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Central activation of the sexual system

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Citation for published version (APA):
Spiering, M. (2004). *Central activation of the sexual system*.

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Chapter 7

The Sexual Unconscious

Unconscious processes set up sexual responding. After a short introduction of cognitive concepts pertaining to the sexual system and a description of unconscious versus conscious processing three hypotheses are discussed. (1) Sexual features are subject of a preattentive search. It would seem to the attentive individual as if the feature commanded attention. (2) Sexually competent stimuli activate motor output by a match with implicit memory; conscious evaluation is not necessary. (3) Hot and cold cognitions are postulated as unconscious products of bodily feedback and explicit memories. Attentional amplification of these cognitions results in conscious experience of sexual feelings and sexual thoughts. These hypotheses about sexual emotions are extrapolations of models of Damasio (2003) and LeDoux (1996). Recent empirical studies are discussed. Finally we put forward a proposal about a sex module within the brain.

Unconscious processes set up sexual responding. To acquire knowledge about the activation of a sexual response, one has to focus on unconscious mechanisms. We propose that (1) sexual features are preattentively processed, (2) sexually competent stimuli elicit physiological arousal before and independent of conscious evaluation, and (3) the subjective experience of a sexual emotion is constructed by attentional amplification of unconscious cognitions. We will describe models of the generation of emotion (Damasio, 2003; LeDoux, 1996) and extrapolate them to the sexual emotions as was earlier done by Janssen et al. (2000). Empirical studies that we recently conducted will be discussed.

The title of this chapter is derived from papers by Kihlstrom (1987) and Kihlstrom et al. (2000), "The Cognitive Unconscious" and "The Emotional Unconscious," respectively. In these papers the importance of implicit processes in cognitive and emotional responding is highlighted. Percepts, memories, and other mental states, which are inaccessible to phenomenal awareness and are somehow independent of voluntary control, influence conscious experience, thought, and action.

The Cognitive Sexual System

Sex can be construed as an emotion. Sexual excitement has a specific pattern of activity and there is coherence in expression and physiology linked to prototypical situational events (Everaerd, 1988). For a full blown sexual emotion, specific components have to be activated (e.g., genital arousal, a subjective experience of sexual arousal) as well as nonspecific components (e.g., heart rate changes, a subjective experience of tension). When writing about the "sexual system" we mean sexually specific as well as nonspecific modules within the brain, which interact to produce a sexual response.

Which are the requirements for the sexual system to operate? Sexuality is prepared at birth. During development and growth there is interaction with the environment, which builds up experience and potentiation of "sexual" stimuli (Everaerd, Laan, & Spiering, 2000). The most probable development is that, in the beginning, pleasurable sensations from tactile stimulation and later from visual, auditory, or olfactory stimulation were pleasurable and not sexual, like many other sensations for which labels and meanings have to be learned after the first experience. It is

implied that stimuli are cognitively transformed into messages that eventually result in a sexual response, subjective sexual experience in particular. Thus, a stimulus is not intrinsically sexual; it becomes sexual by its transformation (Everaerd, Laan, & Spiering).

Sensitivity of the sexual system is depended on biological and psychological factors. On the side of biological factors, the androgen hormones as well as the neurotransmitters norepinephrine and dopamine are considered as most influential (Bancroft, 2002). The focus of this chapter is on psychological factors. Emotional reactions depend on appraisal of the stimulus, which includes memory and attentional processes interacting with each other.

Long-term memory is not a unitary entity, but can be subdivided into explicit (or declarative) and implicit (or procedural) memory (Squire, 1992; Tulving & Schacter, 1990). Explicit memory is consciously accessible; implicit memory is not. Regarding "sexual memory," that is, memory associated with sexual responding, explicit memory refers to, for instance, recollections of sexual encounters, attitudes toward sex, sexual fantasies, and knowledge about sexual rewards or costs. Implicit sexual memory refers to, for instance, innate sexual reflexes, learned (automatized) sexual scripts, and classically conditioned sensations. A stimulus may convey several meanings depending on the circumstances or the individual's history. Different messages, in the same or in different individuals, may thus be accessed by the same stimulus. Sexual meaning and other meanings relevant for different emotions, such as anxiety, anger, or elation, may be present at the same time. The different meanings will be processed as different messages that, by further processing, may develop divergent physiological and behavioral responses and experiences (Everaerd, Laan, & Spiering, 2000).

