CONSUMER BEHAVIOR, HORMONES, AND NEUROSCIENCE: INTEGRATED UNDERSTANDING OF FUNDAMENTAL MOTIVES WHY WE BUY

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Consumer behaviors are shaped by fundamental motives: affiliation, self-protection, status attainment, mate attraction, mate retention, and child-rearing. It has been argued that each fundamental motive is activated by cues pertaining to threats or opportunities linked with each fundamental motive, and may be based on qualitatively different cognitive and neural systems. Steroid hormones influence specific neural systems and consumer behaviors rooted in diverse fundamental motives. By taking steroid sex hormones as examples of internal cues, we suggested that at least three fundamental motives (status attainment, mate attraction, and mate retention) may be explained by common cognitive and neural mechanisms. Consumer behaviors rooted in diverse fundamental motives, including status attainment, mate attraction, and mate retention, may be commonly explained by social motivations/vigilance (amygdala) and reward processing (reward-related brain regions). Neuroscientific tools may be useful for refining the fundamental motive framework, and for understanding more fully consumer behaviors rooted in evolutionary motives.

Key words: consumer neuroscience, fMRI, fundamental motivation framework, hormones, evolutionary psychology

INTRODUCTION

Human behaviors have been shaped and regulated by biological variables. Recently, social sciences have fruitfully harmonized with biological sciences to investigate human behaviors further. Scholars in social sciences have used a range of biological variables associated with neuroscience, genetics, endocrinology, and pharmacology as well as evolutionary biology (Lieberman, 2007; Fowler & Schreiber, 2008; Beauchamp et al., 2011; Goossens et al., 2015; Plassmann, Venkatraman, Huettel, & Yoon, 2015). Consumer science is no exception to this trend. The use of biological variables in consumer science has increased in recent years. For example, physiological responses to marketing stimuli (e.g., ads, products or brand logos) have been investigated with neuroimaging techniques (Plassmann et al., 2015), hormonal assessments (Heany, van Honk, Stein, & Brooks, 2016), and evolutionary biological perspectives (Kenrick, Saad, & Griskevicius, 2013). Further understanding of consumer behaviors based on biology may provide new theoretical frameworks for examining consumption.

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FUNDAMENTAL MOTIVATION FRAMEWORK

Our ancestors (e.g., dwelling hunters) did not shop at Apple stores or 7-eleven. They did not face decisions about which brand of coffee to drink. However, modern consumer behaviors are, nevertheless, linked to the same motivations as our ancestors’ behavior.

From an evolutionary biology perspective, humans have inherited psychological adaptations for survival (Buss, 2015). Humans have “fundamental motivations” shaped by natural and sexual selection to enhance reproductive fitness (Griskevicius & Kenrick, 2013; Durante & Griskevicius, 2016). For successful reproduction, humans must achieve many subsidiary goals, including affiliation, self-protection, status attainment, mate attraction, mate retention, and child-rearing (Griskevicius & Kenrick, 2013; Durante & Griskevicius, 2016). Each fundamental motivation can be activated or primed by cues pertaining to threats or opportunities linked with each evolutionary challenge, leading to specific types of behaviors (Kenrick, Griskevicius, Neuberg, & Schaller, 2010). For example, the self-protection motive can be activated by encountering possible physical dangers (e.g., darkness), which lead people to be more conforming (Griskevicius, Goldstein, Mortensen, Cialdini, & Kenrick, 2006). Given that each challenge must be met for reproductive success, the underlying motives can be regarded as “fundamental motives” that influence modern human behaviors.

Consumer behaviors are also influenced by fundamental motives activated or primed by cues relating to threats or opportunities pertaining to a specific evolutionary challenge (Griskevicius & Kenrick, 2013; Durante & Griskevicius, 2016). Imagine that some people pay a lot of money for luxury goods with no functional merits, while others impulsively buy status goods in a display with sexy images. These ‘irrational’ consumer behaviors can be explained through a fundamental motivation framework (Griskevicius & Kenrick, 2013; Durante & Griskevicius, 2016). For the first example, status motivation can be activated by external triggers such as interacting with rivals or obtaining opportunities for competition (Griskevicius & Kenrick, 2013). The status motivation may lead to the purchasing of luxury goods. For the second example, mate acquisition motivation can be activated by external cues such as seeing sexy images (Griskevicius & Kenrick, 2013). These explanations suggest that a lot of consumer behaviors can be integrally understood via an evolutionary psychological theory such as the fundamental motivations framework.

