NOBA

Drive States

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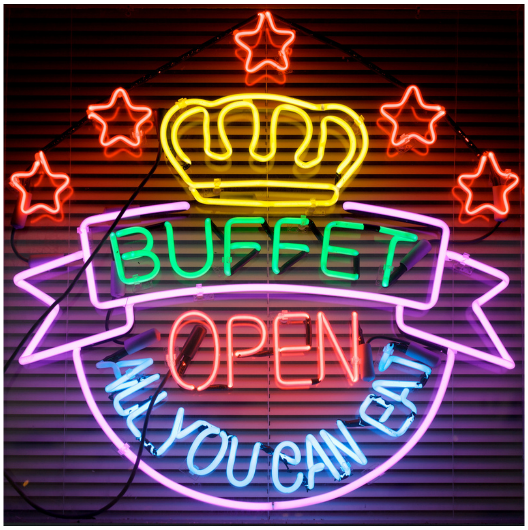
Our thoughts and behaviors are strongly influenced by affective experiences known as drive states. These drive states motivate us to fulfill goals that are beneficial to our survival and reproduction. This module provides an overview of key drive states, including information about their neurobiology and their psychological effects.

Learning Objectives

- Identify the key properties of drive states.
- Describe biological goals accomplished by drive states.
- Give examples of drive states.
- Outline the neurobiological basis of drive states such as hunger and arousal.
- Discuss the main moderators and determinants of drive states such as hunger and arousal.

Introduction

What is the longest you've gone without eating? A couple of hours? An entire day? How did it feel? Humans rely critically on food for nutrition and energy, and the absence of food can create drastic changes not only in physical appearance, but in thoughts and behaviors. If you fasted for a day, you probably noticed how hunger can take over your mind: Direct your attention to the foods that you could be eating (a cheesy slice of pizza, or perhaps some sweet and cold ice cream), and motivate you to obtain and consume these foods. And once you have eaten and your hunger has satisfied, your thoughts and behaviors return to normal.



Hunger is among our most basic motivators [Photo: Jeremy Brooks]

Hunger is a **drive state**, an affective experience that motivates organisms to fulfill goals that are generally beneficial to their survival and reproduction. Like other drive states, such as thirst or sexual arousal, hunger has a profound impact on the functioning of the mind. It affects psychological processes, such as perception, attention, emotion, and motivation, and influences the behaviors that these processes generate.

Key Properties of Drive States

Drive states differ from other affective or emotional states in terms of the biological functions they accomplish. Whereas all affective states possess valence and serve to motivate approach or avoidance behaviors (Zajonc, 1998), drive states are unique in generating behaviors that result in specific benefits for the body. For example, hunger directs individuals to eat foods that increase blood sugar levels in the body, while thirst causes individuals to drink fluids that increase water levels in the body.

Different drive states have different triggers. Most drive states respond to both internal and external cues, but the mix of internal and external, and the specific cues, differ between drives. Hunger, for example, depends on internal, visceral signals as well as sensory signals such as the sight or smell of tasty food. Different drive states also result in different cognitive and feeling states and are associated with different behaviors. Yet despite these differences, there are a number of properties common to all drive states.

Homeostasis

Humans, like all organisms, need to maintain a stable state in their various physiological systems. For example, the excessive loss of body water results in dehydration, a dangerous and potentially fatal state, but too much water can be damaging as well: A moderate and stable level of body fluid is ideal. The tendency of an organism to maintain this stability across all the different physiological systems in the body is called **homeostasis**.

Homeostasis consists of two main ingredients. First, the state of the system being regulated must be monitored and compared to an ideal level, or a **set point**. Second, there need to be mechanisms for moving the system back to this set point, that is, to restore homeostasis, when deviations from it are detected.

Many homeostatic mechanisms, such as blood circulation and immune responses, are automatic and nonconscious. Others, however, involve deliberate action. Most drive states motivate action to restore homeostasis using both a carrot and a stick. The stick is the bad feeling, such as hunger, thirst, or the misery of cold or heat, that occurs when one departs from the set point. The carrot is the pleasure derived from any activity that moves the system back toward the set point. For example, when body temperature declines below the set point, any activity that helps to restore homeostasis, such as putting one's hand in warm water, feels pleasurable, and likewise, when the body temperature is above the set point, anything that cools it feels pleasurable.

