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HIGHER REFLEXES: AN ATTEMPT AT COMPREHENSIVE CLASSIFICATION OF NEURO-BEHAVIORAL ACTIVITY

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Abstract. The term reflex is used in its widest sense and denotes the neural processes and effector responses controlled by the evoking stimulus and the feedback stimuli. The reflexes having their specific component facilitated by drive central processes are denoted as higher. Escape, avoidance and approach higher reflexes are distinguished: they include, respectively, pain, fear and appetite drive central processes. Approach reflex contains in addition pleasure central processes. Higher reflexes are usually in a chain from. The role of the consummatory stage, which is present is some escape and approach reflexes, is analysed. The reflexes are grouped in several systems according to the particular functions they perform in an organism.

I. INTRODUCTION

Although the problem of classification of neuro-behavioral activity (i. e., reflexes in broad sense of this term) was attacked by several authors (Sechenov 1935, Hebb 1958, Beritov 1965, 1967, Konorski 1967), there is no satisfactory classification available. In the previous report (1968) I proposed a new classification of reflexes and now it is presented in a much more elaborated form.

My classification is based on the differences in the biological role of reflexes and the presumably associated differences in their central mechanism. Since I assume that psychic responses exist not only in man but also in higher animals, the introspective data will be extensively utilized. The analysis of emotional psychic responses (i. e. emotions), which are considered the essential manifestations of higher reflexes, will play a great role.

In order to simplify our considerations, two important limitations are made: (i) the plasticity of reflexes will not be discussed: conditioned

reflexes will be considered in their firmly established state, and (ii) the interaction of reflexes will be neglected.

The already existing terms will be utilized as much as possible. Some of the terms will be used in their very broad sense. The main term "reflex" is an example (*see* Section II). A glossary is provided at the end of the paper.

II. FUNDAMENTALS

The term *reflex* will denote the neural processes and the effector (behavioral) responses controlled by the *evoking* stimulus and the *feedback* stimuli. In many reflexes feedback control is provided by means of kinesthetic and visual stimuli. The role of feedback control is especially important in chain reflexes (*see* Section V).

The components of reflex

In order to make the analysis of reflexes easier, several reflex components will be distinguished. They are as follows: (i) *lower specific* component, (ii) *orienting* component, (iii) *arousal* component, (iv) *emotional* component, and (v) *higher specific* component. All these components are composed of neural and behavioral counterparts.

In the reflex evoked by a nociceptive stimulus acting on a leg, for example, these components may be manifested overtly as follows: the lower specific component by the flexion of the leg, crossed extension, etc.; the orienting component by directing the head and eyes toward the stimulated leg; the arousal component by the pupillary dilatation, changes in the heart rate, etc.; the emotional component by the facial expression of fear; and the higher specific component by removing the nociceptive agent with an appropriate tool.

Emotional component

Behavioral analysis of the emotional component is difficult. Central emotional processes, however, are well manifested introspectively.

An emotion I will denote as any unpleasant of pleasant psychic response (*see* Żernicki 1968). Four main types of emotion will be distinguished: *pain, pleasure, fear* and *appetite.* The corresponding central processes are, respectively, pain, pleasure, fear and appetite processes. All these terms are used, of course, in the broadest sense of the word. Pain, for example, may be evoked by a nociceptive cutaneous stimulus, by dehydration of body, by a loud noise, etc. Alimentary or sexual appetites, for example, may be produced, respectively, by the sight of tasty food and the sight of an attractive member of the opposite sex.

Pain and sometimes pleasure are primary emotions. Fear, appetite and sometimes pleasure are secondary emotions: they are produced by the stimuli signalling pain or primary pleasure. The stimuli evoking pain, primary pleasure and fear will be called, respectively, *painful*, *pleasant* and *fearful*. The stimulus evoking appetite and secondary pleasure (e. g., the sight of food) will be called *appetitive*. This "double" meaning of the appetitive stimuli will be discussed in detail in Section III. Pain, fear and appetite are negative emotions or *drive emotions*, whereas pleasure is the positive emotion.

