 experimental trials would begin.

Phase 4: Series 2, measurement of subjective sexual arousal. After a 5-minute resting period during which participants listened to music, we presented a new block of trials. We informed participants that they would be exposed to a similar series of trials. However, this time we asked them to answer the two sexual arousal questions after each slide presentation. They could give answers by pushing one of the seven buttons on the box in front of them. In addition, we explained that reaction times would not be measured during this series. Six practice trials preceded the block of 40 experimental trials.

Phase 5: forced-choice recognition test. Immediately following the last experimental phase, we started a forced-choice recognition test. We presented a selection of 20 primes again, randomly intermixed with 20 distractor stimuli. We randomly selected five sex and five plant prime slides from Series 1 and five sex and five plant primes from Series 2. The distractor stimuli consisted of 10 sex and 10 plant slides that were matched for content, composition, and luminance. To minimize response biases, we added 20 slides (*fillers*) that participants had consciously perceived earlier in the study, during the adaptation phase and the practice and experimental trials. For each slide, participants were asked whether or not they believed they had seen it before. After the participant responded, he was shown the next slide.

Results

One participant was excluded from analyses because his decision times were extremely long (M = 1,577 ms; SD = 479) compared to a mean decision time of 417 ms (SD = 79) for the other participants.

Threshold Determination and Recognition Test

Identification thresholds ranged from 10 to 25 ms with a mean of 13 ms (SD = 4). The mean SOA in the experimental series was 10 ms (SD = 3). In the exit interview, none of the participants reported having seen presentations of a slide between mask and target in the experimental series.

We determined accuracy of the old-new decisions obtained during the recognition task by calculating hit rates (true positive rates), false alarm rates (false positive rates), and predictive values positive and negative (Janssen et al., 2000; Weinstein & Fineberg, 1980). Hit and false alarm rates provide information about accuracy in terms of *detection,* the proportion of stimuli that is correctly or incorrectly identified as prime. Predictive values positive and negative provide information about accuracy in terms of *discrimination,* the proportion of "seen before" and "not seen before" responses that corresponds 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 value reflects the probability of a correct response when participants indicate they have seen a slide before. Predictive

values negative were calculated as the proportion of correct decisions given the response "not seen before."

The mean hit rate for the fillers (i.e., slides that were presented before at a conscious level) was .73 (SD = 0.09). Table 2.2 shows the hit rates, false alarm rates, and predictive values positive and negative for the priming stimuli. The relatively low hit rates indicate that the participants were not accurate in detecting priming stimuli. False alarm rates were also low, suggesting that the participants accurately detected distractors. The combined results indicate that the decision "not seen before" prevailed regardless of the true nature of the presented stimuli. Paired t tests revealed no significant effect for false alarm rates between neutral and sexual stimuli, $t(28) = 0.57$, *ns*, whereas the hit rates of neutral stimuli were significantly higher, $t(28) = 2.60$, $p < .02$.

Table 2.2 *Mean Number and Accuracy of Old-New Decisions in Recognition Task (N = 29)*

	Sexual		Neutral		Sexual & Neutral	
	Primes	Distractors	Primes	Distractors	Primes	Distractors
Decision "Seen before"	1.9	1.3	3.0	1.5	4.8	2.8
Decision "Not seen before"	8.1	8.7	7.0	8.5	15.2	17.2
	M	*SD*	*M*	*SD*	*M*	*SD*
Hit rate	0.19	(0.17)	0.30	(0.17)	0.24	(0.13)
False alarm rate	0.13	(0.13)	0.15	(0.16)	0.14	(0.11)
Predictive value positive	0.60	(0.34)	0.73	(0.20)	0.65	(0.20)
Predictive value negative	0.52	(0.06)	0.55	(0.06)	0.53	(0.04)

Predictive values negative were all about .50, indicating that the response "not seen before" was given equally often for primes as for distractors. The mean predictive value positive was relatively high. A one-group t test showed that there was a significant deviation from chance, $t(28) = 3.67$, $p < .01$. Although the predictive values positive were higher for neutral stimuli compared to sexual stimuli, these two values did not differ significantly according to a paired t test, $t(24) = 1.38$, *ns*.

Decision times

Within a total of 1,160 trials, participants made 40 reponse errors, *M* = 1.4, *SD* = 1.2 (i.e., participants pressed the sex button in response to a plant target and vice versa). Table 2.3 shows means and standard deviations of errors per condition. A Friedman test, $c^2(3, N = 29) = 0.54$, *ns*, revealed no significant differences.