What happens when a person is confronted with a sexually competent stimulus? How is stimulus information transformed into particular sorts of actions? When confronted with a sexual stimulus arousal will be generated, which subsequently signals reward. At the same time motor preparation is activated for eventual approach to the rewarding stimulus (Both, Everaerd, et al., 2003). The emotional experience of sexual arousal is the subjective awareness of autonomic arousal, of the reward expectancy, and of the felt tendency to act (Everaerd, 1988; Frijda, 1986). Arousal alone is not sufficient to produce subjective sexual experience. This experience

ultimately depends on the individual's awareness and definition of the response as sexual.

Central regulation of emotional responses is essential for adaptive functioning. When a stimulus has been identified as sexual, regulation of information processing is needed. Although sexual excitement can be enhanced by intentionally bringing (explicit) sexual memories into awareness, probably most of the time regulation actually consists of inhibition. Since sexual behavior goes together with important concerns (e.g., reproduction, intimacy), attentional mechanisms are triggered and activational stages are accompanied by conscious inhibitory control (Baars, 1998b; Gross, 1998; Fuster, 1997).

Unconscious versus Conscious Processes

Information processing in the brain can be divided into unconscious and conscious. For every conscious state there is an associated neural state; a change of conscious state is impossible without a corresponding change in neural state. However, not all neural activities have corresponding conscious representations (Frith, Perry, & Lumer 1999). Unconscious processes have two essential features: they are inaccessible for phenomenal awareness and independent of voluntary control.

Kihlstrom et al. (2000) distinguish between the "cognitive unconscious" and the "emotional unconscious." The cognitive unconscious constitutes four categories of phenomena: Implicit memory, implicit learning, implicit perception, and implicit thought. Implicit or nondeclarative memory can be defined as an unconscious influence of past experience on current performance of behavior (Schacter & Buckner, 1998). Implicit learning refers to one's acquisition of new patterns of behavior without being aware of the patterns themselves (Kihlstrom et al., 2000). Automatization is a relevant concept in this. Implicit perception includes preattentive or preconscious processing. It is defined as the effects of a current event on one's performance, in the absence of conscious perception of that event. Finally implicit thought, for example the correct solution to a problem, influences experience, thought, or action even though one is unaware of the thought itself (Kihlstrom et al., 2000).

How does the emotional unconscious relate to this? If emotion is defined as a conscious feeling state, an emotional unconscious is precluded.

But when the subjective component of an emotion (i.e., the conscious feeling state) is absent, while the behavioral and physiological components persist outside of phenomenal awareness, why can't we say that there is an unconscious emotion or at least an unconscious emotional response (Kihlstrom et al., 2000)? From an information processing perspective subjective components of an emotion, just as physiological and behavioral components, are the products of processing, which is inaccessible for phenomenal awareness and independent of voluntary control, that is, emotional unconscious processes.

We will now look at unconscious processes from the other side, by describing conscious processes. The essential feature of consciousness is awareness; to be conscious is to be aware of things. Attention is a prerequisite of consciousness. Consciousness refers to those thoughts, memories, sensations, and actions of which one is aware, whereas attention refers to those processes that modulate neuronal activity (Tassi & Muzet, 2001). The results of selection are always conscious, whereas the processes of selecting, deselecting, and maintaining selection may or may not be. "Attention involves the selection of targets for the searchlight to shine on, while consciousness results from illumination of the target" (Baars, 1998a, p. 59). Phenomenally, we experience conscious visual scenes; but we are not necessarily conscious of visual selection processes that can reasonably be called attentional. Attention can be subdivided in three systems with different functions: orienting to sensory stimuli, activation of ideas from memory, and maintaining the alert state (Posner, 1994). Consciousness is a form of output associated with focal attentive processing that does not enter into cerebral processing (Velmans, 1991).

Dehaene and Naccache's (2001) global neural workspace hypothesis describes the relation between unconscious processes and a conscious state. At any given time, many modular cerebral networks are active in parallel and process information in an unconscious manner. Information becomes conscious if the neural population that represents it is mobilized by top-down attentional amplification into a brain-scale state of coherent activity that involves many neurons distributed throughout the brain. The long-distance connectivity of these "workspace neurons" can make the information available to a variety of processes including perceptual categorization, long-term memorization, and intentional action. It is postulated that this global availability of information through the workspace

is what we subjectively experience as a conscious state (Dehaene & Naccache).