The emotions are usually accompanied by gnostic psychic responses (gnostic perceptions and images). The pain emotion evoked by a cutaneous stimulus and the fear emotion evoked by the sight of a predatory animal, for example, are accompanied by gnostic perceptions localizing these stimuli.

Pain central processes and primary pleasure central processes are usually innate. In the process of perceptual learning, however, a number of stimuli evoking primary pleasure, and perhaps also those evoking pain, may be increased. For example, the pleasure evoked by some sophisticated kinds of tasty food, by good music of by a beautiful picture may be acquired. In contrast, fear, appetite and secondary pleasure central processes are usually acquired. Even in man, however, some of these processes may be innate. For example, the sight of a predatory animal and height may evoke innate fear, and the sight of an attractive member of the opposite sex evokes innate sexual appetite and secondary pleasure.

Specific components

A specific component can play two roles. Firstly, the specific effector response can be directed to the stimulus evoking the reflex, and it abolishes or at least decreases its intensity (Fig. 1). For example, a nociceptive stimulus is removed by flexion of the leg. Second, the specific effector response can provide a *goal* stimulus (or *antidrive* stimulus, *see* Konorski 1967), which inhibits the drive emotional processes (Fig. 1). In the flight reflex of a child, for example, the goal stimulus is contact with the mother and this stimulus inhibits fear central processes. The first category of effects is more common for the lower specific component, and the second, for the higher specific component.

The higher and lower specific components differ also in several other aspects:

1. Only the higher component is facilitated by drive central processes (negative emotional central processes). This point will be discussed in detail in Section III.

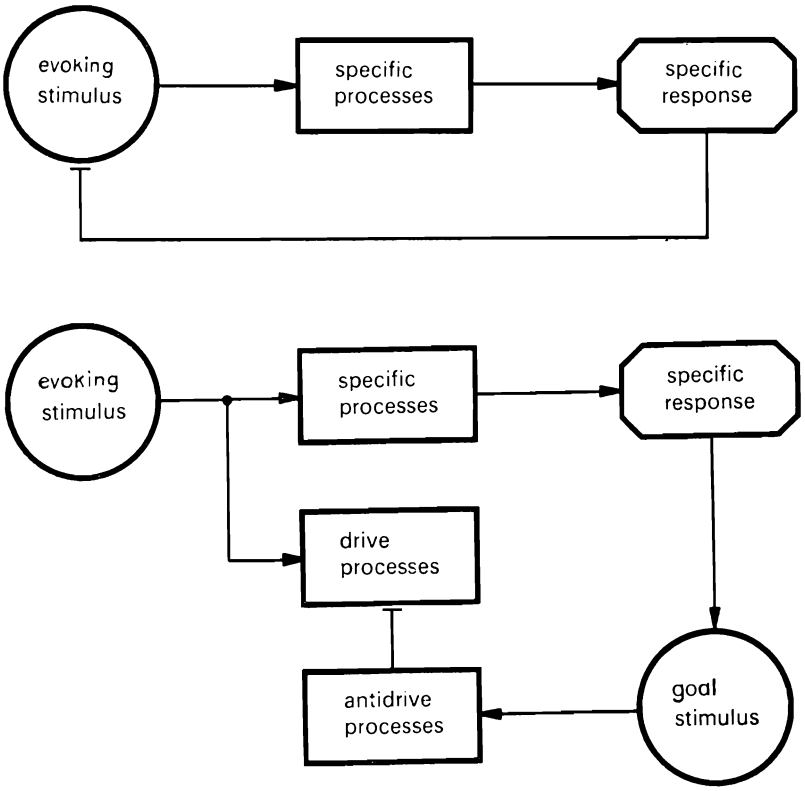

Fig. 1. Two possible effects of specific response. Above: the response diminishes the intensity of the evoking stimulus. Below: the response provides a goal stimulus inhibiting the drive central processes.

Explanations for this and subsequent figures: Stimulus, central processes and specific effector response are located, respectively, in the circle, in the rectangle, and in the octagon. Arrow denotes evoking the central processes, or an effector response, or a stimulus. Line ended by perpendicular dash denotes inhibition of central processes, of abolition (or diminution) of a stimulus. Bent arrow denotes facilitation of central processes. Interrupted line denotes weak influence. Underlining indicates the lower specific component.