The body needs homeostasis and motivates us - through both pleasure and pain - to stay in balance. [Photo: Ian Sane]

The Narrowing of Attention

As drive states intensifies, they direct attention toward elements, activities, and forms of consumption that satisfy the biological need associated with the drive. Hunger, for example, draws attention toward food. Outcomes and objects that are not related to satisfying hunger lose their value (Easterbrook, 1959). Indeed, at a sufficient level of intensity, individuals will sacrifice almost any quantity of goods that do not address the need signaled by the drive state. For example, cocaine addicts, according to Gawin (1991:1581), "report that virtually all thoughts are focused on cocaine during binges; nourishment, sleep, money, loved ones, responsibility, and survival lose all significance."

Drive states also produce a second form of attention narrowing: a collapsing of time-perspective toward the present. While this form of attention-narrowing is particularly pronounced for the outcomes and behaviors directly related to the biological function being served by the drive state at hand, it applies to the general concern for the future as well. Ariely and Loewenstein (2006), for example, investigated the impact of sexual arousal on the thoughts and behaviors of a sample of male undergraduates. These undergraduates were lent laptop computers that they could bring back to their private residences, where they answered a series of questions both in normal states and in states of high sexual arousal. Ariely and Loewenstein found that being sexually aroused made people extremely impatient for both sexual outcomes and for outcomes in other domains, such as those involving money. In another study Giordano et al. (2002) found that heroin addicts were more impatient with respect to heroin when they were craving heroin than when they were not. More surprisingly, they were also more impatient toward money (they valued delayed money less) when they were actively craving heroin.

Yet a third form of attention-narrowing involves thoughts and outcomes related to the self versus others. Intense drive states tend to narrow one's focus inwardly and to undermine altruism. People who are hungry, in pain, or craving drugs tend to be selfish. Indeed, popular interrogation methods involve depriving individuals of sleep, food, or water, so as to trigger intense drive states leading the subject of the interrogation to divulge information that may betray comrades, friends, and family (Biderman, 1960).

Two Illustrative Drive States

Thus far we have considered drive states abstractly. We have discussed the ways in which they relate to other affective and motivational mechanisms, as well as their main biological purpose and their general effects on thought and behavior. Yet despite serving the same broader goals, different drive states are often remarkably different in terms of their specific properties. To understand some of these specific properties, we will explore two different drive states that play a very important role in determining behavior, and in ensuring human survival: hunger and sexual arousal.

Hunger

Hunger is a paradigmatic drive state that results in thoughts and behaviors related to the consumption of food. Hunger is generally triggered by low glucose levels in the blood (Rolls, 2000), and behaviors resulting from hunger aim to restore homeostasis regarding glucose and its presence in the body. Various other internal and external cues can also cause hunger. For example, the chemical composition of the food training from the stomach serves as an internal cue for the body to initiate the search for food (Greenberg, Smith, & Gibbs, 1990). External cues include the time of day, estimated time until the next feeding (hunger increases

External cues, like the sight and smell of food, can ignite feelings of hunger. [Photo: Royal Olive]

immediately prior to food consumption), and the sight, smell, taste, and even touch of food and food-related stimuli. Note that while hunger is a generic feeling, it has nuances that can produce the eating of specific foods that correct for nutritional imbalances, which we may not be conscious of.

The **hypothalamus** plays a very important role in eating behavior. It is responsible for synthesizing and secreting various hormones. The lateral hypothalamus (LH) is concerned largely with hunger. Lesions of the LH can eliminate all eating to the point where animals will starve to death unless kept alive by force feeding (Anand & Brobeck, 1951). Additionally, artificially stimulating the LH, using electrical currents, can generate eating behavior if food is available (Andersson, 1951).

Activation of the LH cannot only increase the desirability of food but can also reduce the desirability of nonfood-related items. Brendl, Markman, and Messner (2003), for example, found that participants who were given a handful of popcorn to trigger hunger not only had higher ratings of food products, but also had lower ratings of nonfood products, compared with participants whose appetites were not similarly primed.