Top down should not be taken too literally. Since there is no single organizational summit to the brain, it only means that such attentional amplification is not just modulated bottom up by features internal to the processing stream in which it rides, but also sideways influences, from competitive, cooperative, collateral activities (Dennet 2001). It is "not that this global availability causes some further effect or a different sort altogether – igniting the glow of conscious qualia, gaining entrance to the Cartesian Theatre, or something like that – but that it is, all by itself, a conscious state" (Dennet 2001, p. 223).

In the next three sections we will review our three hypotheses that were mentioned at the start of this chapter. Theoretical and empirical arguments are presented in a temporal structure: Unconsciously, sexual features attract attention, produce motor output, and enable a conscious experience.

Preattentive Selection of Sexual Features

Taken literally, the term preattentive means before attention operates. So-called preattentive search is really a search in which attention is distributed widely over the whole display rather than narrowly focused and is directed serially to one subgroup at a time (Treisman & Gormican, 1988; Treisman & Souther, 1985). Preattentive search can be construed as a filtering of information so that some features or aspects of an array are "passed through" and others are "filtered out." A feature passed through is more likely to come to focal attention than one filtered out (Öhman, Flykt, et al., 2001). It would seem to the (attentive) individual as if the feature commanded attention; it would appear to "pop out" from the array (Treisman & Gormican, 1988). Preattentive visual search was defined as fast, automatic, and parallel and works on low-level stimulus features with the primary objective of delineating objects in the spatial surroundings. Focal attention is slow, deliberate, and serial and is concerned with more complex inferential and interpretative processes in identifying the located objects in perceptual awareness (Posner & Snyder, 1975; Shiffrin & Schneider, 1977; Schneider & Shiffrin, 1977). When unexpectedly encountered, peripheral significant events may interrupt ongoing processing

and call for prioritized focal attentive processing (Öhman, Flykt, et al., 2001).

We propose that sexual features are preattentively processed. We derive this from emotion research in which threat features preattentively elicit focal attention: the face-in-the-crowd paradigm. No direct empirical support for this proposal regarding sexual features is present yet, however, some indirect support is discussed later in this section.

Hansen and Hansen (1988) introduced the face-in-the-crowd effect. In experiments participants were presented with arrays of faces in which one facial expression differs from the others in emotional valence. Participants were asked to detect the "odd face out" as quickly as possible. Angry faces were found more efficiently in happy crowds than were happy faces in angry crowds. Also, the latency to discover an angry face in a happy crowd was not influenced by the number of happy-face distractors in the crowd, whereas the number of angry-face distractors dramatically influences the latency to discovery of a discrepant happy face. It was surmised that the face-in-the-crowd effect was due to a stimulus confound (Purcell, Stewart, & Skov, 1996). However, recently Öhman, Lundqvist, et al. (2001) successfully replicated the findings with schematic facial stimuli.

Facial threats command attention, an angry face in a happy crowd is found quite readily, whereas a happy face in a crowd of attention-grabbing angry faces is easily overlooked. Arrays are preattentively searched in parallel for features of facial threat, an angry face in a happy crowd pops out and does not require an extensive, time-consuming, serial attentive search to discover its presence. However, a happy face in an angry crowd is not preattentively distinctive; it does not pop out, and discovering its presence requires a serial search of the faces.

Detection and location of a feature can be accomplished preattentively, whereas discrimination requires attentional processing. An angry face could be detected and located in a happy crowd, but its content (i.e., that it was, in fact, an angry face) could not be discriminated preattentively. The consequence of preattentive face processing from which the face-in-the-crowd effect was derived then, would be a shift of attention to a preattentive located point in the crowd. Given time to complete an attentional shift to that point, the target could be seen as an angry face (Hansen & Hansen, 1988).

Öhman, Flykt, et al. (2001) examined another class of evolutionary fear-relevant stimuli within the same paradigm: snakes and spiders. Stimuli related to recurrent survival threats in the environment of evolutionary adaptedness may have been selected to become more or less automatic triggers of attention. The reproductive potential of individuals was predicated on the ability to efficiently locate critically important events in the surroundings. To detect threatening events outside the spotlight of focused, conscious attention, there must be perceptual processes that automatically scan and analyze the perceptual field.