Each motivational domain (corresponding to subsidiary goals: affiliation, self-protection, status attainment, mate attraction, mate retention, and child-rearing) has been considered to be based on qualitatively distinct cognitive and neural systems (“domain-specific hypothesis”; Kenrick et al., 2010; Griskevicius & Kenrick, 2013; Kenrick et al., 2013; Durante & Griskevicius, 2016). Consumer behaviors associated with status attainment, mate attraction, and mate retention motives are considered to be accompanied by different cognitive and neural functions (Kenrick et al., 2010; Griskevicius & Kenrick, 2013; Kenrick et al., 2013; Durante & Griskevicius, 2016). This hypothesis has been derived from animal and human neuroscience literatures. Human and non-human neuroscience studies have suggested that each domain of a fundamental motive may be based on distinct cognitive and neural systems (Kenrick et al., 2010). For example, it has
been suggested that birds use distinct, domain-specific neural systems for processing information connected to affiliation (e.g., remembering the species’ song) and self-protection (e.g., remembering the places where food can be found; Kenrick et al., 2010). Similarly, evolutionary psychologists have insisted that human beings are likely to use distinct, domain-specific neural systems for processing affiliation (e.g., remembering faces) and nausea-inducing foods (e.g., self-protection; Kenrick et al., 2010). However, the domain-specific hypothesis has not been directly tested so far, and it remains elusive whether fundamental motives have common or different cognitive and neural mechanisms.

**Hormones and Fundamental Motivations**

Fundamental motives can also be activated by internal cues, such as hormones (Griskevicius & Kenrick, 2013; Durante & Griskevicius, 2016). In addition to psychology and neuroscience (Meyer-Lindenberg, Domes, Kirsch, & Heinrichs, 2011; Motoki et al., 2016), consumer researchers have incorporated hormones into their field. Even though the number of publications have been few, increasing interest has recently been paid to the relations between consumer behavior and hormones based on the fundamental motivation framework (Stanton, 2016). It has been suggested that hormonal investigations in consumer research are potentially useful for understanding the biological mechanisms involved and for advancing the theory of fundamental motivations in relation to consumer behavior.

Sex steroid hormones in particular are likely to influence a set of motives among these fundamental motives, and these hormones are useful for investigating the domain-specific hypothesis. Testosterone, estrogen, and progesterone are sex steroid hormones, and commonly activate a set of fundamental motives (status attainment, mate retention, and mate acquisition) underlying many consumer behaviors. However, it remains uninvestigated whether these hormones modulate common or different cognitive and neural systems when activating each fundamental motive.

**Consumer Neuroscience**

Neuroscience has also been applied to consumer research, and a field called consumer neuroscience has emerged (Ariely & Berns, 2010; Smidts et al., 2014; Plassmann et al., 2015). Consumer neuroscience has investigated neural mechanisms of consumer behavior with neuroscientific tools. Consumer neuroscience has proved advantageous in advancing theoretical understandings of consumer behavior (Plassmann et al., 2015). Neuroscientific tools such as functional magnetic resonance imaging (fMRI) allow researchers to investigate what is happening in the brain while processing consumer stimuli (e.g., goods, advertising, or brand logos). Therefore, brain data rely less on self-report, and may be less influenced by responses biases, including social biases, memory distortion, and fabrication (Reimann, Schilke, Weber, Neuhaus, & Zaichkowsky, 2011). A pioneering experiment offers a good example of the advantage of fMRI data. Yoon and colleagues showed that brand and
human personality were differentially processed in the brain even though subjective reports were the same, and consumer scholars have suggested common cognitive mechanisms (Yoon, Gutchess, Feinberg, & Polk, 2006). Given that evolutionary motives and hormones unconsciously influence consumer behavior (Durante & Griskevicius, 2016), neuroscientific tools may provide a better understanding of the mechanisms of how each fundamental motive, influenced by hormones, is mapped on the brain, and further advance theory of the fundamental motives.