2. Only the higher component contains gnostic central processes (manifested by gnostic perceptions and images).

3. In the majority of cases the higher specific component is totally or partially acquired, whereas the lower component is innate.

4. For the higher component the cerebrum is essential, whereas the lower component is localized mainly in the segmental part of the CNS. Therefore, after decerebration, under narcosis and during sleep the higher component it lost, whereas the lower component is essentially intact.

The lower specific component can play three different roles:

1. Together with the higher component it constitutes one functional entily: the higher component is "superimposed" on the lower. In the reflex evoked by a painful stimulus acting on the leg, for example, the flexion can be in part the lower component and in part the higher component.

2. It is a necessary background for the higher component. In the locomotor reflex to food, for example, several postural responses constitute such a background. However, for simplicity, this role of the lower component will be omitted in our discussion.

3. In constitutes the final stage of the reflex. This stage will be called *consummatory*. Swallowing, for example, is the consummatory stage of the alimentary reflex. This role of the lower component will be discussed in detail in Section III.

Higher and lower reflexes

Those reflexes, which contain a higher specific component, will be denoted as *higher*, whereas those reflexes, which are devoid of a higher component, will be called *lower*. Our further discussion will be devoted only to the higher reflexes.

Higher reflexes contain also all others of the above-mentioned components. For simplicity, however, we will discuss only their specific and emotional components [1].

III. TYPES OF HIGHER REFLEXES

Using the differences in emotional component as a criterion, *escape*, *avoidance* and *approach* reflexes will be distinguished. The escape reflex is manifested by pain emotion, the avoidance reflex by fear emotion, and the approach reflex by appetite and pleasure emotions. These reflexes are evoked, respectively, by painful, fearful, and appetitive stimuli (*see* Section II).

Escape, avoidance and approach reflexes can be subdivided by the direction of the specific response to the evoking stimulus or to the goal stimulus (*see* Fig. 1), and by the presence or absence of the consummatory stage. The espace reflex can be directed to the evoking stimulus or simultaneously to the evoking and goal stimuli. The avoidance reflex is directed to the evoking stimulus or to the goal stimulus. The approach

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[1] The orienting and arousal components were discussed in our previous report (Żernicki 1968), and the orienting component will be the subject of a subsequent paper (B. Żernicki, in preparation).

reflex is always directed to the goal stimulus. Some escape reflexes directed to the evoking and goal stimuli and some approach reflexes contain the consummatory stage (Table I).

TABLE I

Types of higher reflexes

I. Escape reflexes
  1. directed to the evoking stimulus
  2. directed to the evoking stimulus and to the goal stimulus
    a) without consummatory stage
    b) with consummatory stage

II. Avoidance reflexes
  1. directed to the evoking stimulus
  2. directed to the goal stimulus

III. Approach reflexes (all directed to a goal stimulus)
    a) without consummatory stage
    b) with consummatory stage

Escape reflexes

Escape reflex directed to the evoking stimulus. A painful stimulus evokes lower specific central processes, higher specific central processes and pain central processes (Fig. 2). The higher specific central processes are facilitated by pain processes. Higher and lower specific effector responses cooperate closely in the abolition of the painful stimulus. In the above-mentioned reflex evoked by a painful stimulus acting on the leg, the flexion can be in part the lower component and in part the higher: the higher component is superimposed on the lower. In addition, in this example the higher specific response can consist in movement of the hand removing completely the nociceptive agent.

Escape reflexes directed to the evoking stimulus and to the goal stimulus. These reflexes are evoked by humoral stimuli which will be called *hunger* stimuli. Accordingly in these reflexes the drive and antidrive central processes and the goal stimulus will be called *hunger* and *antihunger* central processes and *antihunger* stimulus.

a) Reflex without consummatory stage. In this reflex the higher specific response decreases the intensity of the hunger stimulus and provides simultaneously the antihunger stimulus inhibiting the hunger central processes (Fig. 3). Such reflex occurs, for example, in the regulation of body temperature: when during a hot day a subject takes a bath in a swimming pool, the cold water is the antihunger stimulus abolishing