Participants were faster in finding snakes and spiders against backgrounds of flowers and mushrooms (neutral stimuli) than the other way around (Öhman, Flykt, et al., 2001). Furthermore, whereas it took longer to locate fear-irrelevant targets with more distractors, finding fear-relevant targets was independent of matrix size. The effect of fear relevance was enhanced in fearful participants. Similar to controls, fearful participants were faster to find a fear-relevant target that they did not fear (e.g., a spider for a snake-fearful participant) than fear-irrelevant targets, but they were even faster to find a fear-relevant stimulus (e.g., a snake for a snake-fearful participant). Threatening stimuli were located in a preattentive, parallel-processing perceptual stage, whereas non-threatening targets had to be searched for with a more laborious post-attentive strategy.

The data suggest that snake- and spider-fearful participants were sensitized specifically to have their attention captured by the feared stimulus. Comparable, Gilboa-Schechtman, Foa, and Amir (1999) tested social phobics and found greater attentional bias after angry faces in this paradigm. There might be attention control settings that tune the likelihood to capture attention in accordance with their relevance for the current goals of the individual (Folk, Remington, & Johnston, 1992). If emotions are action sets (Frijda, 1986), which imply a set of goals, it could be suggested that the generation of emotions involves attention control settings that make goal-relevant stimuli salient. As a result, these stimuli may then automatically capture attention (Folk et al., 1992).

Junghöfer, Bradley, Elbert, and Lang (2001) provide converging empirical data, with negative as well as positive (including sexual) pictures. They introduced a new experimental paradigm: rapid serial visual presentation. It allows investigation of rapid detection and perceptual processing of emotionally salient stimuli after a single scan, as stimuli occur

fleetingly, or as the eye flicks rapidly through a scene. Participants viewed 700 complex pictures, varying in affective arousal, at high-speed presentation (3 or 5 per s). Event-related potentials (ERPs) are assessed to determine attention capture. ERPs were more negative for high than low arousal pictures suggesting that the brain is specially tuned to detect and process motivationally relevant stimuli (Lang et al., 1998). Affect discrimination of pictures was independent of formal visual properties of the stimuli, including color, brightness, spatial frequency, and complexity (Junghöfer et al., 2001).

We propose that sexual features also can be preattentively processed (see Figure 7.1). Which arguments do we have for this? In daily life, one may recognize the attention-grabbing capacity of sexual features by its use in advertisement and video-clips. Theoretically, the fact that the pop-out effect was not found for happy faces does not imply that all approach stimuli are excluded from being preattentively processed. Both sexually appetitive and anxiety inducing stimuli generate action tendencies; although the direction of eventual behavior is presumed to be different, that is, approach versus avoidance (Both, Everaerd, et al., 2003). Regarding the criteria of goal-relevance and reward value, sexual stimuli may have a higher valence than happy faces.

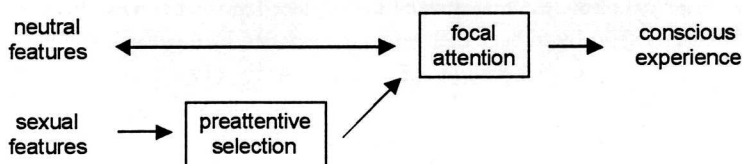


Figure 7.1. Unlike neutral stimuli, sexual features may be preattentively selected to trigger focal attention.

A straightforward test for preattentive selection of sexual features would be to include them in the face-in-the-crowd paradigm (however, see Chapter 6, p. 123-124). This has not been done. There is some indirect support for our hypothesis. The findings described before fit into a voluminous literature showing attentional bias for threat in anxiety patients, e.g., the dot-probe paradigm or the emotional Stroop task (Mogg & Bradley,

1998; Williams, Mathews, & MacLeod, 1996). The general tendency, even among non-anxious individuals, to attend to threatening stimulus content may reflect the same type of preattentive process as displayed in the face in the crowd paradigm.

Geer and colleagues discovered a delay in information processing caused by sexual words (Geer & Bellard, 1996; Geer & Melton, 1997). This could very well be compared to the attentional bias phenomenon caused by threatening information (Mogg & Bradley, 1998; Williams, et al., 1996). Recently, we conducted an experiment in which both sexual and threatening pictures, that had to be ignored, decelerated categorical decisions (Chapter 5). This deceleration-effect replicates Geer's findings and extends it to threatening information, resembling the emotional Stroop effect. Sexual information, just like threatening information, interferes with information processing by automatic activation of focal attention. This could indicate the preattentive processing of sexual features.