NEUROSCIENCE, FUNDAMENTAL MOTIVATIONS, AND HORMONES

The emerging research domains of neuroscience, fundamental motivations, and hormones have not yet intersected. Investigating consumer behavior with neuroscience and hormones at the same time may provide plentiful integrated biological information on the fundamental motives behind buying behavior. Neuroscientific tools such as fMRI can reveal neural mechanisms of the effects of hormones on consumer behavior underlying fundamental motives, and infer the cognitive mechanisms from the brain. Although specific cognitive mechanisms remain unclear with fMRI (Poldrack, 2006), it shows a range of potential cognitive mechanisms (Yarkoni, Poldrack, Nichols, Van Essen, & Wager, 2011). Neuroscientific tools can allow us to answer important questions about the relations between hormones and consumer behavior, such as whether the influence of hormones on each fundamental motive produces the same or different cognitive mechanisms (the same or different brain regions constitute the basis for each fundamental motivation).

In this paper, we propose an integrated understanding of the fundamental motives of

![Diagram](Fig. 1. Three fundamental motives (status attainment, mate attraction, and mate retention) may be explained by common cognitive and neural mechanisms. Sex steroid hormones (internal cues) commonly influence these motives and specific cognitive and neural systems. Consumer behaviors rooted in these fundamental motives may be commonly explained by social motivations/vigilance (amygdala activity) and reward processing (reward-related brain activity).)
consumer behavior that examines hormonal and neuroscientific perspectives. By taking sex steroid hormones as examples of internal cues activating fundamental motives, we suggest that at least three fundamental motives (status attainment, mate attraction, and mate retention) may be explained by common cognitive and neural mechanisms (Fig. 1). First, we explain previous research, which demonstrated relations between consumer behaviors, rooted in diverse fundamental motives, and sex steroid hormones. Then, we discuss the underlying neural mechanisms of sex steroid hormones relating to the fundamental motives of consumer behaviors, and propose that a set of consumer behaviors activated by sex steroid hormones may be explained by common cognitive and neural mechanisms. Next, we discuss how the potential cognitive and neural mechanisms among three fundamental motives can be modulated by internal and external cues (i.e., social relations). Finally, we offer concluding remarks.

**Testosterone and Consumer Behaviors Rooted in Fundamental Motives**

Testosterone is one of the sex steroid hormones. It is mainly produced by the Leydig cells of the testes in men, and by the ovaries and placenta in women. The adrenal cortex also secretes it in both men and women (Mazur & Booth, 1998). Although testosterone is well known for the development of secondary sexual attributes (e.g., increased muscle, bone mass and body hair in men), it also influences socio-emotional behaviors (Eisenegger, Haushofer, & Fehr, 2011), including dominant behavior, aggression, sexual behavior, cooperation and violence. Considering the effects of testosterone on socio-emotional behaviors, consumer researchers have recently investigated relations between testosterone and consumer behaviors rooted in fundamental motives, including mate retention, mate acquisition and status attainment (Stanton, 2016).

