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An Integrative Theoretical Framework for Understanding Sexual Motivation, Arousal, and Behavior

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An integrative theoretical framework and model for understanding sexual motivation, arousal, and behavior is presented, combining the principles of incentive motivation theory and the hierarchical control of behavior. It is intended to stimulate discussion. The framework can serve as a "route map" in understanding the links between different component processes and their interactions, as well as the relations between different academic perspectives on understanding sexuality. It is suggested that both excitation and inhibition of sexual motivation, arousal, and behavior act at various levels in a hierarchical structure, and much confusion can be avoided by distinguishing these levels. The model integrates information from different branches of psychology: biological, evolutionary, clinical, cognitive, developmental, and social. It describes interactions between sexual behavior and anxiety, attachment, aggression, and drug taking; and it is applied to gender differences, evolutionary psychology, sexual deviancy, sexual addiction, and the biological bases of sexuality.

In trying to explain sexual motivation and behavior, a bewildering array of terms is employed for the *excitatory* concepts—for example, lust, arousal, desire, libido, drive, fantasy, attraction, and incentive. A slightly shorter list describes the concepts offering *restraint*—for example, superego, satiation, fatigue, inhibition, and self-regulation. Therefore, by what means are sexual motivation and behavior organized on the basis of such opposing contributions? I suggest how the underlying processes can be characterized and combined. I propose a framework that can help to organize the terms and empirical findings. In the language of evolutionary psychology (Tooby & Cosmides, 1990), I suggest how the psychobiological processes underlying sexual motivation and its expression are *designed*.

To understand complex psychobiological systems involving motivation, sex researchers sometimes employ theoretical models as explanatory tools and means to organize scientific thinking systematically. These summarize the interactions between the parts of a system and thereby suggest how the properties of behavior arise. Some models are expressed simply in words (Beach, 1976; Hardy, 1964), whereas others take the form of diagrams showing boxes and flows of signals between them (Bancroft, 1999; Barlow, 1986; Bem, 1996) or even computer-based models (Freeman & McFarland, 1974).

The most-favored general model of motivation appears to be the incentive motivation model (Berridge, 2001; Bindra, 1978; Bolles, 1972; Depue & Collins, 1999; Depue & Morrone-Strupinsky, 2005; McClelland, 1987; Toates, 1986). This model has been applied to sexual motivation and behavior (Singer & Toates, 1987; Toates, 1980, 1986; Toates & O'Rourke, 1978) and, in so doing, has been a guide to subsequent theorizing (e.g., Basson, 2003; Both & Everaerd, 2002; Both, Everaerd, & Laan, 2003, 2007; Pfaus, Kippin, & Centeno, 2001).

The basic incentive motivation model of sex shown in Figure 1 is applicable widely across a range of mammalian species. Incentives and cues associated with them (conditional stimuli) impinge on the nervous system, which triggers sexual motivation. Motivation links to both autonomic effects and behavior. Sexual behavior first exerts positive feedback in terms of enhancing motivation but, subsequently, negative feedback reduces motivation as a function of orgasm and ejaculation. Satiety is assumed to strengthen the future power of the incentive in its capacity to trigger sexual motivation.

As useful as this model has been, it captures in a simplified form only some of the processes that underlie sexual motivation and behavior. Here, I develop the model and suggest that further insights require (a) looking more closely at the pathway of information between stimulus and response and (b) considering how the processes captured by the original model are embedded within other processes.

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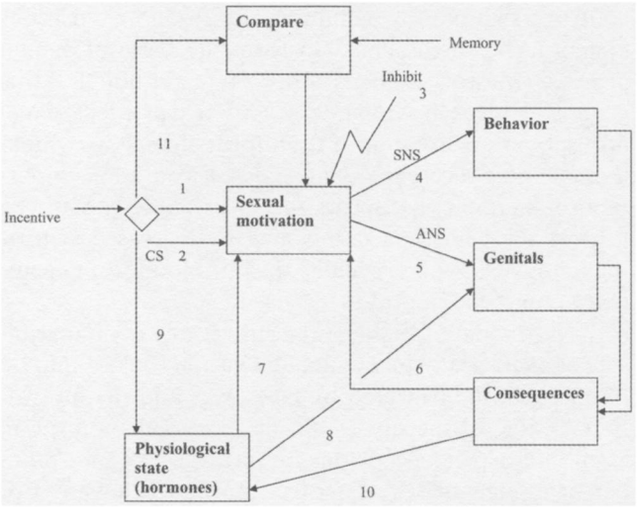

Figure 1. The basic incentive motivation model. *Note.* A sexual incentive triggers sexual motivation (1), as well as affecting hormone levels (9), and is compared with memories of earlier experiences (11). Conditional stimuli (CS) also tend to excite sexual motivation (2). Sexual motivation is sensitized by hormones (7). Inhibition is exerted on sexual motivation (3). Sexual motivation links to behavior via the somatic nervous system (SNS; 4) and to events at the genitals through the autonomic nervous system (ANS; 5). Information on the consequences of the behavioral and genital reactions feeds back to affect motivation (6) and hormones (10). Hormones influence events at the genitals (8).

This development arose from several closely related considerations:

1. It is now some 30 years since the original application of an incentive-based model to sex, and there have been enormous experimental and theoretical developments since. I bring the model up-to-date and show how an extended model can establish links with more recent research findings and theoretical developments.
2. The model was developed primarily with reference to nonhumans. Although some of its basic features are applicable across vertebrate species, refinements are needed, particularly to apply it to humans.
3. Sex research suffers from fragmentation and lack of over-arching theoretical synthesis. For example, restraint processes are studied within cognitive (Graham, Sanders, Milhausen, & McBride, 2004), clinical (Barlow, 1986), evolutionary (Bjorklund & Kipp, 1996), biological (Bancroft, 1999), social (e.g., Baumeister & Vohs, 2003), and developmental psychology (e.g., Steinberg, 2004). Hence, there is a need for integration across traditional boundaries. The model was developed within a broad framework of motivation theory. By its extension, sex research might benefit from the study of general principles of motivation and the control of behavior.
4. Suggestions regarding evolutionary function have been a guide in the investigation of the motivational processes underlying aspects of sexual behavior and cognition—for example, sex differences (Symons, 1979), arousal (Spiering & Everaerd, 2007), fantasy (Ellis & Symons, 1990), inhibition (Bjorklund & Kipp, 1996), and rape (Thornhill & Palmer, 2000). However, there has been little corresponding input to evolutionary psychology arising from a causal (proximate) perspective on motivation. I aim to offer such insights.

Figure 1 involves a single route from the stimulus input, through motivational processes, and out to autonomic and behavioral reactions. However, accumulating evidence shows the situation to be more complex. For example, there is parallel processing of sexual information (Janssen, Everaerd, Spiering, & Janssen, 2000). In humans, some processing is done with full access to conscious awareness (controlled processing), whereas some is performed unconsciously (automatic processing; Janssen et al., 2000; Spiering & Everaerd, 2007). There can be considerable dissociation between genital reactions and subjective sexual arousal (Laan, Everaerd, van der Velde, & Geer, 1995).

As important as incentives are, humans are not simply passive until triggered by external incentives. Not captured in Figure 1 is that humans exhibit highly complex cognition involving conscious awareness, goals, and intentions (G. A. Miller, Galanter, & Pribram, 1960; Ramanathan & Menon, 2006). For example, sexual desire can, of course, be triggered within the imagination. Also, the model shows a single type of inhibition, whereas there is evidence that different forms of inhibition can act at more than one level (Bancroft, 1999; Bancroft & Janssen, 2001). When the same term is used for some very different forms of inhibition, there is the potential for great confusion (Geer, 2007); I hope that I can clarify the issue.

One way of assimilating these observations into a theory of sexual motivation, arousal, and behavior is to apply a hierarchical model in which stimuli and cognitions interact in determining behavior. Such hierarchical principles have yet to be applied to sexual behavior and an extension of the incentive motivation model is a means to do so.

Incentive motivation theory was originally developed on the basis that more than one motivation can relate to the attraction of a given incentive (Bindra, 1978). However, within the study of the incentive motivation of sex, this consideration has so far not been taken into account. For example, the links between attachment and sexual motivations have been recognized (Diamond, 2003), and animal models of this have been proposed (Young & Wang, 2004). Such interactions provide powerful inputs to sexual motivation, and suggestions are made as to how they can be fitted to incentive motivation theory.

First, I consider the bases of the original incentive motivation model and then suggest several additions that allow it to be applied to a wider range of phenomena.

The Basic Incentive-Motivation Model

In the case of sexual motivation, the incentive process interacts with a parameter termed *arousal.* In this section, I consider the nature of the interaction between these two processes.

The Principle of Incentive Motivation

Arising within biological psychology, the central idea of incentive motivation theory is as follows. The strength of motivations, such as those toward sex, food, or water, depend on the strength of stimuli (e.g., food or a mate) impinging on a nervous system that is sensitized by such physiological states as hormone levels and nutrient deficits (Berridge, 2001; Bindra, 1978; Bolles, 1972; Toates, 1986). This idea is compatible with a range of theoretical formulations and empirical data within biological, social, and developmental psychology: The physical presence of an incentive strongly increases the level of motivation directed to that incentive, an "immediacy effect" (Baumeister & Vohs, 2003; Hardy, 1964; Metcalfe & Mischel, 1999; Mischel, 1974; Steinberg, 2004). It fits a number of conceptualizations of sexual motivation (Byrne, 1983; Hardy, 1964). Hence, the model differs from that of Fisher (1998) in which distinct sex drive and attraction systems are involved. Similarly, in arguing against intrinsic drives, Both et al. (2007) suggested that "sexual motivation does not emerge through a deficit signalled by the hypothalamus but through the attractiveness of possible rewards in the environment" (p. 329).

The Link with Sexual Arousal

The term *sexual arousal* is used here to refer to the activity within a particular circuit of neurons, which is functionally tied to both sexual motivation and controlling the state of the genitals. This circuit links processes of sexual motivation within the central nervous system (CNS) to autonomic processes of blood vessel dilation and constriction at the genitals. The circuit also underlies orgasm. Although changes at the genitals depend on sexual arousal, there is not necessarily a simple one-to-one link. In principle, there could be central arousal but with a blockage of small arteries at the genitals or, conversely, there could be local vasodilation in the absence of arousal. It is assumed that sexual arousal can enter a positive feedback process, with changes at the genitals affecting the state of arousal.

The exact contribution, in terms of the relative weight of sympathetic and parasympathetic branches, remains controversial; but, by definition, the autonomic nervous system (ANS) is assumed to form the basis of genital arousal (Meston & Bradford, 2007). Although some general changes in sympathetic activity can affect sexual arousal, an assumption of a uniform change in sympathetic activity accompanying arousal would be simplistic. For example, it appears that decreased sympathetic tone at the penis is accompanied by increased sympathetic tone elsewhere, such as to shift blood to the penis (McKenna, 2007).

In the model of Figure 1, incentives and genital arousal act reciprocally in a dynamic relation (links 5 and 6): Arousal can be triggered by incentives and the motivational value of incentives can be increased by arousal. Such interdependence forms an integral part of a number of models of sexual motivation and behavior. For example, in response to Kaplan's triphasic model, Meston (2000) noted: "Yet in actual clinical practice, sexual desire, arousal and orgasm difficulties coexist more often than not. For example, hypoactive sexual desire disorder frequently occurs secondary to other sexual disorders such as arousal disorder, anorgasmia, or dyspareunia (sexual pain)" (p. 8). Meston posited a feedback effect such that incentive value and arousal depend on the individual's past history of sexual experiences.