Unconscious Activation of the Sexual System

Emotional responses are consequences of affective computations outside conscious awareness. In this section we will review evidence of unconscious activation of sexual response. We propose that sexual features activate implicit memory and bodily responses before conscious appraisal. First, LeDoux's (1996) work on the role of the amygdala is presented because of its great influence on thinking about unconscious activation of emotions. Next, relevant studies from emotion and sex research are discussed.

The amygdala is the core of the network that computes the affective value of the stimuli an organism encounters (LeDoux, 1993). Empirical support for this was found in relation to negative as well as positive emotions, including the sexual (Zald, 2003). LeDoux discovered parallel transmission to the amygdala from (a) the thalamus and (b) the cortex (1996, 2000). (a) The thalamo-amygdala projections appear to be involved in the processing of the affective significance of relatively simple sensory features. These subcortical pathways provide a crude image of the external world. (b) The thalamo-cortico-amygdala projections are necessary when more complex aspects of stimuli are processed. More detailed and accurate representations become available from the cortex. While the pathway from

the thalamus to amygdala only involves one link, at least two links are required to activate the amygdala by way of the cortex. Since each link adds time, the thalamus pathway is faster. This direct route, initiated by the amygdala, can preattentively initiate bodily responses. Low-level stimulus features can trigger emotional functions by the rapid arrival of crude stimulus information from the thalamus to the amygdala (LeDoux, 1996).

Data from recent experiments using fMRI and Pet scans corroborate the pivotal role of the amygdala in unconscious emotional activation. Subliminally presented angry faces lead to neural activity in the amygdala along with heightened SCRs (Morris et al., 1998). In an experiment of Whalen et al. (1998) signal intensity within the amygdala changed following subliminally presented angry faces as well as happy faces. Although LeDoux (1996) offers a specific neurobiological model by which stimulus features activate emotional responses, the temporal resolution of the designs of Morris et al. and Whalen et al. does not directly address the issue that the amygdala receives stimulus information directly from the thalamus. However, it supports the main thesis of LeDoux that affective computations are made without the need, and before focal attention or awareness. Stimulus features automatically activate bodily responses, and conscious appraisal of the stimulus occurs against a background of physiological activation.

Others have stressed which features are capable to unconsciously activate responses and which bodily responses can be elicited unconsciously. Öhman and Soares (1994) subliminally presented pictures of snake and spiders to snake fearful and spider fearful participants. Snake fearful participants showed enhanced SCRs to snake stimuli and spider fearful participants to spider stimuli. Merely a preattentive analysis of emotionally relevant features is sufficient to elicit a fear response and very brief presentations of emotional slides thus do not seem to prevent a relatively specific analysis of content.

Reactions in facial muscles were successfully elicited in participants unconsciously exposed to pictures of angry and happy faces. Just as in full-awareness conditions (Cacioppo, Petty, Losch, & Kim, 1986) increased zygomatic muscle ("frown-muscle") activity was found after subliminally presented pictures of angry faces and increased corrugator muscle activity ("smile-muscle") after subliminally presented pictures of happy faces (Dimberg, Thunberg, & Elmehed, 2000; Rotteveel et al., 2001). It was suggested that unconscious facial reactions are even larger compared to

conscious ones, because they are unaffected by conscious regulation (Rotteveel et al.).

To what extent unconscious activation of the sexual system has been studied? Janssen et al. (2000) tested the hypothesis of genital activation without awareness. Consciously perceived sexual slides were subliminally primed with sexual vs. neutral slides. In Figure 7.2 LeDoux' s model (1996) is depicted with a sexually competent stimulus; by presenting slides subliminally the pathway from explicit memory to attention was blocked. Genital blood flow of the first 5 seconds after presentation of the target was measured by penile circumference-differences (only men were tested). Contrary to prediction, penile responses on sexually primed slides were smaller than responses on neutrally primed slides. However, in early stages of arousal the penis may primarily grow in length, which is associated with a simultaneous decrease in circumference (Earls & Marshall, 1982; Kuban, 1997; McConaghy, 1974). Instead of circumference measures, future studies might profit from volumetric measures or from registration of corpus cavernosum smooth muscle action potentials to pick up small priming effects (Geer & Janssen, 2000; Jiang, Speel, Wagner, Meuleman, & Wijkstra, 2003; Wagner, Gerstenberg, & Levin, 1989). Still, initial support for preattentive genital activation seems present.