**Testosterone and Consumer Behavior Rooted in the MateRetention Motive**

The first study investigated the role of testosterone in gift-giving, which is linked with mate retention among the fundamental motives (Nepomuceno, Saad, Stenstrom, Mendenhall, & Iglesias, 2016a). To gift-give is to present something to someone to sustain and promote social relations (Carmichael & MacLeod, 1997). Considering that testosterone relates to cooperation, it would not be surprising that testosterone is linked with gift-giving. The study used the 2D:4D digit ratio (the proxy of prenatal testosterone exposure that compares the length of one’s second to fourth digit) as testosterone measures, instead of circulating testosterone (Stanton, 2016). Prenatal testosterone exposure inhibits the growth of the second digit (index finger) relative to the fourth digit. People with masculine digit ratios (i.e., lower) were exposed to a high testosterone-to-estrogen ratio, whereas people with feminine digit ratios (i.e., higher) were exposed to a low testosterone-to-estrogen ratio (Manning, Scutt, Wilson, & Lewis-Jones, 1998). The result showed that men with more
masculine digit ratios were more likely to offer erotic gifts (e.g., lingerie and erotic products) to romantic partners when their mating confidence (i.e., perception of how easily they feel able to gain sexual access to others) is high (Nepomuceno et al., 2016a).

**Testosterone and Consumer Behavior Rooted in the Mate Acquisition Motive**

A second study tested for the relationship between testosterone and mate acquisition motives on courtship-related consumption (Nepomuceno, Saad, Stenstrom, Mendenhall, & Iglesias, 2016b). Courtship-related consumption was defined as consumer behaviors used to woo potential or current mates. Given that testosterone relates to sex drives and opposite-mate acquisitions (Studer, Aylwin, & Reddon, 2005), people with higher testosterone would be more likely to show courtship consumption behaviors. Courtship-related consumptions were measured by subjective questionnaires, and reflected the tactics of mate attraction. Participants indicated how often they engage(d) in certain behaviors to become more attractive to the opposite sex when they are (were) single (1 = never, 7 = always). The example items included, “I went to the gym to become attractive,” or “Whenever I bought something expensive, I showed it off to women,” for males, and, “I wore makeup that accentuated my looks,” or “I wore jewelry,” for females. The study showed that men with more masculine digit ratios were more likely to engage in courtship-related consumption, and the interactions of masculine digit ratios, courtship-related consumption and mating confidence (the perceived ease with which one gains sexual access to others) was significant, indicating that the relation between masculine digit ratio and courtship-related consumption was greater when mating confidence was higher. In contrast, women with more masculine digit ratios were more likely to engage in greater courtship-related consumption.

**Testosterone and Consumer Behavior Rooted in the Status Attainment Motive**

A third study investigated the relation between testosterone and consumer behavior rooted in the status attainment motive (Saad & Vongas, 2009). The study investigated whether circulating testosterone levels can be increased after interacting with status goods (Saad & Vongas, 2009), relating to status motivation among the fundamental motives. Given that testosterone levels changed after attaining signaling status (e.g., experiences of winning; Bernhardt, Dabbs, Fielden, & Lutter, 1998), interacting with status goods would be expected to boost testosterone levels. The authors had participants drive either a new Porsche (status goods) or a 20-year old Toyota (non-status goods). After driving the Porsche, participants’ testosterone increased, whereas driving the Toyota car did not increase testosterone. The authors interpreted the results as demonstrating how conspicuous consumption (experiences of status goods) could affect circulating male hormones.
Although Saad and Vongas (2009) indicated that conspicuous consumption influenced testosterone levels, a recent study suggested that testosterone causally influenced status-related consumption (Nave, Nadler, Dubois, Camerer, & Plassmann, 2016). Two large studies (n = 243 males) showed that pharmacological manipulations of testosterone increased the preference for status goods. The first study revealed that single-dose testosterone administration (vs. placebo) led to greater preferences for brands with high status than for those with equivalent quality (e.g., Armani versus North Face). The second study showed that testosterone administration increased preference for brands advertised as high status, but not as high quality or high power.

This evidence suggests that testosterone relates to consumer behaviors rooted in various fundamental motives, including mate retention, mate acquisition, and status attainment.

**Brain Functions of Testosterone**

No study has investigated the influence of testosterone on consumer behaviors using fMRI. We reviewed previous fMRI studies of testosterone. The studies largely used socio-emotional paradigms, which divide, mainly, into processing of reward and negative facial expressions. From the literature, we discuss how testosterone potentially influences neural mechanisms of consumer behaviors rooted in fundamental motives.