Dichotomies of desire and arousal that describe which factor comes first might be misleading (cf. Pfaus, 2007b). It appears that sometimes desire can be high, associated with urges and fantasies, and yet arousal, as measured by penile tumescence can be low (Barlow & Durand, 1995). Laan and Everaerd (1995) wrote: "We conclude that functional women do not tend to use feedback from genital arousal in order to assess their subjective feelings of sexual arousal. Rather, external information is used to label an internal event" (p. 65). This analysis suggests the possibility that internal arousal acts as a modulator of the efficacy with which external information and cognitive interpretations are linked to subjective sexual arousal (i.e., a multiplicative relation exists).

Arousal that is specifically sexual interacts with arousal of a more general kind. Depending on how the arousal is interpreted centrally, even that arising from, say, anxiety can sometimes contribute to sexual arousal (Bancroft, 1999). When it is made artificially high, false feedback on heart rate can increase the attraction rating of an incentive (Valins, 1970), a situation indicating the role of cognitive interpretation.

It is logical to assume that the link between incentive value and arousal has a developmental and learning history, to which I now turn.

Developmental Factors

It is commonly assumed that "incentive value" is acquired, at least in part, by experience: Arousal plays a role in *labeling* incentive value (Bem, 1996; Money,

1986; Pfaus, 2007a; Storms, 1981). Exposure to *particular* potential sexual incentives in early life accompanied by general arousal (e.g., from nonsexual sources) is thought to attribute actual incentive value to them. Evidence on boys aged 11 to 12 years points to arousal from nonsexual sources triggering erection (Ramsey, 1943), a response that could set the conditions for a link with incentives. It has been suggested that genes have the influence of setting certain tendencies on which arousal further acts to consolidate sexual orientation. A similar idea is that exposure to a potential incentive or a media representation is followed by rehearsal of the imagery in fantasy accompanied by arousal, which reinforces its actual incentive value (Hardy, 1964; Storms, 1981; Wincze, 2000). Any actual sexual experience with the incentive might further consolidate the strength (Hardy, 1964).

For some individuals, such labelling might never occur, in which case the person would not come to experience sexual desire. Under other conditions, labelling might occur in conjunction with deviant stimuli and lead to a paraphilia (Geer, Lapour, & Jackson, 1993).

Laws and Marshall (1990) suggested that humans are *prepared* to form particular associations between stimuli and sexual arousal, most obviously corresponding to a heterosexual partner. Other associations, such as pedophiliac arousal, represent a less probable location on a continuum of possibilities. Laws and Marshall described the process of forming sexual associations as one that is "primitive" (not cognitive) and one that cannot be modified in the light of new information. In hierarchical terms (described shortly), this would correspond to a low level of organization. Baumeister (2000) argued that, in such an imprinting-like process, males are relatively flexible regarding the preferred sexual incentive when young but inflexible when adult, whereas females retain greater flexibility throughout life.

Once the initial pattern is set, a rich variety of conditional stimuli arising both outside the individual and in the imagination can then come to form triggers to arousal. Masturbation can powerfully act to consolidate particular courses of desire (Barlow & Durand, 1995; Laws & Marshall, 1990).

Strengthening and Maintaining Incentive Value

Incentive value appears to be consolidated and maintained in part via the *consequences* of interaction with the incentive, particularly if these involve orgasm (Depue & Morrone-Strupinsky, 2005; Laws & Marshall, 1990; Pfaus et al., 2001). "Interaction" is meant both in reality and in the imagination. For people in a negative mood, an even temporary lifting of mood in association with sexual interaction is likely to increase the value of the incentive. Strengthening of the power of the incentive arises not only from orgasm *per se* but also from such associated factors as lowering the level of anxiety or depression (Bancroft, 2007; Janssen & Bancroft, 2007). It is possible that negative mood could act as a contextual factor to increase the salience of sexual incentives (Bancroft, 2000).

If punishment (e.g., a gesture of disapproval) follows arousal to a particular sexual stimulus, its incentive value can sometimes decline (Laws & Marshall, 1990). Laws and Marshall saw this occurrence as one possible basis of sexual deviancy: "Becoming sexually aroused to unpunished deviant acts... while being punished for appropriate behaviors will lead to an increased tendency to act deviantly and a reduced tendency to act appropriately" (p. 217).

So much for the principles of incentive motivation and arousal seen somewhat in isolation; it is now necessary to view these within the context of the hierarchical organization of the controls of behavior.

Hierarchical Organization of Behavior

Basic Principles

Across species, evidence suggests that the controls of emotion (Bonanno, 2001; Rolls, 2004, 2005), motivation (Berridge, 2001), and action (Dehaene & Naccache, 2001; Gray & McNaughton, 2000; Hughlings Jackson, as cited in Taylor, 1958; G. A. Miller et al., 1960; Toates, 1995, 1998, 2006) are organized hierarchically. Evolutionarily newer ("high-level") structures coexist and share control with evolutionarily older ("low-level") structures. Corresponding to this structure, emotion (Bonanno, 2001; Ochsner & Barrett, 2001), motivation (Berridge, 2001), and behavior are controlled by a combination of (external) stimuli and (internal) cognitive events (Carver, 2005; Metcalfe & Mischel, 1999; Strack & Deutsch, 2004). These triggers sometimes act in the same direction ("cooperatively") but at other times pull in opposite directions (Berridge, 2001; Toates, 1995, 1998, 2005, 2006). A model of how this dual control can be realized within a hierarchical structure has been proposed (Toates, 1995, 1998, 2006).

The hierarchical model is based on the assumption that behavior arises from a complex interaction between direct (as in Figure 1) and indirect controls. The direct control is excited by the basic perceptual analysis of the *physically present stimuli.* In humans, the indirect control is based on refined cognitions ("representations") held in memory (e.g., the meaning attached to the potential interaction) and is associated with common-sense notions of conscious intentions, for example, in the sexual domain of the kind "I intend to pursue this sexual goal because of the consequences that I expect to follow from it." Motivation depends on a combination of such stimulus-based ("online") and cognition-based ("offline") information.

Looking broadly at brain and behavior, evidence suggests that the relative weighting given to online and offline controls varies with a number of factors:

1. *Learning*: With repetition, behavior tends to become more online ("habit-like"; G. A. Miller et al., 1960; Zuckerman & Kuhlman, 2000).
2. *Age*: In general, development consists of the emergence of a greater role for cognition (Metcalfe & Mischel, 1999), sometimes expressed as increasing voluntary control relative to "reactive" determination of behavior (Derryberry & Rothbart, 1997).
3. *Phylogeny*: Relative to other species, humans have a particularly large capacity to use offline controls (McClure, Laibson, Loewenstein, & Cohen, 2004).
4. *Brain damage*: Damage to a specific brain region can be associated with disruption to either direct or indirect controls (McDonald & White, 1993). For example, damage to the prefrontal cortex has a particularly disruptive effect on offline controls, whereas damage to the dorsal striatum disrupts online controls.
5. *Chemicals*: Various chemical manipulations change the weighting. For example, alcohol tends to induce alcohol myopia, the result of which is that immediately present stimuli assume more weight than representations of remote factors (Baumeister & Vohs, 2003; Steele & Josephs, 1990). In some circumstances, testosterone can lower the weight of offline controls relative to online (van Honk & Schutter, 2007).
6. *Emotion and stress*: These tend to decrease the weight of offline controls relative to online (Arnsten, 1998; Mischel, Ayduk, & Mendoza-Denton, 2003).
7. *Gender*: In the domain of sexual motivation (reviewed later), evidence suggests a greater weight of offline controls in women as compared to men.

Consideration of such a hierarchical structure provides insight into some of the more peculiarly (offline) human features of motivation and how they interact with the more general lower (online) layers of control. As such, the model permits cross-fertilization with some powerful theoretical models advanced in recent years in the psychology literature (Baumeister & Vohs, 2003; Carver & Scheier, 1990; Metcalfe & Mischel, 1999; Ramanathan & Menon, 2006).

It is possible to fit such ideas to current theories on the nature of conscious and unconscious processing of information (Baars, 1988; Dehaene & Naccache, 2001; Toates, 2006). Intentional action is said to be associated with conscious processing as organized by a workspace within the brain. Conscious states are based on coherent activity between various brain regions. Linking this to ideas of incentive motivation, one might suggest that as the strength of the incentive increases, so its ability to lock into such coherent circuits of brain activity and form the goal of intentional action also increases.

According to a variety of experimental evidence, we do not necessarily have conscious access to all the determinants of our behavior, even at the high level of intentions (Berridge, 2001; Fitzsimons & Bargh, 2003; Nisbett & Wilson, 1977; Robinson & Berridge, 1993). For example, a person might find himself pursuing a particular route home that is associated with a drug or sexual incentive, but without being consciously aware of having made such a choice of route.

Application to Human Sexuality

Several features of human sexuality are entirely congruent with the idea of layered and hierarchical organization, as described next. Behavior is determined by a combination of excitatory and inhibitory processes (Bancroft, 1999; Bancroft & Janssen, 2001); it is argued that these act at various levels. Cognitive processes, involving *representations* of (a) incentive stimuli and (b) consequences of interaction with them, can offer either excitation or inhibition of behavior depending on the quality of the representation and the circumstances in which the person finds him- or herself. The top level of the hierarchy corresponds to abstract (often long-term) goals, such as to maintain moral purity or an idealized self-image (Carver & Scheier, 1990) or to seek to become a sexually fulfilled person. Behavior that brings reality closer to the goal is associated with positive affect, whereas increased disparity between goal and reality triggers negative affect (Carver & Scheier, 1990).

Some examples of the relevance to human sexuality of hierarchical organization and the contributions to change of weight are given in the following sections, after excitation and inhibition have been related to the hierarchical structures.

Excitation within a Hierarchical Organization

In this section, I examine the evidence that—at least in humans—the sources of excitation of sexual arousal and motivation can arise at more than one level. Table 1 shows two layers of contribution to sexual excitation, and Figure 2 shows the basic incentive motivation "design" embedded within a hierarchical structure.

Triggering by Incentives

It appears that, across a range of species, sexual arousal and motivation are triggered (online) by the

Table 1. *Two Levels of Excitation*

Level in Hierarchy	Terminology	Properties and Bases
Online (stimulus triggered)	$E_{incentive}$	Based on stimulus properties and memories of these. Can engage conscious processing, but some stimuli might not reach conscious awareness (links from sensory stimuli to subcortical structures and temporal cortex). Arousal and motivation triggered directly by early processing of sexual information.
Offline (cognitive and intentional)	$E_{cognitive}$	Involves complex representations and meanings held in memory; conscious awareness is central. Holding sexual images in focus in absence of corresponding stimuli. Use of working memory (prefrontal cortex in conjunction with temporal cortex); subject to rapid revision in the light of experience. Arousal and motivation triggered by late stages of cognitive processing.

detection of an attractive conspecific and stimuli associated with one ($E_{incentive}$; Both et al., 2007; see link 1a in Figure 2). The conspecific provides a target for the direction of behavior, controlled by motivation. Whether an incentive triggers motivation depends on the sensitivity of internal processes (e.g., appropriate hormonal sensitization), novelty or familiarity, and an array of individual learned (e.g., cultural) factors.

Stimuli to sexual arousal engage both automatic and controlled processing (Janssen et al., 2000). In terms of the hierarchical model, some stimuli trigger sexual arousal by rapid online (automatic) processing (link 1c in Figure 2) followed by slower offline (controlled) processing (link 1b). By means of memories triggered ("erotic-related"), controlled processing can strengthen arousal tendencies arising online (link 2; plus sign). Conversely, an automatic tendency to arousal might be countered by the result of controlled processing when the memories that are revived are incompatible with sexual arousal, link 2 with minus sign (e.g. worry-related).