For the remaining 1,120 trials, we eliminated outliers using the following procedure. First, we excluded decision times below 100 ms and above 1,000 ms. Second, we removed decision times of three standard deviations above a participant's mean (cf. Janssen et al., 2000; Mogg, Mathews, & Eysenck, 1992; Ratcliff, 1993). This procedure led to the exclusion of another eight trials. Participants' mean decision times over all 40 trials varied between 345 and 550 ms (*M* = 419, *SD* = 49). Table 2.3 shows means and standard deviations for each condition.

Table 2.3 *Mean Decision Time (in ms), and Errors in a Categorization Task (Series 1) and Subjective Responses (Series 2) for Sexual and Neutral Targets by Prime Content in Experiment 1 (N =29)*

	Series 1				Series 2			
	Decision Time		Errors		Question 1 subjective arousal		Question 2 arousability of slides	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sexual targets								
Sexual primes	409	(61)	0.3	(0.5)	2.9	(1.3)	3.6	(1.2)
Neutral primes	424	(73)	0.4	(0.7)	2.9	(1.2)	3.7	(1.1)
Neutral targets								
Sexual primes	424	(47)	0.3	(0.6)	1.9	(0.9)	1.2	(0.3)
Neutral primes	419	(43)	0.3	(0.5)	1.8	(0.9)	1.2	(0.3)

A 2 (Prime: sex, plant) X 2 (Target: sex, plant) repeated measures ANOVA with decision time as the dependent variable revealed no significant main effects [Prime: $F(1, 28) = 1.14$, *ns*; Target: $F(1, 28) = 0.26$, *ns*] but did reveal a significant interaction of Prime X Target, $F(1, 28) = 6.25$, $p < .02$. Follow-up paired *t* tests to explore this Prime X Target

interaction revealed a significant effect for sex targets in the predicted direction. Sexual targets preceded by sexual primes were categorized as sexual more quickly than were sexual targets preceded by plant primes, $t(28) = 2.25$, $p < 0.04$. For plant targets, mean decision times did not significantly differ by prime content, $t(28) = 1.10$, *ns*.

The relationship between the results of the recognition test and the effects of priming was explored using correlational analyses. We calculated Pearson product-moment correlations between an index of "recognition" and an index of "effect of priming" (cf. Janssen et al., 2000). We created the index of recognition by multiplying predictive values positive by the associated hit rates. Thus, this index consisted of weighted predictive values positive. We created the effect of priming index by subtracting responses obtained in the congruent trials from responses obtained in the incongruent trials. The correlations between the two indices were $r = .42$, $p < .03$, for the sexual stimuli and $r = .12$, *ns*, for the neutral stimuli.

Subjective Sexual Arousal

The mean response to the first question ("To what degree do you feel sexually aroused at this moment?") varied from 1.0 to 4.8 ($M = 2.4$, $SD = 0.9$). For the second question ("To what degree did you find the last slide sexually arousing?") the range was 1.5 to 3.9 ($M = 2.4$, $SD = 0.6$). The correlation between the two questions was $r = .73$ ($p < .01$). Means and standard deviations per condition are presented in Table 2.3.

A 2 (Prime: sex, plant) X 2 (Target: sex, plant) repeated measures ANOVA was performed with the first question as the dependent variable. We found no main effect of Prime, $F(1, 28) = 0.03$, *ns*. However, the main effect for Target was significant, $F(1, 28) = 26.55$, $p < .01$; sexual targets elicited more arousal compared to neutral targets. We found no significant interaction between the factors, $F(1, 28) = 0.02$, *ns*. A 2 (Prime: sex, plant) X 2 (Target: sex, plant) repeated measures ANOVA with the second question as the dependent variable revealed the same pattern: no main effect for prime, $F(1, 28) = 1.11$, *ns*; a main effect for target, $F(1, 28) = 167.61$, $p < .01$, indicating higher arousal ratings after sexual targets; and no significant interaction effects, $F(1, 28) = 1.59$, *ns*.

To investigate a possible relationship between priming effects and the level of awareness, we correlated the recognition index with the effect of priming. The priming index was created by subtracting responses obtained in

the incongruent trials from responses obtained in the congruent trials. The correlations between the two indices were not significant: first question, sexual stimuli r = .26, neutral stimuli r = -.07; second question, sexual stimuli r = .34, neutral stimuli r = .15.