A meta-analysis of fMRI studies of socio-emotional paradigms (e.g., face, crying infant, monetary incentive delay task) with testosterone administrations showed significant activation in emotional regions such as the bilateral amygdala, parahippocampal regions, and the right striatum compared with placebo (Heany et al., 2016). Although circulating testosterone studies include either female or male participants, or both, it should be cautioned that all samples used in pharmacological fMRI studies were female. This is because an established pharmacological paradigm does not exist in male populations, and it remains unknown when testosterone peaks following pharmacological manipulation in males. Nevertheless, the meta-analysis suggests that effects of testosterone on socio-emotional stimuli would be mediated by the functioning of the affective brain regions.

**Testosterone and Processing of Reward in the Brain**

Studies suggest that testosterone influences reward-related regions such as the stratum while processing rewarding stimuli, and the amygdala, in response to social information.

A single dose of testosterone enhanced striatal responses during reward anticipation in women (Hermans et al., 2010). Testosterone levels were positively correlated with the striatal response to receiving a monetary reward in adolescents for both sexes (de Macks et al., 2011). Moreover, fetal testosterone enhanced reward-related brain activity during processing of positive facial expressions for teens (Lombardo et al., 2012), while women following testosterone administration also demonstrated increased amygdala activation.
when seeing happy faces (Bos, van Honk, Ramsey, Stein, & Hermans, 2013).

Combined, this evidence indicates that testosterone boosts reward sensitivity to economic stimuli by enhancing reward-related brain activity and social motivations to social cues by increasing activity in the amygdala.

**TESTOSTERONE AND PROCESSING OF NEGATIVE FACIAL EXPRESSIONS IN THE BRAIN**

Studies suggest that testosterone influences amygdala activity while processing negative facial expressions, and it may be modulated by the orbitofrontal cortex (OFC).

Derntl et al. (2009) showed that circulating testosterone is positively correlated with amygdala activity during processing of negative facial expressions in men, but not women. Other studies also show that a single administration of testosterone increases amygdala activity while seeing angry facial expressions (Hermans, Ramsey, & van Honk, 2008) and while processing a threat (angry face) approach, but decreases it during threat avoidance (Radke et al., 2015). Testosterone administration reduces functional connectivity between the amygdala and the OFC in response to angry and fearful faces (van Wingen, Mattern, Verkes, Buitelaar, & Fernández, 2010), but has also been shown to decrease functional connectivity between the amygdala and the OFC during judgments of unfamiliar faces, while increasing amygdala responses to untrustworthy faces (Bos, Hermans, Ramsey, & van Honk, 2012).

It has been proposed that testosterone increases social vigilance (sensitivity to negative social information) via increased amygdala activation. Reduced connectivity between the amygdala and OFC by testosterone may produce diminished inhibitory control from prefrontal-amygdala, and increase social vigilance.

**POTENTIAL NEURAL AND COGNITIVE MECHANISMS OF INFLUENCES OF TESTOSTERONE ON CONSUMER BEHAVIORS ROOTED IN FUNDAMENTAL MOTIVES**

Testosterone affects fundamental motivations, including mate retention, mate acquisition, and status. Previous studies show that testosterone relates to erotic gift-giving (mate retention; Nepomuceno et al., 2016a), courtship-related consumption (mate acquisition; Nepomuceno et al., 2016b), and status consumption (status attainment; Saad & Vongas, 2009; Nave et al., 2016).

These consumer behaviors related to testosterone may be commonly attributable to increased social motivations (enhanced amygdala activity to social cue) and rewarding processing (enhanced reward-related neural activity). In addition, situational variables (i.e., mating confidence) influencing the effects of testosterone on consumer behavior may be reflected in social vigilance (increased amygdala activity through less inhibition of the OFC). For example, individuals with high testosterone may feel more social motivation and rewarding experiences when they are engaged in mate retention, mate acquisition, and status consumption. The tendency may be inhibited when they feel more social vigilance.
Evolutionary psychologists have hypothesized that each motivation is qualitatively different and domain-specific (Kenrick et al., 2010). However, neuroimaging studies indicate that the effects of testosterone on consumer behaviors rooted in fundamental motives are likely to be explained by a unified cognitive and neural mechanism across each motivation.