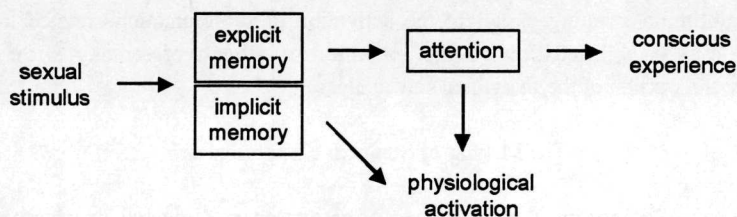


Figure 7.2. A sexual stimulus activates bodily responses implicitly and explicitly. The implicit pathway is independent of conscious experience.

In a sequel study (Chapter 2) the activation process was tapped in an earlier phase. The way explicit memory mediates between stimulus and subjective experience, implicit memory can be seen as the mediator between stimulus and bodily response. It was found that subliminally presented

sexual pictures facilitate the identification of following sexual pictures without an effect on subjective sexual arousal. It can be concluded that sexual features activated implicit sexual memory bypassing products of explicit memory.

Also in this study only men were tested. A replication in women succeeded but showed weaker effects (Chapter 3). Several hypotheses can be formulated for this. Emotional responses to sexual stimuli are more blended in women than in men (Everaerd, Laan, Both, et al., 2000), which can make implicit activation more diffuse. Another hypothesis is that men and women do differ on a primary level of responding. Dissimilarities between prehistoric gender roles might have influenced preattentive processing of sexual features nowadays (Bjorklund & Kipp, 1996). Men have been selected to maximize their mating opportunities; women do not benefit by increasing the number of sexual partners and would risk producing offspring of low quality if they mated indiscriminately (Bailey et al., 1994). Furthermore, ontogenetic and cultural factors differentially influence men and women.

Finally, preattentive activation of sexual representations was found in relation to sexual harassment (Bargh, & Raymond, 1995; Bargh et al., 1995). In an analogue study an unconscious unidirectional link was shown between the concept of power and sex. Participants were male students who indicated on a self-report measure that they were attracted to sexual aggression. Using a subliminal priming paradigm the activation of representations related to sex was established through the activation of other representations (i.e., power), outside of the individual's awareness.

The Making of Subjective Experience

In this section the final stage of activation is discussed in which a subjective experience of sexual arousal is added to physiological activation. A feeling is defined as "the perception of a certain state of the body along with the perception of a certain mode of thinking and of thoughts with certain themes" (Damasio, 2003, p. 86). A complete emotional experience consists of awareness of bodily responses (e.g., "I feel sexually aroused") plus the cognitive appraisal of the stimulus as emotional (e.g., "this is a sexual arousing stimulus"). We introduce the concepts "hot" versus "cold" cognition to distinguish between these two experiences and will see that they

originate in implicit versus explicit memory respectively. At the end, empirical findings on this topic are presented.

In the previous sections we stated that in the first stage of activation a sexually competent stimulus activates bodily responses by a match with implicit memory. Conscious appraisal of the stimulus is not necessary for this. Two different pathways can now lead to a subjective experience. (1) Attentional focus results in conscious appraisal. The appraisal process is contingent on the match between stimulus characteristics and explicit memory. The individual defines the stimulus as sexual. (2) Feedback representations of peripheral arousal provide input to conscious awareness (Critchley, Mathias, & Dolan, 2002). Body-sensing brain regions produce a map of what is occurring in the body (Damasio, 2003) and the perception of this map can result in a conscious sexual feeling.

The concepts of "hot" versus "cold" cognition were introduced in social psychology to contrast between affectively laden and motivationally driven versus anhedonic and purely informational processes (Lepper, 1994). We incorporated these concepts in our model (see Figure 7.3). Cold cognitions are defined as representations activated in explicit memory. Hot cognitions are defined as bodily feedback representations that originally result from implicit activation. The focus of attention in emotion can switch between hot and cold cognitions and yield awareness of bodily phenomenology or emotion thoughts (Lambie, & Marcel, 2002).