Hunger is only part of the story of when and why we eat. An analogous process, satiation, relates to the decline of hunger and the eventual termination of eating behavior. In fact, hunger and satiation are two distinct processes, controlled by different circuits in the brain and triggered by different cues. Distinct from the LH, which plays an important role in hunger, the ventromedial hypothalamus (VMH) plays an important role in satiety. While lesions of the VMH can make an animal overeat to the point of obesity, the relationship between the LH and the VMH is quite complicated. Rats with VMH lesions can be quite finicky about their food (Teitelbaum, 1955).

Other brain areas, besides the LH and VMH, also play important roles in eating behavior. The sensory cortices (visual, olfactory, and taste), for example, are important in identifying food items. These areas provide informational value and not hedonic evaluations. While many of their functions are roughly stable across different psychological states, other functions, such as the detection of food-related stimuli, are enhanced when the organism is in a hungry drive state.

After identifying a food item, the brain also needs to determine its **reward value**, which affects the organism's motivation to consume the food. The reward value ascribed to a particular item is, not surprisingly, sensitive to the level of hunger experienced by the organism. Neurons in the areas where reward values are processed, such as the orbitofrontal cortex, fire more rapidly at the sight or taste of food when the organism is hungry relative to if it is satiated.

Sexual Arousal

A second drive state, especially critical to reproduction, is sexual arousal. Sexual arousal results in thoughts and behaviors related to sexual activity. As with hunger, it is generated by a large range of internal and external mechanisms that are triggered either after the extended absence of sexual activity or by the immediate presence and possibility of sexual activity (or by cues commonly associated with such possibilities). Unlike hunger, however, these mechanisms can differ substantially between males and females, indicating important evolutionary difference in the biological functions that sexual arousal serves for different sexes.

Unlike other drive states the mechanisms that trigger sexual arousal are not the same for men and women. [Photo: Matthew Romack]

Sexual arousal and pleasure in males, for example, is strongly related to the **preoptic area**, a region in the anterior hypothalamus. If the preoptic area is damaged, male sexual behavior is severely impaired. Interestingly, damage to the preoptic area does not affect certain types of sexual motivations. For example, rats that have had prior sexual experiences will still seek out sexual partners after their preoptic area is lesioned. However, once having secured a sexual partner, rats with lesioned preoptic areas will show no further inclination to actually initiate sex.

For female behavior, the ventromedial hypothalamus plays a similar role. Neurons in the ventromedial hypothalamus determine the excretion of estradiol, an estrogen hormone that regulates sexual receptivity. In many mammals, these neurons send impulses to the periaqueductal gray, a region in the midbrain responsible for defensive behaviors (such as freezing immobility, running, increases in blood pressure, and so on) and other motor responses. During sexual arousal, these defensive responses are weakened and **lordosis** behavior, a physical sexual posture that serves as an invitation to mate, is initiated (Kow and Pfaff, 1998).

Other differences between males and females involve overlapping functions of neural modules that often provide clues about biological roles played by sexual arousal and sexual activity in males and females. Areas of the brain that are important for male sexuality overlap to a great extent with areas that are also associated with aggression. In contrast, areas important for female sexuality overlap extensively with those that are also connected to nurturance (Panksepp, 2004).

One region of the brain that seems to play an important role in sexual pleasure, for both males and females, is the septal nucleus, an area receiving reciprocal connections from many other brain regions, including the hypothalamus and the amygdala. This region shows considerable activity, in terms of rhythmic spiking, during sexual orgasm. It is also one of the brain regions that rats will most reliably voluntarily self-stimulate (Olds & Milner, 1954). In humans, placing a small amount of acetylcholine in to this region, or stimulating it electrically, has been reported to produce a feeling of imminent orgasm (Heath, 1964).

Conclusion

Drive states are evolved motivational mechanisms designed to ensure that organisms take self-beneficial actions. In this module, we have reviewed key properties of drive states, such as homeostasis and the narrowing of attention. We have also discussed, in detail, two important drive states—hunger and sexual arousal—and explored their underlying neurobiology and the ways in which various environmental and biological factors affect their properties.