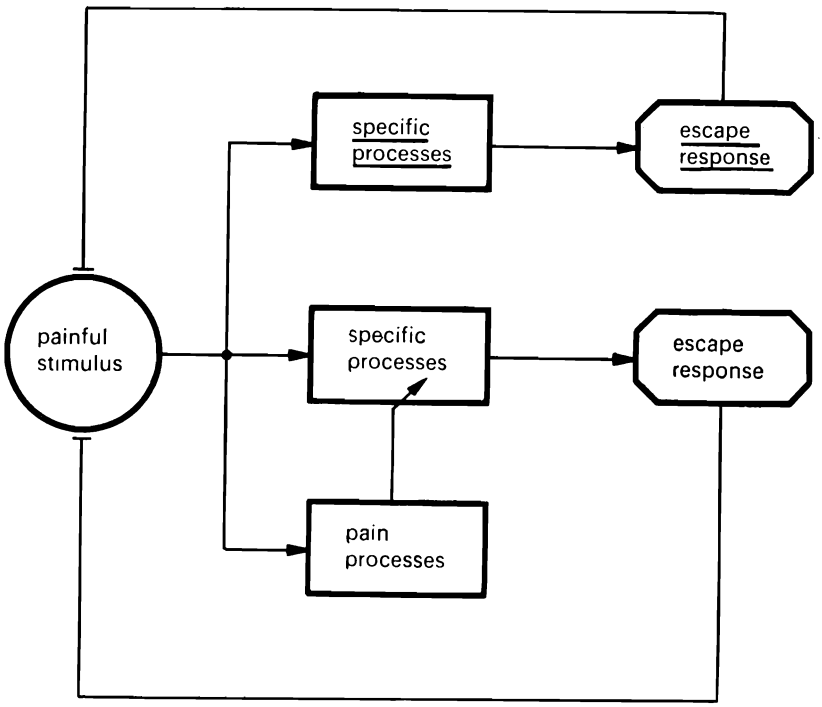

Fig. 2. Escape reflex directed to the evoking stimulus. The lower specific component is shown in the upper part of the figure.

the feeling of heat and simultaneously it cools slowly the body.

b) Reflex with consummatory stage. The reflex consists of two stages: the first stage will be called *preparatory* and the second, *consummatory* (Fig. 4). During the preparatory stage the higher specific response provides the antihunger stimulus. For example, in a pure escape alimentary reflex the antihunger stimulus is a tasteless food and in a pure escape water reflex the antihunger (antithirst) stimulus is water. The antihunger stimulus inhibits the hunger drive processes and evokes the consummatory stage, which is constituted by the lower specific component (*see* Section II). In the above-mentioned alimentary and water reflexes this stage consists of swallowing.

Avoidance reflexes

Avoidance reflex directed to the evoking stimulus. A fearful stimulus produces higher specific central processes and fear central processes, the latter facilitating the specific processes (Fig. 5). The avoidance response cuts off the fearful stimulus.