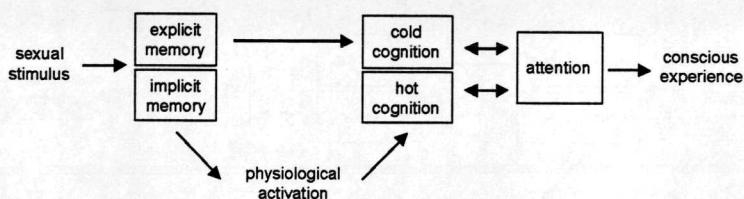


Figure 7.3. The conscious experience is constructed by attentional amplification of unconscious hot and cold cognitions. These cognitions can be seen as the products of implicit and explicit activation.

We will now describe both pathways more precisely and describe which are the main brain structures involved. Explicit memory is situated in the neocortex and is mediated by the hippocampus (LeDoux, 1996; Squire, 1992). The amygdala is the central brain structure for implicit memory. LeDoux describes the parallel functioning if stimuli that were present during a trauma reactivate both structures. "Through the hippocampal system you will remember who you were with and what you were doing during the trauma, and will also remember, as a cold fact, that the situation was awful. Through the amygdala system the stimuli will cause your muscles to tense up, your blood pressure and heart rate to change, and hormones to be released, among other bodily and brain responses" (p. 202, LeDoux, 1996).

The insula might be a crucial brain structure in the way bodily feedback provides input to awareness (Craig, 2002; Damasio, 2003; Sumich, Kumari, & Sharma, 2003). The hot cognition, the feeling, is an interoceptive sensation, based on an image of the state of the body. The insula is engaged in the transfer of bodily responses and subjective feelings (Morris, 2002).

How does a conscious state appear from an unconscious cognition? Information becomes conscious if the neural population that represents it is mobilized by top-down attentional amplification (Dehaene & Naccache, 2001). The prefrontal cortex and anterior cingulate are presumed to represent this attentional amplifier (Fuster, 1989; Posner, 1994). In Figure 7.4 the psychological concepts of Figure 7.3 are replaced by its main neurological structures.

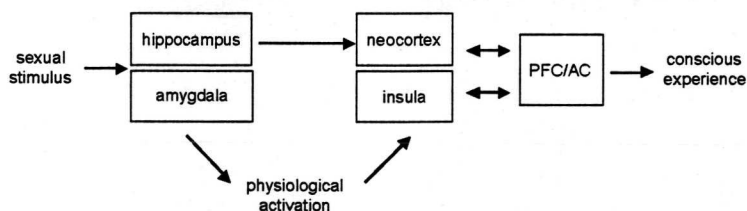


Figure 7.4. The main brain structures that underlie the psychological concepts of Figure 7.3. PFC/AC = prefrontal cortex and anterior cingulate.

Disagreement between sexual response components was explained by independent contributions from explicit and implicit memory. For instance, low self-reported emotional ratings and a relatively high physiological

response was found when women were exposed to male-centered erotic film excerpts (Laan et al., 1994). The stimulus matched with implicit sexual memory and led to physiological sexual arousal. Meanwhile, the stimulus activated nonsexual meanings (e.g., awful, coarse, obscene) in explicit memory. When focus of attention is directed to these activated cold cognitions a genital response is present while the subjective experience of sexual arousal is absent (Everaerd, Laan, Both, et al., 2000; Geer et al., 1993; Janssen et al. 2000).

In a recent study (Chapter 4) we manipulated focus of attention in order to create different access to memory (Robinson & Clore, 2002). Men and women were asked to rate sexual pictures that were primed by male versus female oriented sexual pictures (i.e., explicit vs. romantic). Two ratings were collected. First, participants were asked for a hot cognition: "To what degree do you feel sexually aroused at this moment?" Second, they were asked for a cold cognition: "To what degree do you find the last slide sexually arousing?" In this way, we may distinguish between implicit versus explicit contributions to emotional self-report.

A gender difference was not present in hot cognitions (first question) and was present in cold cognitions (second question). Women rated targets as less arousing when they had been preceded by explicit primes than did men. Correlations between the two questions were higher for men than for women. Especially after the male-oriented explicit primes the correlation for women was low. Explicit primes match with implicit sexual memory and activate physiological arousal. When asked for an introspective assessment, (i.e., first question), physiological feedback might result in subjective sexual arousal. However, conscious evaluation of the stimulus (i.e., second question) is more dependent on explicit memory and explicit sexual primes were evaluated as not arousing by women. This pattern could be a manifestation of response disagreement as was found in the Laan et al. study (1994), however, considering the lack of a physiological measure of sexual arousal in this study (Chapter 4), this explanation remains somewhat speculative.