Determinants of behavior can sometimes engage conscious processing but at other times engage only unconscious processing (Baars, 1988). The triggers to sexual desire and arousal fit this dual pattern (Janssen et al., 2000; Spiering & Everaerd, 2007). There is a rapid automatic, unconscious response to sexual stimuli, but

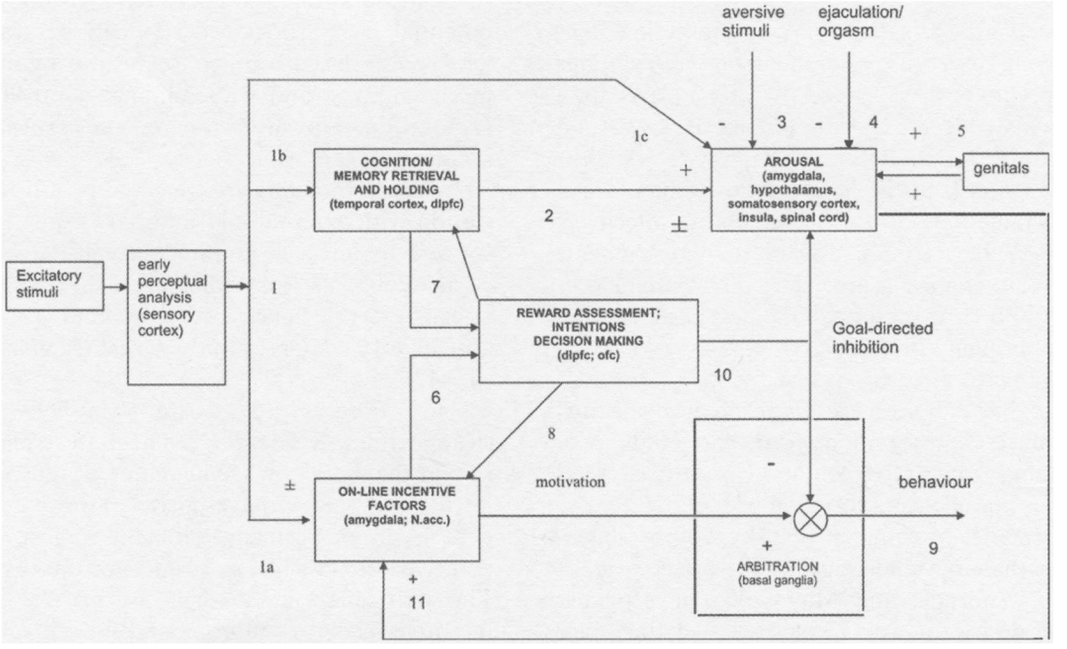

Figure 2. Enlarged model. *Note.* Excitatory stimuli impinge on the nervous system and early perceptual analysis yields detection of sexual stimuli (1). This information is transmitted three ways: (1a) to ONLINE INCENTIVE FACTORS (1b) to COGNITION, whereby associations and meanings are accessed, and (1c) to AROUSAL. There is also a cognitive input to arousal (2), whereby arousal can be enhanced (+) or inhibited (–)—for example, fear of performance failure and the subjective aspect of arousal is computed. (For simplicity, objective and subjective aspects of arousal are not distinguished in the diagram). Aversive stimuli can lower arousal (3), as can ejaculation or orgasm (4). Arousal determines the state of the genitals (5), and this feeds back on arousal. REWARD ASSESSMENT is influenced by online processing (6), as well as cognition (7). Decision making affects the sensitivity of online processing (8). Motivation enters an arbitration box, the outcome of which decides whether it is translated into behavior (9). Goal-directed inhibition can be exerted on both the arbitration process (10) and also on arousal. Arousal is shown to affect motivation (11). For simplicity, not shown is that the decision-making process is influenced by feedback from the genitals, and sexual behavior will change the nature of the excitatory stimulus. N.acc. = nucleus accumbens; dlpfc = dorsolateral prefrontal cortex; ofc = orbitofrontal cortex.

subjective sexual arousal depends on a slower and conscious appraisal of arousal (Spiering, Everaerd, & Janssen, 2003).

Although our principal focus is on positive incentives, of course, a given conspecific that is positive for one individual can be negative (something to be avoided sexually) for another (Barlow, 1986; Byrne, 1983; Hardy, 1964). In some individuals, even a brief touch can trigger fear, panic, or disgust (Barlow & Durand, 1995). Ambivalence can also be found, with switches between approach and avoidance, according to circumstances (Hardy, 1964). Thus, in incentive terms and comparing either between individuals or within an individual over time, the same stimulus information can obtain dominant modulation from either approach or avoidance (Brown & Brown, 2005). Hence, there are plus and minus signs associated with 1a.

The incentive-based process shown in Figures 1 and 2 is an important factor in both rat and human sexuality and presumably for a range of vertebrate species. However, at least in the case of humans, sexual desire is aroused not only by the presence of external stimuli but also by representations in memory, to which the discussion now turns.

Triggering by Representations

Basic principles. Clearly, conscious reflection, fantasy, and craving reflect the use of internal representations of desired incentives as a source of (offline) excitation (Ramanathan & Menon, 2006), termed $E_{cognitive}$ and represented by COGNITION and REWARD ASSESSMENT in Figure 2. In the here-and-now, humans can run mental simulations of anticipated future affectively loaded events ("prospection"), apparently by using some of the same brain regions as are engaged by actual incentive contact (Gilbert & Wilson, 2007). Sexual motivation is aroused by bringing these desired representations into conscious awareness at such times as the internal state is sensitized (e.g., by sex hormones). In the absence of actual incentive contact, representations form part of the goal structure leading to incentive contact; gaps in space and time can thereby be filled as a coordinated part of incentive approach (Depue & Morrone-Strupinsky, 2005; Klinger, 1971; Ramanathan & Menon, 2006).

Kavanagh, Andrade, and May (2005) investigated primarily the desire for drugs but suggested that their analysis is equally applicable to any desire. They defined desire as "an affectively charged cognitive event in which an object or activity that is associated with pleasure or relief of discomfort is in focal attention. In humans it can be referred to as a conscious wish or urge to gain pleasure" (p. 447).

In relation to its adaptive significance, Kavanagh et al. (2005) suggested that desire-related imagery would "therefore assist in selection of behavioral alternatives and in preference of outcomes. Approaches to the target would both increase image vividness and increase the potency of associated affective responses" (p. 449).

Kavanagh et al. (2005) made the assumption that "initial thoughts about the consummatory target generate some of the same neurochemical processes and physiological sensations that are related to ingestion of the target substance or engagement in the target activity (albeit in a weakened or partial form)" (p. 456). In support of this assumption, they cited an array of imaging studies in which activation of the brain by imagining something has similarities to triggering by encountering the object.

Concerning desire-related imagery, Kavanagh et al. (2005) distinguished between (a) automatic *intrusive thoughts* and (b) a controlled process termed *cognitive elaboration*. Cognitive elaboration involves executive control and consists of holding the desire-related information in working memory while it is manipulated and its significance assessed in terms of related information. For example, the intrusive image of smoking a cigarette might trigger thoughts about where to obtain cigarettes and a process of scanning the environment for cigarette-related cues. Kavanagh et al. noted that desires are conscious (although based on extensive prior unconscious processing), exhibit the qualities of intensity and duration, and can have a strong motivational potential. A particular desire can be transitory and fleeting, displaced from consciousness by other competing cognitions, and with minimal controlled cognitive elaboration. However, intense and protracted desires ("craving") can occur.

Intrusive thoughts are triggered by a process of association with external and internal events. Five types of triggers to intrusive thoughts are listed by Kavanagh et al. (2005) as "physiological deficit states, negative affect, external cues, other cognitive activity, and anticipatory responses to the target (such as salivation)" (p. 447).

The triggers to desire can be unconscious (Ramanathan & Menon, 2006). Affect plays a central role in the model of Kavanagh et al. (2005). The initial intrusion is said to have positive affective value, which persists if engagement with the object of desire is perceived as possible, safe, and not-too-distant in time. The individual might then ascend the sequence of incentive-related cognitions and movements. However, *negative affect* is a generic term applicable equally to any desire.

Negative affect tends to prime intrusive desire imagery through the memory that it offers the potential (real or imagined) to take corrective action to counter the negative affect. In sex offenders, negative affect increases the frequency of intrusions of deviant sexual fantasies and increases the risk of re-offending (Cortoni & Marshall, 2001).

Determinants of sexual thoughts. To adapt the model of Kavanagh et al. (2005) to the case of sex, there is no obvious associated physiological deficit or displacement. However, sex hormones appear to serve in a similar way by increasing the probability that sex-related desire imagery will be triggered. The trigger factor, "anticipatory responses to the target," would appear to correspond rather well to genital reactions, which can be triggered initially, unconsciously, by a sexual stimulus, and only *sometimes* are associated with desire. External cues would consist of such things as perfume or a location associated in the past with sexual stimuli. A particular type of sexual thought is termed *fantasy*.

Fantasy. Sexual fantasy represents the conscious elaboration of desire based on memories and synthesis of new imagery. It can stimulate arousal, as manifest in genital reactions. Fantasy should not be seen as an abnormality or reaction to the lack of a sexual outlet. Rather, contemporary theorists suggest that *not* to have fantasy is a sign of something being wrong, indicative of "inhibited sexual desire" (Leitenberg & Henning, 1995). One index of hypoactive sexual desire disorder (HSDD) is "recurrently deficient (or absent) sexual fantasies and desire for sexual activity" (as cited in Basson, 2000, p. 55). Sex therapists encourage nonorgasmic women to employ fantasy during masturbation and intercourse.

Those who show the highest sexual activity and the fewest problems experience the most sexual fantasies (Leitenberg & Henning, 1995). In other words, a high desire ("high sensitivity of incentive motivational circuitry") is also reflected in an active fantasy life (Gosselin & Wilson, 1980). Testosterone affects not only behavior, but the frequency of sexual thoughts and fantasy (Leitenberg & Henning, 1995; Regan & Berscheid, 1999).

Fantasy tends to be more common and more explicit in men than in women (Ellis & Symons, 1990). This could be interpreted in terms of the greater adaptive value of being highly sensitized to detect and to elaborate a range of erotic stimuli in males (Leitenberg & Henning, 1995).

Combined Sources of Excitatory Motivation

Incentives and cognitive representations of them interact dynamically in the control of behavior (links 6 and 8 in Figure 2; Ramanathan & Menon, 2006). Drawing closer to that which is desired would be associated at some stage with a shift from pure imagination to direct sensory stimulation. Of course, the presence of an incentive can be the trigger for further imagination-based desire.

So much for the basics of the excitatory component. I next consider the inhibitory component, before looking more closely at their combined control of motivation and behavior.

Inhibition within a Hierarchical Organization

For inhibition, as for excitation, a closer scrutiny reveals the inadequacy of a *single* level. In this section, I suggest that there are at least three different levels at which inhibition can be exerted on sexual arousal and behavior (see Table 2). In reality, there are doubtless conditions in which these levels are strongly interactive.

Goal-Directed Inhibition

The term *goal-directed inhibition* is used to refer to that which underlies restraint on sexual behavior, in some cases consisting of active withdrawal from sexual contact (link 10 in Figure 2). It refers to actions as mediated by the skeletal muscles. Such inhibition is perhaps most familiar in terms of a conscious and rational calculation that, in a particular situation, an alternative behavior is more desirable and so the term *active* could be applied to such inhibition. However, goal-direction is also strongly influenced by unconscious factors (Fitzsimons & Bargh, 2003). Goal-directed inhibition permits an alternative course of goal-direction (e.g., moving away from the incentive), often amounting to "resisting temptation" (Norman & Shallice, 1986). Sexual desire and arousal might be high but sexual approach is resisted. This level of inhibition appears to be similar to what is termed "inhibition due to threat of performance consequences" used by Janssen, Vorst, Finn, and Bancroft (2002; see Table 2).

In addition to overt reactions, there can be some inhibition of sexual arousal (link 10). This is assumed to arise from "self-distraction or a shift of attention" (Barlow, 1986, p. 142), alternatively expressed as "emotional self-regulation" (Beauregard, Lévesque, & Bourgouin, 2001; Ochsner & Barrett, 2001). It can derive from high-level conscious cognition described by such terms as *rationalization* and *reappraisal*. Under natural circumstances, this might reflect a by-product of switching to an incompatible course of behavioral action and it might be expected to assist the behavioral decision of restraint.