**ESTROGEN, PROGESTERONE, AND CONSUMER BEHAVIORS ROOTED IN FUNDAMENTAL MOTIVES**

Estrogen and progesterone are female sex hormones (Nelson, 2005). They are produced primarily in the ovaries; the adrenal glands also make them. They are responsible for developing the female reproductive system and secondary sex characteristics. They help in growth of the breasts, creating hair, keeping bones healthy, and the beginning of menstruation. These hormones not only influence ovulation but also affect affective and cognitive functions (Toffoletto, Lanzenberger, Gingnell, Sundström-Poromaa, & Comasco, 2014), relating to consumer behavior rooted in various fundamental motives, including mate retention, mate acquisition and status attainment.

The role of estrogen and progesterone in consumer research has recently focused, mainly, on women. Rather than directly using circulating hormones, most preexisting works on consumer behavior have used menstrual cycles (related to fluctuations of estrogen and progesterone levels). Levels of estrogen peak (but lower progesterone) in the ovulatory phase each month when women are most fertile (the periovulatory period; Jones & Lopez, 2013). Most research has focused on this period and, therefore, the existing research may primarily indicate the role of high estrogen and low progesterone on consumer behavior.

This line of consumer research has been largely inspired by the ovulatory shift hypothesis (Gangestad & Thornhill, 1998), which is a grounding theory of evolutionary psychology. The ovulatory shift hypothesis suggests that women’s behaviors, such as sexual desire and mate choice, are influenced by menstrual phases, due to evolutionary pressures. It also indicates that menstrual cycle fluctuations associated with estrogen and progesterone lead to shifts in status attainment, mate acquisition, and mate retention among the fundamental motives.

**ESTROGEN, PROGESTERONE, AND CONSUMER BEHAVIOR ROOTED IN MATE ACQUISITION AND MATE RETENTION**

There is a set of research applying the ovulatory shift hypothesis to consumer settings rooted in fundamental motives, including mate acquisition and mate retention. Firstly, Durante and colleagues revealed that women in the periovulatory phase were more likely to choose sexier clothes and accessories (goods with signals showing their attractiveness to males or mates; Durante, Li, & Haselton, 2008). The result was consistent with a diary study of actual expenditures on beauty-related consumption. Women in the periovulatory
phase paid more money for beauty-related items of consumption (Saad & Stenstrom, 2012). Saad and Stenstrom (2012) also showed that women in the periovulatory phase paid less money for items of food consumption, possibly indicating that the women had the intention of keeping their figures attractive and avoiding weight gain to improve their physical attractiveness. Similar effects were revealed in field studies. Women in the periovulatory phase were more likely to wear sexy and revealing clothing (Durante et al., 2008), and behave in a more provocative way in a social environment (a bar/club; Grammer, Renninger, & Fischer, 2004).

Further, Durante, Griskevicius, Hill, Perilloux, and Li (2011) investigated whether perceptions of rival women could alter their choices of sexy clothes depending upon their menstrual phases. After perceiving attractive women, women in the periovulatory phase were more likely to choose sexy clothing. The authors argued that the women perceived the attractive women as a competitive threat and that they had to beat rivals with more sexual signaling products.

**Estrogen, Progesterone, and Consumer Behavior Rooted in Status Attainment and Mate Retention Motives**

Durante, Griskevicius, Cantu, and Simpson (2014) also investigated the influence of menstrual cycles on consumer behaviors rooted in status attainment and mate retention motives. They investigated whether the menstrual cycle affects women’s use of status-goods (conspicuous consumption) to boost their position relative to rival women. The results showed that women in the periovulatory phase are motivated by relative, but not absolute, status, and sought status goods (diamond rings and cars) that provided them with a relative gain compared with other women.

Together, these studies support the ovulatory shift hypothesis, and indicate that women in the periovulatory phase (and, possibly, those experiencing increases in estrogen and decreases in progesterone) may seek sexier or higher status goods to outperform rival women.