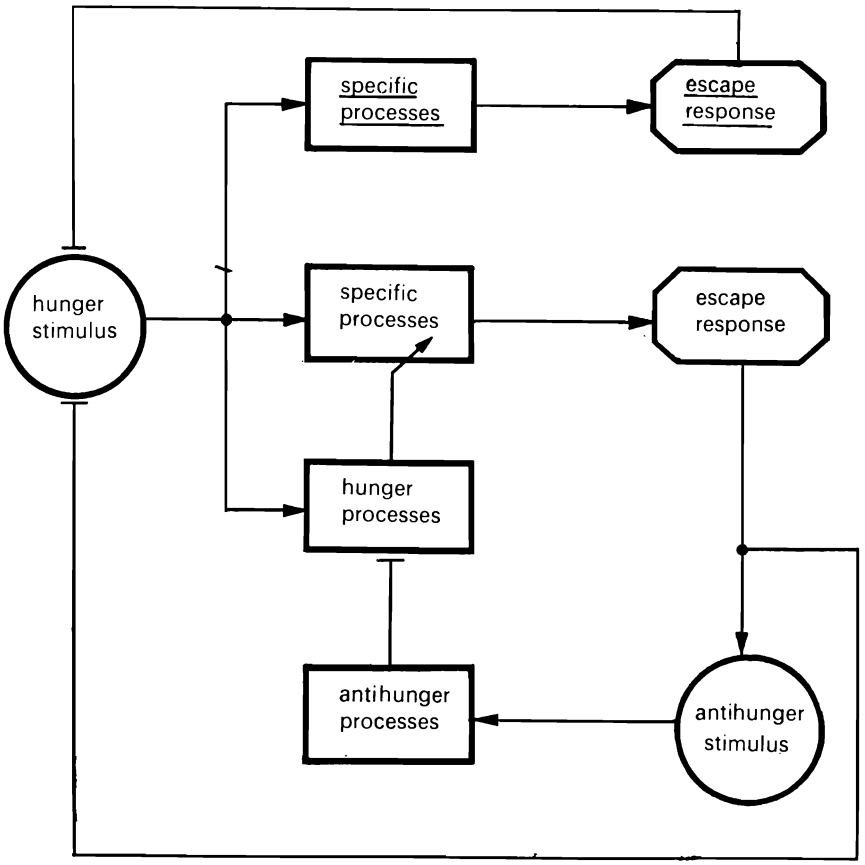

Fig. 3. Escape reflex directed to the evoking stimulus and to the goal stimulus and without consummatory stage. The lower specific component is shown in the upper part of the figure.

Avoidance reflex directed to the goal stimulus. The higher specific response provides the goal stimulus which will be called *antifear* stimulus (Fig. 6). This stimulus inhibits the fear central processes. The antifear stimulus can be, for example, a kinesthetic stimulus or the sight of a safe place achieved by a locomotor reaction.

Approach reflexes

Approach reflex without consummatory stage. An appetitive stimulus evokes the higher specific central processes and the facilitating appetite processes (Fig. 7). The approach response provides a *pleasant* goal stimulus. The pleasure central processes evoked by this stimulus completely inhibit the appetite processes. Turning on the radio to hear good music is the example of such reflex.

In addition the appetitive stimulus seems to produce secondary pleasure processes, which, however, are too weak to inhibit completely the appetite processes. The secondary pleasure processes are particularly clear in the sexual approach reflex with consummatory stage (*see* below): the

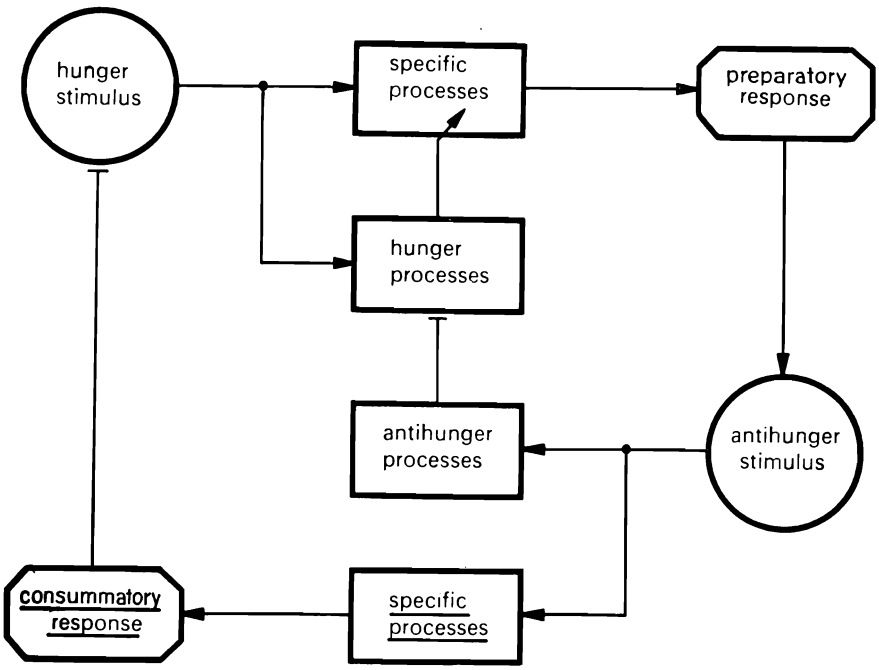

Fig. 4. Escape reflex directed to the evoking stimulus and to the goal stimulus and with consummatory stage.