Bjorklund and Kipp (1996) appeared to be describing this level of inhibition, and suggested: "cognitive inhibition mechanisms evolved from a necessity to control social and emotional responses in small groups of hominids for the purpose of cooperation, group cohesion, and individual political success" (p. 163).

Aversion-Related Inhibition

The term *aversion-related inhibition* refers to that which is activated when there is the goal-directed intention and the wish to engage in sexual behavior, but sexual arousal is reduced by the simultaneous presence of an aversive signal (see Table 2). Unlike goal-directed

Table 2. *Three Levels of Inhibition*

Type of Inhibition	Trigger	Effect	Specificity to Sex	Properties and Biological Basis
Goal-directed ($I_{goal\text{-}directed}$) rational and pragmatic	Cognitions; might be rational ("relatively cool") calculation of cost attached to sexual behavior or might be influenced by fear or guilt	Lower (sexual) approach tendency; sexual motivation present but its expression in behavior is blocked; can be some lowering of arousal by conscious strategy (Beauregard, Lévesque, & Bourgouin, 2001)	Low (Depue & Collins, 1999)	CNS. Associated with a conscious intention (prefrontal cortex-striatum links and prefrontal-amygdala links)
Aversion-related ($I_{aversive}$)	(1) External stimuli (e.g., associated with fear or disgust); general behavioral inhibition system (Bancroft, 1999; Gray & McNaughton, 2000); (2) intrinsically triggered, cognitively based aversion (e.g., guilt) or anticipated performance failure	Lower sexual arousal or motivation	Appears to exhibit features that are both specific (Janssen & Bancroft, 2007) and general (Depue & Collins, 1999).	CNS. Amygdala as influenced by both direct (sensory) and indirect (cortical signals)
Ejaculation- or orgasm-related	Internal events (ejaculation or orgasm)	Lower genital blood flow with consequent lowering of motivation	High	ANS; role of CNS opioids and serotonin (Fernández-Guasti & Rodríguez-Manzo, 2003); Centrally mediated via α-2 adrenoreceptors (Bancroft, 1999); a role for prolactin (Krüger, Haake, Hartmann, Schedlowski, & Exton, 2002)

Note. CNS = central nervous system; ANS = autonomic nervous system.

inhibition, aversion-related inhibition runs quite counter to the person's goal (i.e., to continue sexual activity) and can be described as *passive*. The source of the aversion could be external (i.e., stimulus-based; e.g., a disturbing noise; link 3, Figure 2) or internal (i.e., based on an interpretation of the situation; e.g., fear of performance failure or presence of guilt; link 2). It might or might not engage conscious processing. This level of inhibition appears to incorporate what is termed by Janssen et al. (2002) "inhibition due to threat of performance failure."

This theoretical position is entirely congruent with the investigation of child development. For example, Kochanska and Knaack (2003) distinguished between the inhibition associated with effortful control (termed *active* and here described as *goal-directed*) and meaning "the ability to suppress a dominant response to perform a subdominant response" (p. 1088) and that associated with fear (termed *passive*). Nigg (2000) suggested a neural embodiment of different layers of inhibition: a (bottom-up) reactive inhibition system, associated with anxiety and based in limbic structures; and a (intentional) goal-directed system, based in the frontal cortex.

Ejaculation- and Orgasm-Related Inhibition

Ejaculation- or orgasm-related inhibition refers to inhibition that is triggered by orgasm or ejaculation (link 4; Figure 2 and Table 2). It appears that a cocktail of different neurochemicals, such as opioids, serotonin, and noradrenalin, is involved in such inhibition or "satiation" (Fernández-Guasti & Rodríguez-Manzo, 2003). Another possible candidate, acting both locally at the genitals and centrally in the CNS, is prolactin (Krüger, Haake, Hartmann, Schedlowski, & Exton, 2002).

Comparing Levels of Inhibition

Some of the properties of these three processes are summarized in Table 2. Bjorklund and Kipp (1996) and Bancroft (1999) raised the issue of whether inhibition is "domain-specific" or "domain-general." As Bancroft (1999) noted, inhibition that is reflected in the post-ejaculation refractory period is domain-specific. At another level, inhibition arising from, say, fear (part of Gray & McNaughton's, 2000, "behavioral inhibition system") might be domain general to any appetitive system or specific to sex. However, goal-directed inhibition (e.g., following a calculation of potential cost) would appear to recruit a domain-general process. Evidence suggestive of this is that high risk-taking (low-intentional inhibition) tends to generalize across various activities such as risky sex and drug-taking (Zuckerman & Kuhlman, 2000).

A given behavior might be influenced simultaneously by more than one such level of inhibition. For example,

a goal-directed decision to resist temptation might in part be influenced by fear triggered within the situation.

The Combined Effect of Excitation and Inhibition

Basics

Motivation, arousal, and behavior would normally exhibit a balance between excitatory and inhibitory processes, just described. Table 3 gives some examples of various possible combinations of excitation and inhibition. Ejaculation- and orgasm-related inhibition might be expected to be exerted throughout.

An obvious feature of human sexual motivation is the common presence of an element of conflict. Wants are often unfulfilled due to partner resistance, anticipated risks, social and moral conventions, and legal sanctions. I believe that such conflict can be better understood in terms of competition between layers within a hierarchy. In such terms, the (stimulus-based) incentive factor represents only one such layer. Having presented the basics of the combined excitatory–inhibitory hierarchical model and its relevance to human sexuality, it is useful to see possible links with related theoretical perspectives, to develop a more integrative picture.

Link with Other Theoretical Perspectives

Baumeister, Heatherton, and Tice (1994) described self-regulation as a process of "overriding" that "prevents this normal or natural response from occurring and substitutes another response (or lack of response) in its place" (p. 7). Baumeister et al. suggested that the higher levels involve longer time spans, are more abstract, and are associated with more distal goals. Stress tends to disrupt such self-regulation. This model is entirely in keeping with this. Baumeister et al. wrote, "The more one thinks about the immediate pleasure, the harder it becomes to resist it in favor of the delayed reward. By extension, an important cause of self-regulation failure is the salient presence of the immediate temptation" (p. 69).

The theoretical approach advanced here is also congruent with the notion of "hot" and "cool" systems (Metcalfe & Mischel, 1999). In this, immediately available trigger stimuli are described as hot and restraint is offered by a cool system.

These perspectives allow some integration between the principles of hierarchical control and those of incentive motivation, to which I now turn.

Table 3. *Some Possible Combinations of Excitation and Inhibition*

Combination	Exemplified by
$E_{incentive}$ plus $E_{cognitive}$	Conflict-free sexual behavior (e.g., happy monogamous relationship with strong physical attraction or multiple-partner strategy that is free of care, concern, and guilt)
$E_{incentive}$ plus $I_{aversive}$	Triggers to sexual desire and arousal present but combined with aversive stimulus (e.g., fear triggered by physically present stimuli or performance demands)
$E_{incentive}$ plus $I_{goal\text{-}directed}$	Sexual desire and arousal combined with cognitive projection of either (a) future aversive state (e.g., possibility of disease or being discovered engaging in an illegal or immoral behavior) or guilt about sexual immorality or (b) desirability of waiting until later (deferred gratification; Carver, 2005)
Relatively small $E_{incentive}$ with large value of $E_{cognitive}$	Sexuality aroused by intentional and contextual desires (e.g., affection) in absence of powerful immediate sexual trigger stimuli (e.g., wish simply to please another person)
Low or negative values of $E_{incentive}$ and $E_{cognitive}$	Aversive or indifferent value of stimulus. Sexual behavior engaged in under coercion, duty (Stuart, Hammond, & Pett, 1987) or distasteful commercial transaction.

Integration with the Incentive Model

Experimentation and theory point to the relevance of incentive considerations in understanding conflict. In tipping the scales toward giving in to temptation and engaging in a behavior, small amounts of drugs or food are very effective (Loewenstein, Nagin, & Paternoster, 1997; Metcalfe & Mischel, 1999; Mischel, 1974). By extrapolation, one might similarly understand how exposure to an attractive incentive or pornographic image could comparably tip the scales.

In the presence of an attractive partner, approach can be based partly on incentive properties, but what constitutes avoidance? The potential partner might simultaneously trigger fear by virtue of certain intrinsic properties or conditional stimuli (in terms of Table 3, $E_{incentive}$ plus $I_{aversive}$). However, the avoidance component might arise purely from a calculation of a hypothetical future cost, for example, pregnancy, disease, legal sanction, or loss of an established partner through infidelity. Unconscious factors might be expected to play a role in influencing such a decision (Fitzsimons & Bargh, 2003). These are offline cognitive estimations, and so this situation would pit offline against online controls ($E_{incentive}$ plus $I_{goal\text{-}directed}$).

The avoidance part, of course, might be the result of refusal or request for delay by one's potential partner. Sex is a good example of conflict triggered in this way (cf. Mischel et al., 2003).

What happens to the relative weight of approach and avoidance signals as a person gets nearer to the incentive? Traditionally, based on rats approaching shock-related goal-boxes, the approach–avoidance model suggested that avoidance increases at a greater slope than approach as the goal is neared (Klinger, 1971; N. E. Miller, 1959). However, for humans

approaching alcohol or drugs, the approach gradient appears to increase more sharply than that of avoidance (Astin, 1962; Heilizer, 1964). This difference occurs because the gain of reward on reaching the goal is immediate, as opposed to the delay of aversion, as with hangover or withdrawal. In high sensation-seekers, the approach gradient is relatively steep and the avoidance gradient relatively shallow (Zuckerman & Kuhlman, 2000).

In the case of sex, this model suggests an increase in appetitive strength as distance is reduced, and when sensory processing is triggered by the presence of the primary incentive and conditional stimuli. Ditto, Pizarro, Epstein, Jacobson, and MacDonald (2006) suggested that, under these conditions, stimulus control can come to dominate with "little conscious mediation or sense of having 'decided' to act" (p. 110). These authors coined the term "motivational myopia" induced by stimulus properties as an analogy to "alcohol myopia."

The nature of control described so far in this section clearly relates to risk-taking and health, to which I now turn.

Health Implications

Avoidance, if any arises, is often likely to be based on hypothesized future scenarios. Because it could be that there are few, if any, obvious physically present cues to trigger it, avoidance might not increase with reduced distance. The strength of avoidance triggered by, say, fear of disease might be relatively flat as a function of distance, because this is a hypothetical aversive stimulus. Indeed, the arousal triggered by the physical properties of an attractive partner might even change the weight of control such as to allay fears concerning disease (Blanton & Gerrard, 1997).

Impulsive and high-risk behavior involving drugs or sex was found to be positively linked to the participants' tendency to discount the future (Robbins & Bryan, 2004). To counter disease, the need for "present orientated" messages was mentioned. Similarly, MacDonald, Zanna, and Fong (1996) obtained evidence that alcohol acts together with sexual arousal to bias against safe sex, and they suggest placing HIV warnings at locations where sexual decision making is likely to occur, such as in bars. In conflict, alcohol tends to tip the balance in favor of sexual engagement (Hull & Slone, 2004)—that is, to decrease the weight of offline control relative to online. The effect can be manifest as increased indiscriminate and unsafe sex, as well as increased tendencies to sexual violence.

The combination of negative mood and high arousal is particularly associated with taking high-risk decisions (Leith & Baumeister, 1996). Sexual arousal increases a male's estimate of his likelihood of engaging in sexually risky behavior and even unethical behavior aimed at achieving sexual goals (Ariely & Loewenstein, 2006). This suggests the value of the advice that decisions should be taken not in the "heat of the moment" but prior to becoming sexually aroused.