**Brain Functions of Estrogen and Progesterone**

No study has investigated the influence of estrogen and progesterone on consumer behaviors using fMRI. We reviewed previous fMRI studies of female hormones (menstrual, estradiol, and progesterone). The studies largely used socio-emotional paradigms, which divide, mainly, into processing of reward and negative facial expressions. From the literature, we discuss how estrogen and progesterone potentially influence neural mechanisms of consumer behaviors rooted in fundamental motives.

A systematic review of the effects of female hormones (menstrual, estradiol, and progesterone) on female brain functions suggests that the underlying neural systems are the amygdala, the anterior cingulate cortex, the insula, and the inferior and middle frontal
The result showed that emotional (amygdala, insula, ventral part of anterior cingulate cortex and prefrontal cortex) and cognitive (dorsal part of anterior cingulate cortex and prefrontal cortex) processes in the brain may be related to female hormonal fluctuations such as estradiol and progesterone (Toffoletto et al., 2014).

**ESTROGEN, PROGESTERONE, AND REWARD IN THE BRAIN**

It has been suggested that estrogen enhances reward responsiveness, while progesterone inhibits the reactions to rewards, and brain imaging findings may support the hypothesis (Sakaki & Mather, 2012).

A study indicated increased activation in OFC and amygdala during anticipatory reward in the mid-follicular phase (high estrogen and low progesterone) compared with the mid-luteal phase (low estrogen and high progesterone; Dreher et al., 2007). Increased activation in the OFC and left insula were observed in response to erotic videos during mid-cycle (high estrogen and low progesterone; Gizewski et al., 2006). mOFC was also more activated during evaluations of male face attractiveness in the late follicular phase (high estrogen and low progesterone) than mid-luteal phase (low estrogen and high progesterone; Rupp et al., 2009). Also, the estrogen to progesterone ratio was positively correlated with mOFC activity (Rupp et al., 2009). Moreover, during the late follicular phase (high estrogen and low progesterone), high-calorie foods (e.g., cookies) induced greater activity in reward-related regions, such as the striatum, than during the luteal phase (low estrogen and high progesterone; Frank, Kim, Krzemien, & Van Vugt, 2010). This tendency was not observed during the luteal phase (high estrogen and low progesterone).

High estrogen may lead to more activation in the valuation systems in the brain such as the OFC, and reward-related regions such as the striatum, when women near or during ovulation evaluate males.

**ESTROGEN, PROGESTERONE, AND PROCESSING OF NEGATIVE FACIAL EXPRESSIONS IN THE BRAIN**

It has been suggested that estrogen decreases responses to negative emotions, while progesterone increases the reactions to negative emotions, and brain imaging findings may support this hypothesis (Sakaki & Mather, 2012).

High estrogen and low progesterone may decrease fearful behavior and decrease amygdala activation. A study demonstrated enhanced activation in the amygdala as well as other regions in response to aversive affective pictures during the early follicular phase (low estrogen) compared with midcycle timing (high estrogen; Goldstein et al., 2005). Bilateral amygdala responses to emotional phases were increased following a single progesterone administration to healthy young women (van Wingen et al., 2008). The right amygdala was also more activated during processing of negative emotions in the high progesterone phase (Andreano & Cahill, 2010). Another study also observed greater
amygdala activity for negative emotional facial expressions during the follicular phase than the luteal phase (Derntl et al., 2008).

These studies indicate that high estrogen and low progesterone may decrease fearful behavior via diminished amygdala activation.

**Potential Neural and Cognitive Mechanisms of Influences of Estrogen and Progesterone on Consumer Behaviors Rooted in Fundamental Motives**

Female hormones (estrogen and progesterone) affect fundamental motivations, including mate retention, mate acquisition, and status. Studies have shown that fluctuations of female hormones (menstrual cycle) are related to sexual signaling products (mate acquisition; Durante et al., 2008) and status-goods (status attainment; Durante et al., 2014), and that they are mediated by the perception of rival women (mate retention; Durante et al., 2011, 2014).