There are many drive states, besides hunger and sexual arousal, which affect humans on a daily basis. Fear, thirst, exhaustion, exploratory and maternal drives, and drug cravings are all drive states that have been studied by researchers (see e.g., Buck, 1999; Van Boven & Loewenstein, 2003). While these drive states share the properties discussed in this module, each also has unique features that allows it to effectively fulfill its evolutionary functions.

One key difference between drive states is the extent to which they are triggered by internal as opposed to external stimuli. Thirst, for example, is induced both by decreased fluid levels and an increased concentration of salt in the body. Fear, on the other hand, is induced by perceived threats in the external environment. Drug cravings are triggered both by internal homeostatic mechanisms and by external visual, olfactory, and contextual cues. Other drive states, such as those pertaining to maternity, are triggered by specific events in the organism's life. Differences such as these make the study of drive states a scientifically interesting and important endeavor. Drive states are rich in their diversity, and many questions involving their neurocognitive underpinnings, environmental determinants, and behavioral effects, have yet to be answered.

One final thing to consider, not discussed in this module, relates to the real-world consequences of drive states. Hunger, sexual arousal, and other drive states are all psychological mechanisms that have evolved gradually over millions of years. We share these drive states not only with our human ancestors but with animals such as monkeys, dogs, and rats. It is not surprising then that these drive states, at times, lead us to behave in ways that are ill-suited to our modern lives. Consider, for example, the obesity epidemic that is affecting countries around the world. Like other diseases of affluence, obesity is a product of drive states that are too easily fulfilled: homeostatic mechanisms that worked well when food was scarce backfire when a meal rich in fat and sugar is readily available. Unrestricted sexual arousal can have a similarly perverse effect on our well-being. Countless politicians have sacrificed their entire life's work (not to mention their marriages) by satisfying adulterous sexual impulses toward colleagues, staffers, prostitutes, and others over whom they have social or financial power. It not an overstatement to say that many problems of the 21st century, from school massacres to obesity to drug addiction, are influenced by the mismatch between our drive states and our uniquely modern ability to fulfill them at a moment's notice.

Outside Resources

Web: An open textbook chapter on homeostasis
http://en.wikibooks.org/wiki/Human_Physiology/Homeostasis

Web: Motivation and emotion in psychology
http://allpsych.com/psychology101/motivation_emotion.html

Web: The science of sexual arousal
http://www.apa.org/monitor/apr03/arousal.aspx

Discussion Questions

1. The ability to maintain homeostasis is important for an organism's survival. What are the ways in which homeostasis ensures survival? Do different drive states accomplish homeostatic goals differently?
2. Drive states result in the narrowing of attention toward the present and toward the self. Which drive states lead to the most pronounced narrowing of attention toward the present? Which drive states lead to the most pronounced narrowing of attention toward the self?
3. What are important differences between hunger and sexual arousal, and in what ways do these differences reflect the biological needs that hunger and sexual arousal have been evolved to address?
4. Some of the properties of sexual arousal vary across males and females. What other drives states affect males and females differently? Are there drive states that vary with other differences in humans (e.g., age)?

Vocabulary

Drive state
Affective experiences that motivate organisms to fulfill goals that are generally beneficial to their survival and reproduction.

Homeostasis
The tendency of an organism to maintain a stable state across all the different physiological systems in the body.

Homeostatic set point
An ideal level that the system being regulated must be monitored and compared to.

Hypothalamus
A portion of the brain involved in a variety of functions, including the secretion of various hormones and the regulation of hunger and sexual arousal.

Lordosis
A physical sexual posture in females that serves as an invitation to mate.

Preoptic area
A region in the anterior hypothalamus involved in generating and regulating male sexual behavior.

Reward value
A neuropsychological measure of an outcome's affective importance to an organism.

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The Diener Education Fund is co-founded by Drs. Ed and Carol Diener. Ed is the Joseph Smiley Distinguished Professor of Psychology (Emeritus) at the University of Illinois. Carol Diener is the former director of the Mental Health Worker and the Juvenile Justice Programs at the University of Illinois. Both Ed and Carol are award- winning university teachers.

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