So much for the adult system. It is now appropriate to consider how this system develops and the implications of this process.

A Developmental Factor

Evidence suggests that the weight of restraint arising from the high level in the hierarchy increases with age. However, there is not a simple relation. Some characterize adolescence as a time of increased risk-taking, involving, for instance, drugs, sex, and fast driving (Steinberg, 2004). At adolescence, the weight of the dopaminergic appetitive system is relatively high compared to those neural processes that offer restraint on behavior (Ernst, Pine, & Hardin, 2005). Increasing years bring maturation of the prefrontal cortex and tend to increase restraint, thereby achieving or making possible more balance between these controls.

Individuals with antisocial tendencies also tend to start sexual activity at a relatively early age and have a relatively large number of sexual partners. A general factor of self-control has been proposed as an explanatory principle underlying such associations (Långström & Hanson, 2006). An important contribution to adolescent pregnancy is a failure to involve reasoning of the "what if" kind (Gordon, 1990).

Having described the basics of a hierarchical model that incorporates an incentive feature, this understanding is now applied to a range of experiments and concepts in the scientific literature. I start with a fundamental distinction between motivational controls and then look at the actual brain processes that embody the parameters suggested in the model.

Wanting versus Liking

Prior to 1991, a straightforward and somewhat linear relation was assumed between incentive value and the consequences of engagement with the incentive: We like what we want and want what we like. However, wanting and liking can be dissociated (Berridge & Valenstein, 1991; Robinson & Berridge, 1993, 2003), with dopamine being involved in wanting rather than liking. The theory has been applied to feeding and drug-taking; there is a need to consider its relevance to sexual behavior.

In this model, the excitatory factors ($E_{incentive}$ and $E_{cognitive}$) exemplify the essence of wanting. Liking does not so obviously map onto the model's parameters but might correspond to the outcome of forward engagement with wanted incentives—that is, the growth of sexual intimacy triggered by the pull of the incentive and appropriate successful performance. This would fit the model of Carver (2004) in which positive affect is

associated with a move toward goals, apparently mediated by opioids released on successful goal attainment (Depue & Morrone-Strupinsky, 2005). Later in the sexual sequence, another measure would be a description of the quality of the feedback signals, from the genitals, for example.

In principle, according to the wanting–liking distinction, one could want sex very much without actually liking it too much (as is the case for some sex addicts, according to Orford, 2001), or, conversely, like it very much without showing wanting to the same extent (Loewenstein, 1996; Stuart, Hammond, & Pett, 1987). Evidence for this dissociation is described later, after wanting and liking are linked to their embodiment in the brain.

The Brain

In this section, I attempt to form links between the processes described in the model (Figure 2) and the brain regions involved. Ideally, different brain regions can be identified with different layers of control, but these various layers and their functions would be expected to interact, thereby providing underlying joint control by incentives and representations. Berridge (2001) described a low-level excitation associated with dopaminergic pathways to the nucleus accumbens (N.acc.) and a high-level (cognitive and intentional) process associated with the prefrontal cortex. High- and low-level controls normally work in interactive cooperation (for details of interactions, see Volkow & Fowler, 2000), but they can be in conflict. Kavanagh et al. (2005) concur with the suggestion of Robinson and Berridge (2003) that high-level conscious desires could, by acting top-down, excite wanting circuits in the limbic system (link 8); however, they suggested that the links are reciprocal. Low-level wanting circuits would tend to excite conscious desire-related processes (link 6).

It is difficult, if not impossible, to perform realistic analysis of blood flows in the brain under natural conditions. Arousal has been induced by viewing pornographic films and changes in brain activation noted. However, as Bocher et al. (2001) pointed out, brain activity could reflect the phenomenological state of conflict between being aroused and the impossibility of translating this into action. They suggested that their own finding of a decrease in rCBF (regional cerebral blood flow) in the medial frontal cortex could form a biological basis of this conflict.

The Mesolimbic Dopaminergic System

The direct incentive-based approach process (Figures 1 and 2) is associated with a dopaminergic pathway from the ventral tegmental area (VTA) to the N.acc. (Berridge, 2001; Zuckerman & Kuhlman, 2000) and various motivations, including sexual, exploit this pathway (Ahron et al., 2001; Depue & Collins, 1999; Depue & Morrone-Strupinsky, 2005; Fiorino & Phillips, 1999). There is evidence of antagonism between the effects of dopaminergic and serotonergic activation in the N.acc. (Spoont, 1992). Low serotonin levels are associated with "a trend towards impulsivity and exaggerated stimulus reactivity" (Spoont, 1992, p. 343; Zuckerman & Kuhlman, 2000). Serotonin re-uptake inhibitors have some efficacy in treating sexual addiction (see later discussion).

High levels of control based on representation and context (organized in the prefrontal cortex and hippocampus, etc). modulate lower levels of incentive-based control, embodied within the VTA–N.acc. link (Depue & Collins, 1999). This process is described as "contextual occasion-setting"—that is, the context can set the occasion for when incentives will gain expression in behavior.

Relevant to this context of sexual incentive stimuli is the assumption that extraverts "possess an exaggerated tendency to approach appetitive stimuli" (Patterson & Newman, 1993, p. 727).

The Amygdala and Other Temporal Lobe Structures

The amygdala processes both positive and negative affective information. Evidence suggests combined internal-external (hierarchical) determination of negative emotion, and its biological bases can be identified, the amygdala being at the hub (Derryberry & Rothbart, 1997; LeDoux, 1989; Ochsner & Barrett, 2001). There are both direct online (subcortical) stimulus inputs to the amygdala (so-called "quick-and-dirty route") and more indirect offline routes (so-called "slow-and-clean route") via the cortex. A variety of aversive stimuli trigger the amygdala (Zald, 2003), which fits with the properties of aversive inhibition, described earlier. It seems reasonable to suggest that such information would act to influence sexual arousal. Activation of the amygdala by positive stimuli seems to reflect the psychological ("incentive motivational") state of wanting. Intense pleasure ("liking," "consummation") appears to deactivate the amygdala (Zald, 2003).

Exposure of males to a sexually explicit film activates the amygdala and hypothalamus (Beauregard et al., 2001). Bechara, Damasio, and Damasio (2003) considered "primary inducers" those that automatically trigger emotional states by virtue of their intrinsic properties (e.g., a loud sound)—in these terms, online determinants. The amygdala has prime responsibility for processing such events.

The Prefrontal Cortex

According to Nigg and Casey (2005), approach (excitation) tendencies as organized in the prefrontal cortex are enhanced by signals from the ventral striatum, hence

increasing approach tendencies. Regions of the prefrontal cortex form an important biological basis of the decision-making process that involves intentions, goal-direction, and goal-directed inhibition (see Figure 2, COGNITION and REWARD ASSESSMENT; Bjorklund & Kipp, 1996; Dehaene & Naccache, 2001), whereas the decision is implemented via the basal ganglia (see Figure 2, ARBITRATION; Prescott, Redgrave, & Gurney, 1999).

The neurochemical serotonin appears to have a role in such decision-making and serotonergic pathways richly innervate the prefrontal cortex (Depue & Collins, 1999). As Depue and Collins expressed it, serotonergic processes play a role in our capacity to "step back from affective engagement for a cool moment of strategic reflection" (p. 552).

Ventromedial prefrontal cortex. Evidence suggests that the ventromedial prefrontal (orbitofrontal) cortex (VMPFC) plays a role in both the attribution of affective value to stimuli (online) and to imagined events (offline), as well as to visceral events (Kringelbach, 2005). Much of the evidence, although not directly about sex, invites extrapolation. Sex surely exemplifies synergism between various sources of reward; this region integrates components of reward and appears to be an important biological basis of the conscious experience of hedonism (Kringelbach, 2005).

The VMPFC is activated in the assessment of beauty in a face, "reward value" (O'Doherty et al., 2003), and sexual attraction (Ahron et al., 2001). In humans, the pleasant quality of a touch stimulus is encoded in the VMPFC, whereas the physical property of the same stimulus appears to be encoded in the primary somatosensory cortex (SSC; Rolls, 2004, 2005). Hence, in this context, gating of a sexual stimulus (such that physical properties are transduced into affective properties) would be expected to occur as the signal passes from the SSC to the VMPFC. Gating might arise from a cognitive appraisal of who is doing the touching and the significance of their action (Rolls, 2004, 2005).

The VMPFC is involved in the rapid reassessment of the value of rewards in the light of changing circumstances (Bechara, Damasio, & Damasio, 2000; Ochsner & Gross, 2004; Rolls, 2004, 2005). Both subjective ratings of pleasantness of an ambiguous odor and the activation it triggers in the VMPFC are modulated top-down by cognitions that give a label to the odor (de Araujo, Rolls, Velazco, Margot, & Cayeux, 2005). Extrapolation would suggest the possibility of a similar modulation of the affective value of sexual odors and touch by meaning. Reward reversal might occur based on highly individual and idiosyncratic changes of context within which the sexual stimulus is appraised. In their sexual stimulation studies, Redouté et al. (2000) attributed to the VMPFC a role in decoding the "motivational significance of stimuli" (p. 174).

Stoléru et al. (2003) performed a PET scan study in which they looked at activation and deactivation of brain regions, comparing men with hypoactive sexual desire disorder (HSDD) and controls. In controls, but not in HSDD, the medial orbitofrontal cortex showed deactivation in response to visual sexual stimuli. As the authors noted, these results fit the interpretation that the medial orbitofrontal cortex is involved in inhibition and that there is a failure to lift such inhibition in HSDD. The authors suggested that, in the case of HSDD, this region encodes devalued representations of sexual stimuli, which inhibits activation of lower-brain regions.

Damage to the orbitofrontal region can be associated with hypersexuality (Bezeau, Bogod, & Mateer, 2004; Frohman, Frohman, & Moreault, 2002; B. L. Miller, Cummings, McIntyre, Ebers, & Grode, 1986; Mutarelli, Omuro, & Adoni, 2006; cf. Starkstein & Robinson, 1997). This effect suggests the release of lower-level organization from top-down restraint that would normally be based on an assessment of a negative outcome, a lifting of goal-directed inhibition in Figure 2.

The amygdala and VMPFC closely interact in determining emotion and decision-making (Bechara et al., 2003). In keeping with a hierarchical interpretation, Bechara et al. (2003) described the relative contribution of these two structures being "at different levels" and noted that emotion can normally be triggered by a given event acting as primary inducer (by virtue of its stimulus properties). The term *secondary inducers* refers to inducers of the kind that exert their influence via the *recall* of information. Such information has personal significance (e.g., a sad or happy event from the past) or is generated purely via the imagination (hypothetical event). This corresponds to offline and requires the VMPFC for its processing.

Dorsolateral prefrontal cortex. The high level of control described earlier involves drawing representations from memory and holding them active in working memory as well as assessing their affective value (see Figure 2, COGNITION). The dorsolateral prefrontal cortex is involved in the control of such memory and its use in behavior (Drevets & Raichle, 1998; McClure et al., 2004). In response to visual sexual stimuli, deactivation was seen in the left dorsolateral prefrontal cortex (Brodmann's areas 45 and 46; Stoléru et al., 1999).

Goal-directed inhibition of sexual arousal is associated with excitation of a region of the right dorsolateral prefrontal cortex (Brodmann's area 10) and a decrease in activity of the amygdala (Beauregard et al., 2001). The dorsolateral prefrontal cortex is associated with the selection of behavioral strategies and inhibition of unwanted candidates (Beauregard, 2007), and its involvement also in emotional inhibition indicates a coordinated action in internal and external environments.