Discussion

As predicted, sexual primes facilitated the recognition of sexual targets. Because the primes were held inaccessible to conscious cognitive elaboration, this facilitation effect provides evidence for the implicit activation of sexual memory. The fact that plant primes did not facilitate the recognition of plant targets is in accordance with the literature, which considers the emotional relevance of a stimulus as a crucial criterion for implicit processing (e.g., LeDoux, 1996; Öhman, 1993; Zajonc, 1980, 1984).

Evidence for the idea that the primes were indeed processed implicitly and not consciously (or explicitly) elaborated or perceived emanates from a number of different findings. Regarding subjective arousal, we found no effect of prime presentations. This suggests that declarative memory was succesfully bypassed. Also, during the exit interview, participants did not report having noticed the presence of the primes.

Comparison of the predictive values positive obtained in the recognition test of this study and in Janssen et al. (2000) reveals that sexual primes were less often detected in this study than in Janssen et al. (.60 vs. .91). However, results from the recognition test of the current study still showed a significant deviation from chance. This seems to contradict the idea of nonconscious processing. Although the 10% difference in recognition between primes and distractors is comparable to studies in which awareness thresholds were estimated using a 10% detection difference in forced-choice trials (e.g., Cheesman & Merikle, 1984; Kemp-Wheeler & Hill, 1992; Marcel, 1983), the framework of our recognition test originated from studies that required no difference between primes and distractors in a test of awareness (e.g., Murphy & Zajonc, 1993; Öhman & Soares, 1994). A recent study by Buckner (2000) is relevant in this context. By analyzing fMRI data obtained in a recognition task, he showed the crucial role of the hippocampus in the difference between knowing and remembering. In the first case, knowing, recognition stems from a feeling of familiarity. There is no involvement of the hippocampus or declarative memory. In contrast,

recognition as remembering does activate the hippocampus and explicit memory. The results of our recognition test seem to reflect the first case, so the above-chance recognition of primes does not necessarily contradict our hypothesis of implicit processing.

Differences in recognition seem to coincide with different magnitudes of priming effects, as was demonstrated by the positive correlation we found between priming effect and the level of awareness (cf. Greenwald & Draine, 1997; Greenwald et al., 1995). This suggests that implicit activation is not an "on or off" phenomenon; instead, depth of processing might be a variable that accounts for response variability. It also calls for more precise definitions of the concepts ***implicit***, ***automatic***, ***unconscious***, and ***unattended***, because implicit or automatic processes most likely do not rule out attention or consciousness (Bargh, 1992; Dehaene et al., 1998; Shiffrin, 1997; Velmans, 1991).

Janssen et al. (2000) found negative correlations indicating that priming effects decreased with higher levels of recognition. A possible explanation for this difference involves the finding that on average, identification thresholds were higher in Janssen et al. (2000) than in the current study (38 ms vs. 13 ms, respectively). Considering that the setting and procedures were largely identical for the two studies, this difference, especially when combined with the higher recogition levels in the Janssen et al. study, suggests a complex, curvilinear relationship between stimulus accessibility and both the strength and direction of priming effects. At a low level of stimulus accessibility, priming effects may be strongest at somewhat longer prime presentation durations (explaining the positive correlation in the current study), whereas at higher levels of stimulus accessibility, the strongest effects may be found with the shortest exposures (explaining the negative correlation found in the Janssen et al. study). This thus further supports the idea that qualitative differences in responding may exist depending on whether primes are implicitly or explicitly processed (cf. Janssen et al., 2000; Murphy & Zajonc, 1993).

A valuable strategy to further elucidate these differences using our paradigm could be to contrast the implicit processing mode with a conscious, explicit processing condition (Baars & McGovern, 1993; Merikle, 1992; Merikle & Reingold, 1992). If explicitly processed sexual primes produce qualitatively different effects from implicitly processed primes, this provides evidence for the idea that two different mechanisms of

information processing have been involved. Clearly, the relevance of studying automatic or implicit processes would be greater if they are not simply quantitatively weaker versions of controlled, conscious processes (Merikle, 1992; Merikle & Reingold, 1992).