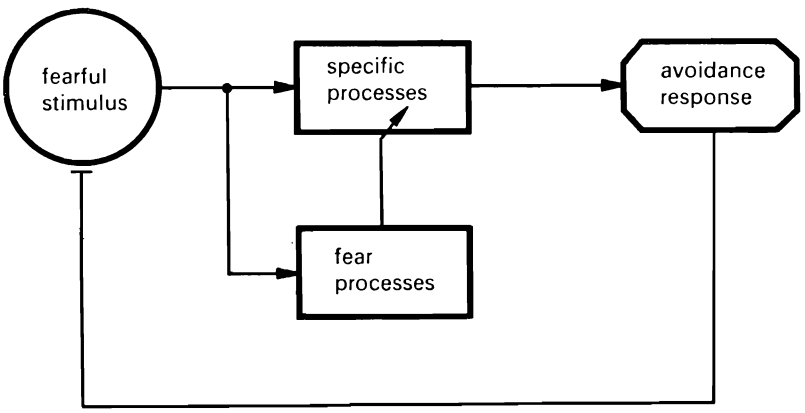

Fig. 5. Avoidance reflex directed to the evoking stimulus.

sight of an attractive member of the opposite sex can evoke simultaneously appetite and secondary pleasure.

The physical difference between the appetitive stimulus and the pleasant stimulus may be only in intensity. For example, barely audible music can be an appetitive stimulus, whereas music of an adequate intensity,

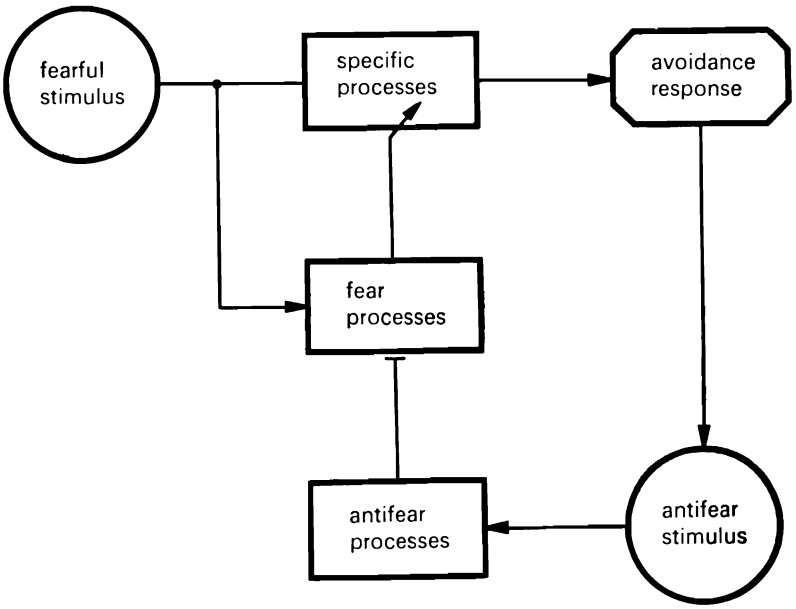

Fig. 6. Avoidance reflex directed to the goal stimulus.