An Evolved Sex Module within the Brain?

We proposed that different unconscious mechanisms are involved in activation of sexual response. Sexual features are subject of a preattentive

search. It would seem to the attentive individual as if the feature commanded attention (Figure 7.1). Sexually competent stimuli activate motor output by a match with implicit memory. Activation of representations in explicit memory and subsequent conscious evaluation is not necessary for this (Figure 7.2). Hot and cold cognitions were postulated as unconscious products of bodily feedback and explicit memories. Attentional amplification of these cognitions results in a conscious experience of sexual feelings and sexual thoughts (Figure 7.3). Empirical support for these hypotheses mainly stems from emotion research in general, for instance imaging studies in which these psychological pathways are representations of underlying neurological structures (Figure 7.4).

Öhman and Mineka (2001, 2003) recently proposed a fear module in the brain that represents an evolved adaptation. This concept is presumed to integrate diverse findings on fear from many domains and to set an agenda for research on fear. Is there also a sex module inside? For this we should abandon the assumption of function generality. Decision rules has coevolved with search engines and memory systems and what kind of information they will retrieve will depend on what adaptive problem they were designed to solve (Klein, Cosmides, Tooby, & Chance, 2002). The brain can be seen a set of computational machines that are adaptive specializations: systems equipped with design features that are organized such that they solve an ancestral problem reliably, economically and efficiently. A host of specialized systems may exist, including ones related to sexual motivation (Duchaine, Cosmides, & Tooby, 2001).

The sex module that might be outlined of our model could be seen as a device for activating sexual physiological responses and sexual feelings to sexual stimuli. According to Öhman and Mineka (2001) a module has four characteristics: selectivity, automaticity, encapsulation, and a specific neural circuitry. The sex module could meet these criteria.

Selectivity

There is selectivity with regard to the input to which the module responds. Rather than being open to any stimulus, the sex module is assumed to be particularly sensitive to stimuli that have been correlated with successful sexual encounters in the evolutionary past, e.g., cues indicating genetic quality.

Automaticity

Automaticity refers to identification of sexual stimuli after a minimum of neural computations and to immediately give them priority, e.g., in terms of efficient attention capture. Features trigger responses in the absence of conscious awareness of the stimulus event. The sex module is not under voluntary control and has a stimulus driven onset.

Encapsulation

Whereas automaticity is primarily related to the initiating of activity, encapsulation refers to the maintaining of activity over time. Once activated, the sex module tends to run its course with a few possibilities for other processes to interfere or stop it.

Specific neural circuitry

The sex module is to be controlled by a specific neural circuit that has been shaped by evolution because it mediates the functional relationship between ecological events and behavior. The brain circuits are likely to be located in subcortical or even brainstem areas. Its subcortical location suggests that it has an ancient evolutionary origin.

The scientific utility of the concept of a sex module still has to be shown. Our model of activation also remains speculative. It mainly is an extrapolation of models of Damasio (2003) and LeDoux (1996) that are still more theoretical than empirical and, besides, these models are not about sex. In our view it is fruitful to implement these cognitive-emotional concepts in sex research. Hypotheses can be specified and tested in paradigms that allow the study of unconscious mechanisms (e.g., the face-in-the-crowd paradigm, priming). Neuroimaging studies could reveal the specific neural circuitry involved in sex (Sumich et al., 2003).

Much can be done with little or no conscious attention. Circumstances that mobilize attention tend to involve novel challenges or unpredictable events to which we need to devote a substantial part of our psychological resources. From a functionalistic perspective, consciousness plays an important role in directing our waking behavior (Zeman, 2001). For sustained response attention to internal or external sexual cues is needed. Without attention the sexual response will fade away. Also, regulation of the response merely functions through conscious evaluation, for which attention

is a prerequisite. However, activation of sexual response is largely unconscious. To increase knowledge about activational mechanisms, one has to focus on the "sexual unconscious," the different processes, inaccessible for phenomenal awareness and independent of voluntary control, which set up sexual responding.