The Caudate Nucleus

The basal ganglia are involved in arbitration between candidates for the control of behavior. This involves inhibiting all but the winning candidate (Prescott et al., 1999). There is a positive correlation between subjective sexual arousal and regional cerebral blood flow in the head of the right caudate nucleus (Stoléru et al., 1999), which Redouté et al. (2000) interpreted as input to the basal ganglia arbitration process (see Figure 2, ARBITRATION). The existence of a high level of sexual arousal is not sufficient to trigger behavior. When motivation cannot be expressed in behavior, an inhibitory signal arises (link 10) and this, it was suggested, is what is recorded in the head of the right caudate nucleus. Obviously, other factors such as the practicality and feasibility of sexual advance must enter the equation. (These must surely be assessed as rather low when in a PET scanner!) In the terms of Table 2, this would correspond to inhibition of the form $I_{goal\text{-}directed}$.

Stoléru et al. (2003) compared men with HSDD and controls. Only in controls was there activation of the head of the right caudate nucleus. Presumably, in HSDD little or no motivational "go" signal to sexual stimuli triggers opposing inhibition.

A factor that appears to be able to alter the brain's processing of sexual information, as expressed in terms of changing weight within a hierarchical structure, is stress, to which the discussion now turns.

Link with Stress

Stress can interact with sexual motivation in several ways to influence behavior. First, some individuals learn to use sex as a means of coping with stress—that is, to trigger a temporary increase in affect (Cortoni & Marshall, 2001). Stress tends to increase tendencies to immediate gratification (Baumeister & Vohs, 2003), which can lead sex offenders to re-offend (Ward & Beech, 2006; see later discussion). Second, by extrapolation from drug-taking, stress can overload the cognitive (offline) layer of control and thereby lower its restraining influence (Tiffany & Conklin, 2000). In the formulation of Mischel et al. (2003), the "hot system" is strengthened by stress, whereas with high levels of stress the "cool system" shuts down. Third, stress can, at least in the short term, increase the activity of the VTA-N.acc. dopaminergic incentive system, which could increase the attraction of sexual incentives (Depue & Collins, 1999). Corticotropin-releasing factor is released at times of stress and, acting at the N.acc., can increase the incentive salience of rewards (Peciña, Schulkin, & Berridge, 2006). In contrast to short-term stress, long-term stress appears to lower activity in the dopaminergic pathway, presumably underlying some loss of the attraction of incentives (Depue & Collins, 1999).

Stress has influences on sexual motivation and behavior, but sexual motivation can itself be a source of stress (frustration), to which I now turn.

Frustration

The existence of sexual desire and motivation is, of course, not an unmitigated good for everyone. For some, unrewarded desire is a source of considerable frustration and stress. As Symons (1979) noted, being attracted by a sexually arousing other is "no more an unmixed blessing than window-shopping is for most poor people" (p. 227). According to this interpretation, frustration does not reflect a pressure build-up arising from some diffuse regulatory substance or energy or even accumulating biochemical deviation from homeostasis that is divorced from cognition. Rather, in keeping with the theoretical position of Carver (2004), frustration would be triggered by (a) the thwarting of forward engagement with sexual incentives and (b) intrusive sexual imagery associated with lack of availability. Kavanagh et al. (2005) noted that negative affect can be triggered by the realization that a suggested goal arising within the desire system is inaccessible. A well-known cause of sexual frustration is the activation of sexual motivation by a class of inaccessible sexual stimuli.

Novelty

The triggering of sexual motivation by a novel stimulus is termed the *Coolidge effect* (Dewsbury, 1981). Novelty and increased appetitive behavior is associated with increased activation of dopamine in the N.acc. (Fiorino, Coury, & Phillips, 1997). This points to modulation of the basic incentive approach system by means of novelty detection. It is often assumed that a relatively high activation of dopamine forms a biological basis of extraversion (Depue & Collins, 1999), with its associated trait of sensation-seeking, including in the sexual domain.

So far, we have considered motivation as something that can be either flexibly expressed in behavior or inhibited. Briefly now, attention needs to be paid to some rather fixed responses that can be recruited under hierarchical control.

Species-Typical Responses

Higher layers in a hierarchy tend to modulate the appearance of certain responses organized at a lower level such that a particular motor response tends to occur in a particular motivational state (Gallistel, 1980). An example of this is the lordosis reflex of the female rat (Pfaff, 1989). Of course, human sexual behavior has gained considerable emancipation from

rigid stimulus-response links of this kind. There is still evidence, however, of a low-level organization that is modulated by motivation. Boys of 10 to 12 years report erections in response to various exciting nonsexual events, such as playing sports, but these erections decline rapidly beyond 12 years of age (Ramsey, 1943). Human sexual desire is associated with an increased probability of showing the responses of licking, sucking, puckering, and touching the lips, as well as tongue protrusion (Gonzaga, Turner, Keltner, Campos, & Altemus, 2006). Looking widely across cultures, there are universal gestures associated with flirting (Eibl-Eibesfeldt, 1975). In humans, sexual arousal accentuates certain spinal reflexes such as to prepare the body for action through the somatic nervous system (Both et al., 2003).

So far, the sexual motivational system has been described somewhat in isolation, but it must also be considered in interaction with several other behavioral systems. Subsequently, an explanation of sexual phenomena will call on an understanding of this interactive nature of sexual motivation.

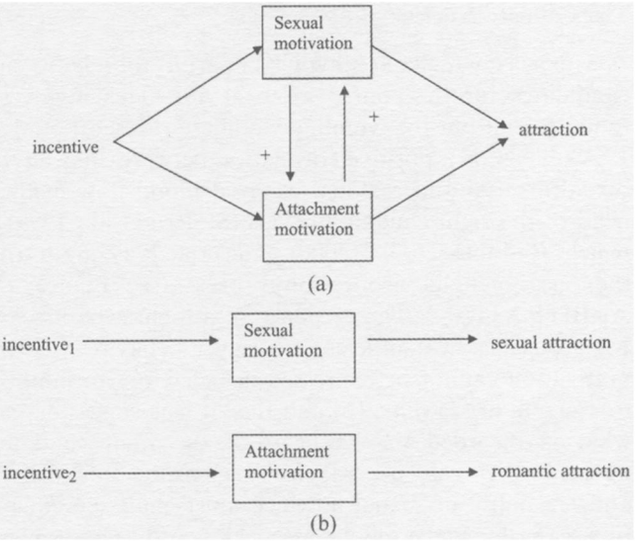

Figure 3. Sexual and attachment systems (a) leading to attraction to a single incentive and (b) attraction to distinct incentives.

Interactions with Nonsexual Processes

It appears that the *strength* of a given sexual incentive can be modulated by activity within other emotional and motivational systems. In this section, I give four examples of activity in other systems that can lock into interaction with sexual motivation. Valuable insight into sexual motivation and behavior can be derived from considering these interactions.

Link with Attachment

There is evidence for an independent motivational system of attachment (Baumeister & Leary, 1995; Bowlby, 1979; Hatfield & Sprecher, 1986) with identifiable biological bases (Aron et al., 2005; Depue & Morrone-Strupinsky, 2005; Fisher, 1998). In humans, sexual attraction and attachment motivation are each associated with distinct facial gestures (Gonzaga et al., 2006).

Evidence suggests that sexual and "romantic attachment" motivations are two distinct systems but with the potential for powerful interactions between them (Diamond, 2004; Fraley & Shaver, 2000; McCall & Meston, 2006). That sex and attachment can be distinct or overlapping controls is recognized in the addiction literature, described shortly (Carnes, Murray, & Charpentier, 2005).

Normally, sexual desire sensitizes any parallel romantic attachment (whether heterosexual or homosexual); however, pointing to the possibility of a fracture line between systems, there are also examples of distinct sexual and romantic incentives (Diamond, 2003).

Even *within* a given individual, the role of intimacy can be seen across behaviors. In contrast to individuals for whom intimacy and attachment amplify sexual attraction, it appears that, for certain individuals characterized as "dismissing," these same processes might exert a negative role. They avoid such signs of intimacy as kissing and mutual gazing and yet they engage in sexual activity as frequently as controls (Fraley, Davis, & Shaver, 1998).

Two situations can be contrasted (see Figure 3). Part "a" shows the most common, in which the systems coalesce in modulating the attraction of a single incentive; and Part "b" shows the unusual situation of two distinct systems with two incentives (e.g., a person of homosexual orientation who develops a strong affinity to a person of the opposite gender).

The involvement of a number of substances such as oxytocin and opioids in both motivations gives pointers to the biological basis for the interactions (Carter, 1998; Depue & Morrone-Strupinsky, 2005; Diamond, 2004). It seems reasonable that oxytocin released at orgasm would tend to increase attachment (Rolls, 2005, p. 394). It appears that the basic incentive value within a sexual motivational system can be modulated by such factors as oxytocin and vasopressin.

Early attachment formations appear to be able to set the scene for the later emergence of sexual orientation (Storms, 1981). Evidence also suggests that an aberrant early attachment history can later yield pathological links with sexual arousal and intimacy (Beech & Mitchell, 2005).

Link with Aggression and Dominance

Sadly, the attraction of a sexual incentive can be increased by activity within a motivational system of aggression (see later discussion; Barclay & Haber,

1965). For male power-holders with a tendency to harass women, the unconscious priming of the concept of power tends to increase the attractiveness of women over whom they have power (Bargh, Raymond, Pryor, & Strack, 1995).

Link with Anxiety

In some people, fear (e.g., threat of electric shock) and anxiety increase sexual arousal and desire (Barlow, 1986; Janssen & Bancroft, 2007). A possible interpretation of at least some examples of such interaction was offered by Kavanagh et al. (2005):

> The involvement of attributional and associational processes implies that desires may arise from attributional errors or salient but misleading associations. An irregular heartbeat may be due to excessive caffeine rather than to a lover's arrival.... We predict that cross-activation of desires will be common in conditions in which information about the physiological deficit is ambiguous. (p. 450)

Some evidence in favor of this anxiety motivation cited by Kavanagh et al. (2005) is the rope bridge experiment (Dutton & Aron, 1974) in which fear appeared to be interpreted as sexual arousal. (A possible neural basis of interactions between fear circuits and incentive motivation circuits, with links to the ANS, was described by Depue & Collins, 1999.)

When arousal arising from aversive stimulation triggers a relatively low level of aversive inhibition, such cases might get placed in (or subsumed under) sexual arousal (Bancroft & Vukadinovic, 2004) because consciousness can have the tendency to be occupied by a single cognition (Baars, 1988; Dehaene & Naccache, 2001).

Link with Drugs

Contemporary theorizing about incentives suggests there is a common appetitive approach system that can be excited by various rewards and conditional stimuli, which are able to access it. Hence, there is the possibility of cross-sensitization in which, for example, drugs can sensitize sexual motivation (Levens & Akins, 2004) and sexual motivation can sensitize drug-seeking. As a possible rat model, Fiorino and Phillips (1999) investigated prior sensitization of the dopaminergic projections to the N.acc. with amphetamine. Subsequent sexual behavior was facilitated, as it was for opiate injections into the VTA (Mitchell & Stewart, 1990).

Bauer and Kranzler (1994) found that erotic stimuli increase the desire of cocaine-dependent people for cocaine. Of the various psychoactive drugs, methamphetamine appears to have the strongest positive effect on each of the variables of sexual desire, behavior, thought, and pleasure (Rawson, Washton, Domier, & Reiber, 2002). Sex addiction commonly is accompanied by drug use, as discussed later.

So far in describing the model, little attention has been paid to gender differences. Having considered the incentive and hierarchical nature of the sexual system within a context of its interactions, understanding can now be gained into certain gender differences.

Gender Differences

In women, explicit sexual stimuli commonly trigger genital arousal unaccompanied by subjective desire or arousal (Basson, 2002; Laan & Everaerd, 1995; Laan et al., 1995). Basson (2002) argued that the processing underlying initial arousal is subject to cognitive influences, which could amplify the desire and arousal system or attenuate it. This suggests parallel processing: a low-level link to the peripheral reaction but a more subtle contextualized link to subjective desire or arousal. The subjective experience might be positive only if there is triggering of explicitly positive cognitions, such as memories (Laan & Janssen, 2007). It might be negative as a result of an incompatible high-level cognitive interpretation (Basson, 2000), as in triggering of explicit memories (e.g., of an immoral association) that are incompatible with arousal (Spiering & Everaerd, 2007). There can be peripheral arousal, as in masturbation to orgasm, in the absence of other sexual stimulation in either reality or fantasy (Basson, 2002). This tends to be more common in women than men (Leitenberg & Henning, 1995).