Two female hormones may conversely affect consumer behavior. High estrogen and low progesterone may decrease amygdala activation and, therefore, fearful behavior. High estrogen and low progesterone may produce higher neural activation in valuation and reward-related regions.

These behavioral shifts, accompanied by ovulation (high estrogen and low progesterone), may be commonly attributable to decreased social vigilance (decreased amygdala activity) and value and rewarding processing (enhanced OFC and reward-related neural activity). For example, individuals near ovulation (high estrogen and low progesterone) may feel less social vigilance to overcome female rivals, and value rewarding experiences by acquiring sexier goods and status goods to attract males.

Evolutionary psychologists have hypothesized that each motivation is qualitatively different and domain-specific (Kenrick et al., 2010). However, neuroimaging studies indicate that the effects of female hormones on consumer behaviors rooted in fundamental motives are likely to be explained from a unified cognitive and neural mechanism across each motivation.

**Refining the Fundamental Motive Framework**

We have proposed that the domain-specific hypothesis has limitations. It has long been argued that each fundamental motive has specific cognitive and neural mechanisms, and that these motives influence consumer behaviors. However, we have discussed evidence that at least three fundamental motives, including mate retention, mate acquisition and status attainment, share common cognitive and neural mechanisms. Sex steroid hormones (testosterone, estrogen, and progesterone) influence diverse fundamental motives, including mate retention, mate acquisition and status attainment. We have suggested that the relation between internal cues (hormones) and fundamental motives (mate retention, mate acquisition and status attainment) may be commonly explained by
social motivations/vigilance (amygdala activity) and rewarding processing (reward-related brain activity).

Although we have focused on steroid sex hormones as examples of internal cues, three fundamental motives activated by external cues may share similar cognitive and neural mechanisms. Mate retention, mate acquisition and status attainment are also activated by similar external cues in the form of social relations (Griskevicius & Kenrick, 2013). Interacting with potential mates, spouse/partners, and friends have been previously considered different cues, each triggering a specific evolutionary motive such as mate acquisition, mate retention, and status attainment (Griskevicius & Kenrick, 2013). However, each cue similarly includes social relations. These motives, activated by social relations, may also integrate into common cognitive and neural mechanisms such as social motivation/vigilance (amygdala) or rewarding experiences (reward-related brain activity).

In this paper, we hypothesized that three fundamental motives—mate retention, mate acquisition, and status attainment—can be explained by common cognitive and neural mechanisms, regardless of internal or external cues. The fundamental motive framework can be refined by incorporating consumer neuroscience perspectives. Future empirical studies should investigate our hypothesis.

**Concluding Remarks**

Consumer behaviors have evolutionary roots and are shaped by fundamental motives: affiliation, self-protection, status attainment, mate attraction, mate retention, and child rearing. Recently, consumer scholars have investigated relations between steroid hormones and consumer behaviors rooted in these fundamental motives. Steroid hormones, including testosterone, estrogen and progesterone, are internal cues triggering consumer behaviors rooted in fundamental motives. In contrast to the traditional view that each motivation is qualitatively different, we proposed that consumer behaviors rooted in three fundamental motives (status attainment, mate attraction, and mate retention) can be explained by a unified cognitive and neural mechanism across each motivation. We have suggested that the influence of cues on the three fundamental motives may be explained by social motivations/vigilance (amygdala activity) and rewarding processing (reward-related brain activity). Internal cues (steroid hormones) as well as external cues (social relations) may modulate the same cognitive and neural mechanism in common, and thus change consumer behaviors rooted in diverse fundamental motives such as status attainment, mate attraction, and mate retention.

Neuroscientific tools such as functional magnetic resonance imaging (fMRI) would be useful in further investigating the issue. The present article has proposed that fMRI and hormones can contribute to revealing the underlying mechanisms of consumer behaviors rooted in fundamental motives. Future studies should investigate this hypothesis. We hope that the intersection of consumer research, endocrinology, and neuroscience will broaden our theoretical understanding of consumption that is rooted in fundamental motives.
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