Besides the results of Janssen et al. (2000), there is additional support for the prediction that conscious appraisal of sexual primes will lead to effects opposite to the ones we found in Experiment 1 with subliminal primes. In lexical decision and reading tasks, delays in responding have been reported when sexual materials are presented (Geer & Bellard, 1996; Geer, Judice, & Jackson, 1994; Geer & Melton, 1997). Geer and Melton (1997) labeled "this hesitancy in decision making related to erotic material as 'Sexual Content-Induced Delay' (SCID)" (p. 296). Geer and Melton provided two explanations for SCID. The first is the response bias hypothesis, which states that when a decision about socially unacceptable stimuli is made, responses are delayed because participants do not want to make an error. The appraisal hypothesis states that the delay is the result of cognitive appraisal of emotional stimuli calling on additional processing, which interferes with the decision making process (cf. Pashler, 1994).

In Series 1, no main effect of Target was found. When this result is looked at in terms of SCID, it contradicts the response bias explanation. If sexual primes that are presented on a clearly conscious level would indeed decelerate subsequent decisions, the appraisal hypothesis for the SCID phenomenon is supported. Thereby, this decelaration further validates our paradigm with respect to implicit processing and extends it to explicit processing of sexual information. Regarding Series 2, the subjective response component, sexual primes that activate sexual representations in declarative memory should be capable of eliciting a subjective experience of sexual arousal, measured on following targets (cf. Geer et al., 1993; Hansen & Shantz, 1993; Power & Brewin, 1990).

Experiment 2

The second experiment was designed to test the hypothesis that explicit presentation of sexual information will have qualitatively different effects from implicit processing of sexual information. We asked participants to respond to sexual and neutral targets that were preceded by sexual and neutral primes. Both primes and targets were presented at a

conscious level. The experiment was composed of two blocks of experimental trials: In Series 1 we tested whether sexual primes would decelerate recognition of following targets, and in Series 2 we tested whether sexual primes would elicit subjective sexual arousal measured on sexual targets.

Method

The procedure, stimuli, and apparatus used in this experiment were identical to those used in Experiment 1, with two exceptions. First, we did not include the threshold determination and recognition test in this experiment. Second, we set prime presentation time (and SOA) at 1,000 ms. Participants were now asked to respond to "the second slide."

Results

Twenty-three newly recruited male university students (M = 23.1 years, SD = 2.9) participated under the same conditions as in the previous experiment. All participants reported sexual desire and sexual behavior. On a 5-point scale they reported an average satisfaction with their current sexual life of 3.2 (SD = 1.1).

Decision Times

Of the 920 decision times, 871 were used for analyses. A total of 27 response errors were made (see Table 2.4). A Friedman test revealed no significant differences for the error rates per condition, $c^2(3, N = 23) = 6.51$, *ns*. We considered 22 decision times outliers (see Experiment 1 for outlier detection and elimination procedures).

The range of the mean decision times over trials was 359 to 654 ms (M = 490, SD = 82). Means for each condition are shown in Table 2.4. A 2 (Prime: sex, plant) X 2 (Target: sex, plant) repeated measures ANOVA revealed no main effects, prime: $F(1, 22) = 2.82$, *ns*; target: $F(1, 22) = 3.23$, *ns*. However, we found a significant interaction between the factors, $F(1, 22) = 4.71$, $p < .05$. Follow-up paired t tests to explore this Prime X Target interaction revealed a significant effect for sex targets: sexual targets preceded by sexual primes were categorized as sexual more slowly than were sexual targets preceded by plant primes, $t(22) = 2.82$, $p < 0.02$. For

neutral targets, mean decision times did not differ by prime content (both 482 ms).

Table 2.4 *Mean Decision Time (in ms), and Errors in a Categorization Task (Series 1) and Subjective Responses (Series 2) for Sexual and Neutral Targets by Prime Content in Experiment 2 (N = 23)*

	Series 1				Series 2			
	Decision Time		Errors		Question 1 subjective arousal		Question 2 arousability of slides	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sexual targets								
Sexual primes	520	(99)	0.4	(0.5)	2.8	(1.1)	3.5	(1.1)
Neutral primes	477	(105)	0.2	(0.4)	2.7	(1.0)	3.3	(0.9)
Neutral targets								
Sexual primes	482	(89)	0.5	(1.0)	2.4	(0.9)	1.4	(0.6)
Neutral primes	482	(75)	1.0	(1.1)	2.2	(0.8)	1.1	(0.2)

Subjective Sexual Arousal

Mean responses on the first question ("To what degree do you feel sexually aroused at this moment?") varied from 1.0 to 4.1 ($M = 2.5$, $SD = 0.9$), while mean responses on the second question ("To what degree did you find the last slide sexually arousing?") ranged from 1.3 to 3.1 ($M = 2.3$, $SD = 0.6$). The correlation between the two questions was $r = .84$, $p < .01$. The means and standard deviations for each condition are shown in Table 2.4.