Wanting and Liking

Symons (1979) noted:

> Men and women differ far less in their potential physiological and psychological responses during sexual activities per se than they do in how they negotiate sexual activities and in the kinds of sexual relationships and interactions they are motivated to seek. (p. 179)

Such an assessment suggests differences at the level of wanting rather than liking. According to Symons, although women can be as strongly aroused by pornography as are men (especially if it is tailored to a female audience), they usually make little or no effort to seek it out. There is, anecdotally, evidence that with the access to the Internet this gender difference might be lessening, although it is still evident (Træen, Nilsen, & Stigum, 2006).

Erotic Plasticity

Baumeister (2000) argued that women exhibit more "erotic plasticity" than men—that is, they are more sensitive to variations in social and cultural factors than

are men. He linked this characteristic to automatic and controlled processing:

> It seems likely that a longer, more complex process is more flexible and more subject to situational and social factors, rather than less. It is well established that quick, automatic responses tend to be simple and efficient but inflexible, whereas controlled, deliberate processes tend to be slow, complex and highly flexible. (p. 362)

This analysis suggests that women's sexual motivation and subjective arousal tend to be more strongly controlled by offline factors, whereas men tend to be more strongly controlled by online factors. A sexual stimulus tends to trigger a wider range of both positive and negative cognitions ("meanings") in women than in men (Laan & Janssen, 2007).

The attraction value of men to women tends to be more strongly influenced by contextual factors such as status than is women's attraction value to men, which is more a function of physical appearance (Symons, 1979). A greater role for appearance per se and for a desire for novelty is evident in men's sexual fantasy (Ellis & Symons, 1990). These differences relate to evolutionary psychology and principles of differential investment (Townsend, Kline, & Wasserman, 1995).

Link with Attachment

Diamond (2003) suggested that fusing between sexual desire and attachment could well be more frequently found in women than in men, which would fit predictions derived from evolutionary psychology (Townsend et al., 1995). Women's sexual fantasy tends to be more commitment oriented than does men's (Ellis & Symons, 1990). Within either gender, differences in attachment style appear to contribute to differences in sexual behavior—for example, the extent to which a monogamous or promiscuous strategy is adopted (Kirkpatrick, 1998). Baumeister and Bratslavsky (1999) suggested that, at times (e.g., in the "full bloom of young love"), the combination of sexual desire and romantic attraction can be such as to give women an apparently higher drive than men. Conversely, lack of affection within marriage is an important contributor to women's loss of desire (Stuart et al., 1987).

An increased role for oxytocin and vasopressin might explain women's greater affiliative link to sexual arousal than men's (Andersen, Cyranowski, & Aarestad, 2000; Peplau, 2003). It might also explain the greater intra-individual fluctuations in sexual desire and expression in women, as a function of current romantic attachments (Baumeister, 2000).

Women tend to report a relative lack of spontaneous sexual desire; rather, the desire they experience tends to be triggered by *personalized* external events (McCall & Meston, 2006). The triggers are often relationship related and hence carry meaning, rather than being purely physical incentives (Peplau, 2003). Women's sexual arousal is particularly sensitive to factors such as the social context, fear, and the broader quality of their relationship (Basson, 2000; Kaschak & Tiefer, 2001; Leiblum, 2002; Peplau, 2003). Self-image is involved in female sexual desire and satisfaction (Ackard, Kearney-Cooke, & Peterson, 2000; Roberts & Gettman, 2004), as well as fantasy (Ellis & Symons, 1990), suggesting that a representation of the self forms part of the complex underlying desire.

This evidence would be represented by a greater degree of offline modulation of the basic desire system, as well as a relatively strong interaction with the attachment system. Discussion as to whether men or women have the stronger sex drive might be somewhat ill-conceived, as it ignores contextual factors (Wallen, 2000).

So far, I have only very briefly touched on the subject of when sexual motivation, arousal, and behavior "go wrong," in the sense of indicating a need for professional intervention. In the next three sections, I turn to the relevance of the model to this subject.

Sexual Arousal Disorders

Loss of Arousal

In terms of this model, loss of arousal, as in performance failure, can arise from a number of causes. These can be grouped as direct (e.g., fear-evoking stimuli) or cognitive (e.g., revival of a memory of performance failure; Barlow, 1986). Such factors can interact, as in the online process triggering incompatible ("off task") memories (e.g., of earlier performance failure; Janssen et al., 2000). However, paradoxically, in some cases of dysfunction, neutral (nonaversive) distraction can either leave unaffected or actually *increase* sexual arousal, as measured by the genital response (Barlow, 1986; Janssen et al., 2000). It seems that, in such cases, competition for conscious processing resources can prevent an occupation with cognitions that are incompatible with arousal. In keeping with the interpretation of Janssen et al. (2000), this analysis would suggest that, by reducing the power of inhibitory cognitions, there remains a relatively high strength of excitatory online control.

Persistent Sexual Arousal Syndrome

The phenomenon termed *persistent sexual arousal syndrome* (PSAS) is experienced by women and is distinct from hypersexuality. PSAS consists of unwanted and distressing peripheral arousal in the absence of desire or pleasure (Goldmeier & Leiblum, 2006; Leiblum & Nathan, 2001). It is interesting in terms of the assumptions of this model:

1. PSAS is perceived as unwanted and is not usually associated with conscious desire, hence showing

that peripheral arousal is not a *sufficient* condition to trigger desire. Arousal can be open to conscious *interpretation* in its integration with exteroceptive and cognitive information as determinants of desire (Laan et al., 1995). It suggests that in the absence of some correlation with the cognitive ingredient of conscious desire, arousal can be labelled as undesired.

2. It is possible that PSAS arises spontaneously, for example, by excitation of a reflex-like process down-stream from erotic sensory input. However, certain stimuli having only a minimal sexual connotation appear to be able to trigger such arousal. This points to the possibility of a low-level sensory input to the arousal process that occurs in the absence of desire (link 1c).

Leiblum and Nathan (2001) argued: "Even when these women report that a stimulus has triggered or augmented their physiological arousal, it is almost as if they experience the stimulus acting directly on their erogenous zones without leaving a sexual impression on their minds" (p. 378).

Paraphilias and Sexual Offending

Several features of paraphilias and sexual offending might be mapped onto abnormality of components of this model.

Approach–Avoidance Problems

It is possible that some paraphilias might be better understood in terms of increasing avoidance aroused by incentives as distance to the incentive is reduced. Klinger (1971) suggested, "For instance, a man who becomes overwhelmed by anxiety in the embrace of a lover may be greatly attracted by pornographic pictures or by the lingerie counter of a department store" (p. 318). Clearly, more research is needed before this idea can be accepted.

Sexual Coercion

Marshall and Barbaree (1990b) wrote, "As we see it, the task for human males is to acquire inhibitory controls over a biologically endowed propensity for self-interest associated with a tendency to fuse sex and aggression" (p. 257). Evidence points to a sexual motive underlying rape, rather than simply motivation for power and dominance (Thornhill & Palmer, 2000). In terms of incentive motivation and principles of interacting controls, it is misleading to argue whether rape is motivated by *either* sexual desire *or* aggressive and power motivation (Symons, 1979, p. 278). A given target can become attractive through an unfortunate coalition of such motives. As Loewenstein et al. (1997) wrote, "We view situations of sexual coercion as involving both sexual and aggressive cues and motives, and sexual offenders as occupying a range of positions on the mix of these two sources of motivation" (p. 443).

The evolutionary view, developed by Malamuth and Heilmann (1998), stresses "both sexuality mechanisms (i.e., impersonal sexual orientation) and incorporating dominance/hostility mechanisms, which may be mobilized in response to blocked goals" (p. 530).

Sexual offending might be viewed as arising from an imbalance between excitatory and restraint processes associated with action selection and self-regulation (Ward & Beech, 2006). As a general feature, psychopaths are associated with abnormally high incentive pull ($E_{incentive}$) and abnormally low restraint ($I_{goal\text{-}directed}$), when in the presence of an incentive (Carver, 2005; Derryberry & Rothbart, 1997). This response takes the form of an exaggerated positive feedback effect triggered by the sexual incentive and energization following thwarting (Patterson & Newman, 1993). Anger that is triggered by a failure of goal attainment can have the unfortunate effect of increasing the effort to attain the goal (Carver, 2004).

Offenders typically exclude thoughts about negative outcomes (Marshall & Barbaree, 1990a), thereby, it would appear, minimizing the possibility of restraint offered at levels of either $I_{aversive}$ or $I_{goal\text{-}directed}$. However, offenders are not simply the victims of external circumstances that they are powerless to resist (i.e., impulsivity). Rather, they commonly go to great lengths to set up the circumstances that permit them to offend (Marshall, Laws, & Barbaree, 1990), exhibiting a high level of $E_{cognitive}$. Impulsive individuals are highly occupied in the decision-making processes that lead to hedonic goals (Ramanathan & Menon, 2006).

Stress and negative affect, accompanied with the use of sexual behavior as a "soothing strategy," are seen as powerful triggers to offending (Marshall & Barbaree, 1990b; Ward & Beech, 2006). Stress reduces the capacity to restrain prohibited sexual thoughts from engaging conscious awareness (Johnston, Ward, & Hudson, 1997). Alcohol is a factor in a high percentage of sexual assaults (Marshall & Barbaree, 1990b), and its effects in reducing the role of inhibitory controls are well established (Steele & Josephs, 1990).

Sexual Addiction and Compulsivity

Basic Principles

The notion of interacting layers of processing, automatic and controlled, holds a central place in the literature on addictions to substances (Tiffany & Conklin, 2000); so far, it has not been applied to sexual addiction. Space precludes discussion of whether sex can truly be said to be addictive; it is sufficient to note that the terms

addiction and *compulsion* can be applied when behavior is excessive and ambivalent, and when it produces conflict and strong negative consequences such as the prospect of loss of income, family, or job.

Do sex addicts have an abnormally high sex drive? In reality, addicts often shun conventional and safer sexual outlets, for example, with a wife (Schneider & Weiss, 2001; Wiederman, 2004). Occasionally, sexual desire seems hypoactive in the context of the addict's relationship with the regular partner (Kafka, 2000), pointing to the role of "particular incentive stimuli" in addiction. The addiction is often to a specific incentive set in a particular context, such as picking up individuals in a bar for a one-night stand (Money, 1986).

The lure of the neighbor's bushes signalling the chance to glimpse a naked body in a window, the red-lights of a region of the town, or even the sound of switching on the computer can acquire incentive motivational value, presumably as a result, at least in part, of conditioning. Rituals often play a part, involving constant and obligatory environmental props such as a fixed location or odor. Within this pattern, some variety can be introduced. Thus, Schneider, Sealy, Montgomery, and Irons (2005) reported, "By avoiding certain geographic settings, eliminating certain items of clothing, certain cologne scents, or music, the addict can prevent aspects of ritualization and avoid acting out" (p. 142).

By extrapolation from evidence derived from the study of other rewards (Tomie, 1996), internet sex might be expected to be particularly addictive because the computer keyboard is so close in distance and time to the desired incentive images. Conversely, many people with a high sexual interest and activity do not display addiction, as defined in terms of risk, conflict and disruption to life. Orford (2001) wrote:

> The disease-like quality of habitual excessive behavior is due to circumstances which allow the flourishing of strong attachment-forming processes, which in some cases are more than a match for forces of restraint, although the latter may appear much the more reasonable and may be much more easily listed in the form of words. (p. 318)

Addicts, whether the addiction is to love, sex, or to drugs, feel themselves to be out of control (Eisenman, Dantzker, & Ellis, 2004). However, the expression "out of control" suggests a dichotomy of "out and in" as clear categories. Rather, Orford (2001) wrote that his approach "rests heavily upon the idea of opposing tendencies towards restraint versus appetitive inclination, the counter-balancing of incentive and disincentive, and the moral conflict between deviant excess and conforming moderation" (p. 205).