A 2 (Prime: sex, plant) X 2 (Target: sex, plant) repeated measures ANOVA was performed with the first question as dependent variable. We found a main effect for prime: sexual primes elicited more arousal compared to neutral primes, $F(1, 22) = 15.15$, $p < .01$. The main effect for Target was also significant, $F(1, 22) = 18.85$, $p < .01$. Sexual primes and sexual targets elicited more arousal than did neutral primes and targets, respectively. There was no significant interaction between the factors, $F(1, 22) = 1.74$, *ns*.

Additionally, we performed a 2 (Prime: sex, plant) X 2 (Target: sex, plant) repeated measures ANOVA with the second question as dependent variable. A main effect for Prime was found, $F(1, 22) = 11.60$, $p < .01$, and

the main effect for Target was also significant, $F(1, 22) = 100.56$, $p < .01$. Sexual primes and sexual targets led to higher assessments compared to neutral primes and targets, respectively. There was no significant interaction between the factors, $F(1, 22) = 0.80$, *ns*.

Discussion

The findings of Experiment 2 present a mirror image of those of Experiment 1, at least where Series 1 is concerned. Sexual primes influenced decisions about sexual targets; however, contrary to Experiment 1, categorization of sexual targets was decelerated (instead of accelerated) when these targets were preceded by consciously perceived sexual primes. With regard to subjective sexual arousal (Series 2), our prediction was confirmed. Sexual targets elicited more arousal (first question) and were rated more arousing (second question) compared to neutral targets; Targets elicited more arousal (first question) and were rated more arousing (second question) when preceded by sexual primes compared to plant primes. These findings support the idea that, since sexual primes influenced subjective (consciously experienced) sexual arousal, conscious cognitive elaboration of the primes occurred.

The finding that decisions in sex-sex trials (Series 1) were slower than decisions in the other three conditions (i.e., sex-plant, plant-plant, and plant-sex) resembles the SCID phenomenon (Geer & Bellard, 1996; Geer & Melton, 1997). It provides convergent validation of this concept; the data in the Geer and colleagues studies were gathered using words and nonwords in a primed and unprimed lexical decision task, whereas the data from Experiment 2 were collected in a categorization task in which pictures were used.

Two hypotheses have been put forward regarding the underlying mechanism of SCID: the response bias hypothesis and the appraisal hypothesis (Geer & Melton, 1997). The results of Experiment 2 seem to contradict both hypotheses. The response bias hypothesis would predict delayed responses on sex targets (because participants do not want to make an error). However, in Experiment 1 as well as 2, we found no main effect for target. The appraisal hypothesis would predict a main effect of Prime in Experiment 2. Conscious cognitive appraisal of sexual primes would call on additional processing which would interfere with the decision making

process. The fact that in this study sexual primes did not decelerate decisions on plant targets contradicts this hypothesis.

Sexual information might trigger regulatory modules that are specific for sexual (or emotional) response. Because specific regulation does not affect neutral responses, sex primes do not interfere with neutral targets. This interpretation can be seen as an elaboration of the appraisal hypothesis of Geer and Melton (1997). To further explore the role of appraisal in the explanation of SCID in a continuing study, (Chapter 5), we replicated Series 1 of Experiment 2 with two modifications. We added primes with other emotional content (threatening information) and we used a manipulation of instruction (ignore vs. focus). Results from this study showed that the SCID effect only emerged when sexual primes were ignored; however, threatening primes also decelerated recognition of sexual pictures. We suggested that SCID could be interpreted as the activation of regulatory modules by emotional stimuli in the stage of elicitation of emotional response (Chapter 5).