In some cases, sexual addiction locks into interaction with romantic attachment, as in repetitive crushes on a series of inaccessible individuals (Kafka, 2000). This interaction appears to be more common amongst women addicts than men. Furthermore, like chemical addictions, sexual addiction often arises at times of particular stress (Schneider & Weiss, 2001), anxiety, or depression (Kafka, 2000).

Explaining Addiction

In hierarchical terms, addiction represents the capture of behavior by a restricted range of stimuli, accompanied by inadequate restraint processes. There is conflict between layers of control: between, at a low level, the basic incentive pull ($E_{incentive}$); and, at a high level, such considerations as self-image and desire to maintain a professional and family life ($I_{goal\text{-}directed}$). Evidence, which is as yet limited, tentatively suggests prefrontal dysfunction is involved in sexual addiction (Spinella, 2007). As noted earlier in Mischel et al.'s (2003) formulation, stress strengthens the hot system and especially high levels of stress shuts down the cool system.

It appears that the sexual incentive can acquire part of its strength through its association with the reduction of negative emotion (e.g., anxiety, depression, boredom, or stress). In one sample, 42% of people with sexual addiction reported reduced anxiety following sexual outlet (Black, Kehrberg, Flumerfelt, & Schlosser, 1997). In other cases, lifting of depressed mood appears to strengthen addiction (Stein, Black, Shapira, & Spitzer, 2001). Consider the description "compulsive sexual behavior as mediated by anxiety reduction, rather than by sexual desire per se" (Leiblum & Rosen, 2000, p. 471). The statement appears to contain a false dichotomy: in incentive terms, the strength of sexual desire is maintained in part by any associated reduction in anxiety or depression (cf. Bancroft & Vukadinovic, 2004). A significant number of addicts report dissociation when engaging in sexual activity, "as if watching someone else" (Black et al., 1997). There is an occupation of conscious awareness with the single goal, a state that is characterized by such terms as *trancelike, not conscious of reality*, and *oblivious of what I am doing* (Bancroft & Vukadinovic, 2004). This suggests domination by a low layer of control that locks into conscious awareness, thereby minimizing the role of high-level inhibition as described by self-regulation.

Combinations of Addictions

The sex addict, not uncommonly, has a simultaneous addiction to alcohol, or prescription or illicit drugs (Washton & Stone-Washton, 1993). This condition makes sense in terms of incentive theory because it suggests that a "common incentive brain machinery" gets captured and exploited, with cross-sensitization from the one activity to the other. As an additional factor, drugs and alcohol can impair high-level inhibitory

processes (Lyvers, 2000). Sex and cocaine are sometimes exploited only in combination, and the use of prostitution and gambling are often found together.

Sexual addiction often interacts in complex ways with chemical addictions to reinforce each other. Cocaine use often strongly excites sexual desire, fantasies, and intrusive thoughts, as well as being associated with sexual addiction (Washton & Stone-Washton, 1993). For cocaine addicts who are trying to quit, because sexual fantasy can trigger powerful urges and craving for cocaine, such sexual events can trigger a relapse. Carnes et al. (2005) describe dopaminergic transmission between the VTA and the N.acc. as a site of common action.

Incentive Salience Sensitization

According to the theory of incentive salience sensitization, drugs sensitize a dopaminergic wanting system (Robinson & Berridge, 1993) associated with increased wanting and craving. Robinson and Berridge (1993) were reluctant to speculate as to whether this model might also be applicable to nonchemical addictions. Of course, by definition, sex addiction does not involve a direct chemical link, and so any sensitization would result from the repeated experience of sexual desire and arousal. However, quite apart from sensitization of the incentive pathway, repeated occupation with a particular goal can impel that goal to occupy the decision-making process (Ramanathan & Menon, 2006).

Although not wishing to gloss over the differences, this perspective draws attention to some tantalizing similarities between sexual and chemical addictions, as follows:

1. In each type of addiction, wanting sometimes increases without a necessary and commensurate increase in liking. Some sex addicts "repeatedly participate in sexual behaviors *despite* finding them *aversive* or *unsatisfying*" (Gold & Heffner, 1998, p. 372; cf. Wiederman, 2004). Such observations underline the strength of the incentive wanting system, even if it sometimes is de-coupled from liking.
2. To some extent, both kinds of addiction can be context-specific. In rats, behavioral sensitization to drugs can be specific to the environment in which the drug was injected (Robinson & Berridge, 2003).
3. Stress increases the tendencies to both chemical (Robinson & Berridge, 2003; Tiffany, 1990) and sexual addiction (Carnes, 2001).

These similarities suggest the possibility of incorporating incentive sensitization as part of a model of sexual motivation, behavior, and addiction. In chemical addiction, craving arises particularly when the automatic layer of control either cannot solve the problem (e.g., through unavailability of drug) or must be resisted (as in trying to fight temptation; Tiffany & Conklin, 2000). It is interesting to speculate as to whether this applies equally to sexual addiction.

Discussion

I hope this review promotes further discussion of the concepts of sexual motivation and arousal, and that Figure 2 provokes arrangement of its component boxes and arrows to bring it closer to reality. It has been shown that much evidence fits the assumptions of an incentive motivation model. However, to advance our understanding, the basic (online) incentive process needs to be placed in the context of (a) higher level (offline) controls in terms of a hierarchy and (b) interactions with other systems such as attachment. Such a hierarchical incentive-based model involving layers of excitation and inhibition can be used to address a number of issues for sex researchers.

Fundamental to the model is the notion of either compatibility or conflict between layers of control. Researchers and therapists might usefully consider the different sources of excitation and inhibition in terms of levels within a hierarchy. Thus, a therapeutic intervention might be appropriate for problems arising at one level but not another.

For example, the modification of sexual desire is a matter of great therapeutic concern and the model might help pinpoint how desire can go wrong. The task of much therapy and the goal of many legal sanctions is to strengthen inhibitory high-level control in the face of the incentive pull of the online control. However, the opposite problem also presents itself: excessive inhibition based on learning, cultural, and moral considerations and relatively inadequate online excitation. In the terms of this model, such excessive inhibition could arise at either the levels of $I_{goal\text{-}directed}$ or $I_{aversive}$ or, perhaps more likely, an interaction of the two.

Sexual Drive

In avoiding the notion of sexual *drive*, the model focuses not on intrinsic sources of motivation, as in the metaphor of energy, but rather on external sources and in cognitive representations of incentives and associations with them (cf. Both et al., 2007; Hardy, 1964). However, other authors still employ the term *drive*; Fisher (1998), for example, used it in her three-component analysis: "The sex drive (the libido, or lust) is characterized by the craving for sexual gratification; it is associated primarily with the estrogens and androgens; and it evolved primarily to motivate individuals to seek sexual union with *any* conspecific" (p. 24).

This analysis differs from this approach in several regards. First, it is not clear how a diffuse drive, originally

modelled on concepts of energy, could give specific direction to behavior (Bindra, 1978). No matter the mating strategy, individuals of a number of species, including humans, are not generally moved to seek union with just *any* conspecific, but rather have a strong preference for a limited range of conspecifics, defined by physical appearance and the contextual associations triggered thereby (Symons, 1979). In terms of function, any indiscriminate mating would be costly compared to a more discriminating strategy, particularly for females (Symons, 1979). Androgens appear to have an important role in human sexual desire; however, although they are usually a contributing factor, desire can be low even in the presence of normal levels of androgens (cf. Both et al., 2007; Stuart et al., 1987). Fisher (1998) continued her description of sexual attraction, as one: "associated primarily with the catecholamines; and it evolved to facilitate mate choice, enabling individuals to focus their mating effort on preferred conspecifics" (p. 24).

However, what Fisher (1998) described as drive is also mediated via catecholamines, such as dopamine. Reciprocally, testosterone also plays a role in the attraction to particular individuals. Attraction is surely a fundamental design feature of any system directed to sexual union, including that which produces behavior divorced from any attachment formation. It is difficult to understand the notion of a drive that is divorced from attraction. This analysis would combine Fisher's drive and attraction systems into a dopamine-mediated system that is triggered by incentives and representations of them, this being sensitized by testosterone. Fisher's system of attachment is similar to that developed here. I suggest that, for so-called monogamous species, this system can lock into interaction with the system of sexual incentive motivation such that *particular* partners can be strongly favored. Insofar as animal models can be applied to humans, they suggest that neurochemicals such as oxytocin "gate" the basic system of sexual incentive motivation (Toates, 2007).

Baumeister and Bratslavsky (1999) noted Michael, Gagnon, Laumann, and Kolata's (1994) observation that frequency of masturbation correlates *positively* rather than negatively with socially mediated sexual outlets. This argues against a drive and compensation model. Rather, it fits an incentive-based model in that a sensitized system can be reflected in a high frequency of outlets in the form of either solitary or partnered sex.

Pleasure

Some assume that liking in the form of pleasure is an essential part of the formation of incentives (Depue & Collins, 1999). I take a more guarded approach, suggesting that, whereas wanting is the common factor in all sexual and romantic attractions, pleasure might or might not have been present to reinforce this tendency. This is not to deny, however, that wanting might be maintained in part because of its association with liking.

Essentialist and Social-Constructionist Approaches

There is an increasing tendency to integrate rather than partition social and biological factors in explaining sexual motivation and behavior (Andersen et al., 2000; DeLamater & Hyde, 1998; Wallen, 2000). Certain biological and social-constructionist theories of human sexuality should not be seen as rival accounts but as capturing processes that can coexist (Tolman & Diamond, 2001). An incentive motivation model with hierarchical controls can serve as a way of formalizing such assumptions and a means of gaining insight into the complexity and subtlety of the causes of sexual desire, maladaptive desire, and loss of desire. Hence, we can escape from simple linear and "one size fits all" thinking (Wood, Koch, & Mansfield, 2006).

The only essentialist feature of this model is, given normal genetics and development, a capacity to assimilate incentives, to form representations of them, and to derive wanting, arousal, and pleasure from this. The environment will largely determine the rest—that is, who constitutes the incentive and what are the contextual and interacting controls over how incentive motivation arises (if at all) and is expressed (if at all).

Evolutionary Psychology

Evolutionary psychologists of the Santa Barbara school suggest the existence of dedicated modules, and the design metaphor is based on this notion. The sexual arousal system has some of the characteristics of such a module (Spiering & Everaerd, 2007). However, as far as behavior and sexual feelings are concerned, the module is embedded within nonmodular processes, which can alter the module's sensitivity to stimuli, as represented in Figure 2 (cf. Geer, 2007).

Differences between the sexes in terms of the triggers to desire also form a foundation of evolutionary psychology (Buss, 2003; Thornhill & Palmer, 2000). Differences are explained in terms of fundamentally different modules. In my approach, I suggest considerable common processing between the two sexes and raise the possibility that differences might arise in different settings of some parameters that are common. For example, although they are not unique to women, restraint processes, contextual modulation, and a link with attachment seem to exert more control over sexual behavior in women than in men. Similarly, using the design metaphor, I suggest quite distinct modules underlying each motivation such as sex or feeding. By contrast, an incentive motivation model raises the possibility of some common processing underlying different motivations and behaviors, as well as common features underlying restraint (Depue & Collins, 1999). It suggests that sexual motivation and behavior is restrained by high-level inhibitory processes ($I_{goal\text{-}directed}$), which might be used to hold in check any of the whole range of different motivations.

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