General Discussion

According to our theoretical view, the activation of the sexual system occurs automatically when conditions of this system match with stimulus features in the environment. In a subsequent stage, cognitive regulatory processes may inhibit or facilitate the sexual response. It is in this stage that subjective sexual arousal arises. This view is consistent with emotion theories, which consider the conscious emotional experience a by-product of or feedback from early emotional processes that took place outside awareness (e.g., involving unconscious appraisal, physiological arousal, or motor activation; see James, 1884; Lang, 1995; LeDoux, 1994; Öhman, 1987; Scherer, 1993). It is important to emphasize that when the emotional response proceeds, conscious, attentional, or strategical processes are an important determinant of sexual arousal. However, this is beyond the scope of this article (see Janssen et al., 2000, for a discussion of this issue).

The two experiments presented in this chapter build on the experiments reported by Janssen et al. (2000). The results of the categorization task of Experiment 1 reflect the existence of an implicit match between sexual memory and a sexual stimulus. The presentation of sexual primes, inaccessible to conscious cognitive elaboration, facilitated the

recognition of sexual targets. Sexual representations in memory were automatically activated. Experiment 2 showed that conscious perception of the primes leads to an opposite effect, with recognition of sexual targets being delayed by sexual primes. The processing of sexual information (i.e., the perception of the sexual prime together with the required decision on the sexual target) probably used additional capacity or called for higher cognitive regulation which may have slowed down decision making (Chapter 5; Geer & Melton, 1997).

Further research in this line should focus on questions about the specificity of the effects described above. Were these effects the result of a specifically sexual valence of the prime, or can they be attributed to its general emotional valence? Regarding explicit activation (Experiment 2), a follow-up study showed that threatening primes also decelerated decisions on sexual targets (Chapter 5). For this condition, an emotional valence rather than sexual valence seems responsible for the effect. Regarding implicit activation (Experiment 1), the question of specificity remains unanswered. Replicating the experiment with slides with different emotional content could clear up this issue. Öhman and Soares (1994) reported a relevant study on anxiety disorders. Snake phobics responded on snake slides, spider phobics on spider slides, but not vice-versa. Very brief presentations of emotional slides thus do not seem to prevent a relatively specific analysis of content.

Another way to explore the specificity of the effects reported here would be to use a sexually specific physiological measure. Although Janssen et al. (2000) found some initial support for the specificity of sexual priming effects, the measurement of circumference changes of the penis proved to be problematic with short stimulus presentations. With some methodological improvements, the registration of corpus cavernosum smooth muscle action potential (Wagner, Gerstenberg, & Levin, 1989) may prove to be a more suitable candidate for this purpose. Clearly, when a penile response is found after subliminal presentation of sexual slides, not only the specificity of the effect but also the automatic activation of the physiological sexual response is demonstrated. However, at this point in time robust registration of fast and small changes in the corpus cavernosum smooth muscle action potential is not possible (Geer & Janssen, 2000).

Regarding subjective sexual arousal, comparison of the two experiments presented here shows that this component of the sexual

response develops at a later stage. Although the sexual primes affected the recognition of sexual targets in the first experiment, there was no effect on subjective sexual arousal. Conversely, conscious perception of the primes in the second experiment did elicit subjective arousal.

Like the emotional Stroop task (Williams, Mathews, & MacLeod, 1996), this paradigm might provide a noninvasive and objective way to discriminate between different patient groups. For example, the implicit priming effect may be impaired in sexually traumatized patients. In this group, sexual primes might unconsciously activate traumatic representations in memory (cf. Shalev & Rogel-Fuchs, 1993). The explicit (SCID) effect might be linked to cognitive interference, which for example is an important factor in psychogenic erectile dysfunction (Barlow, 1986). And the elicitation of subjective arousal (Experiment 2, Series 2) might be correlated with the sensitivity of the sexual system and test arousability. Currently, we are conducting a study in which three patient groups participate: (a) Men with hypogonadism, (b) men with sexual trauma, and (c) men with psychogenic erectile dysfunction (Spiering, Everaerd, & Van Lunsen, 2000). It would be interesting to see if our priming approach is capable of revealing during which stage activation of the sexual response is impaired.

In conclusion, the data presented here provide additional support for the role of implicit processes in the sexual system. By further specifying the hypotheses in future experiments, activational mechanisms of sexual response can be analyzed more precisely. Now, much depends on the addition of a sexually specific physiological arousal as a dependent variable. If this approach would succeed, the paradigm of priming could offer a detailed description of the activation of the sexual response.