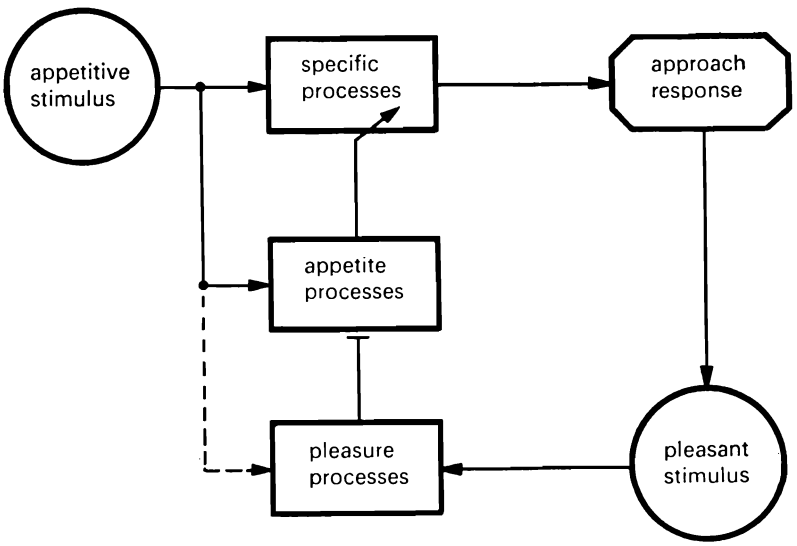

Fig. 7. Approach reflex withouth consummatory stage.

a pleasant stimulus. The approach response may consist here in adjusting the volume dial of the radio. This example is very instructive, because here an appetitive stimulus, when it evokes a satisfactory amount of pleasure processes to inhibit fully the appetite processes, becomes a pleasant stimulus.

Therefore, it may be assumed that the pleasant stimulus has an excitatory connection with the appetite center, but this connection is ineffective because of the simultaneous strong inhibition from the pleasure center. When the intensity of the pleasant stimulus is decreased for any reason, and hence the pleasure central processes are diminished, it becomes immediately an appetitive stimulus. This is particularly demonstrative in the alimentary approach reflex with consummatory stage (*see* below): when a portion of tasty food is swallowed, the residual food present in the mouth immediately produces the appetite, and in consequence, the subject takes immediately the next morsel of food into the mouth (peanut phenomenon).

Approach reflex with consummatory stage. The presence of the consummatory stage makes this reflex different from the preceding one

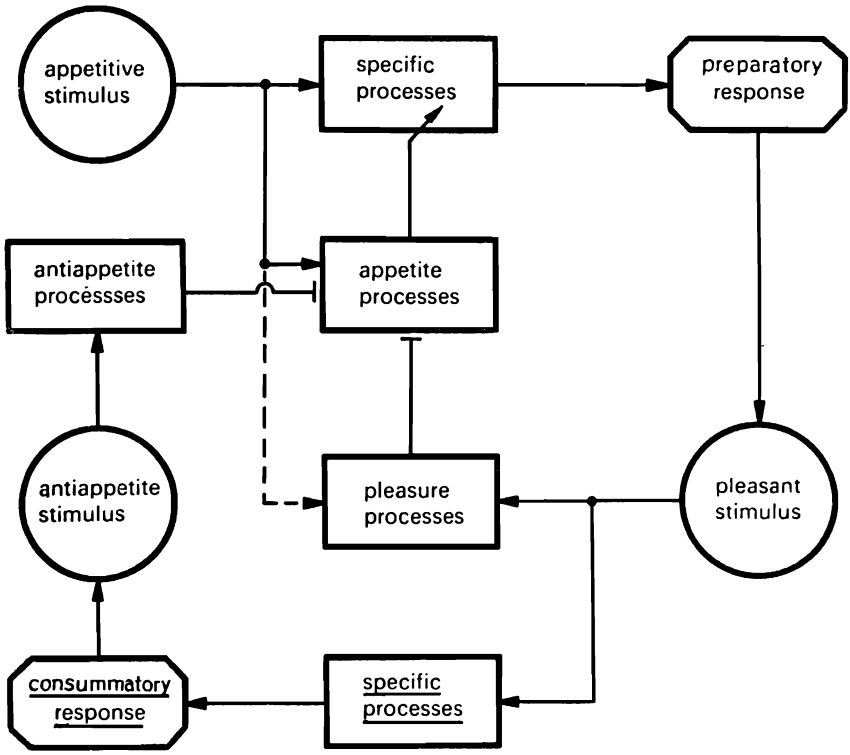

Fig. 8. Approach reflex with consummatory stage.

(Fig. 8). Two goal stimuli appear successively. The pleasant goal stimulus provides (via the consummatory stage) an interoceptive goal stimulus, which will be called *antiappetitive*. This stimulus evokes *antiappetite* central processes inhibiting the appetite processes. In consequence, the appetite central processes are inhibited in two ways, by the pleasant stimulus and by the antiappetite stimulus. The alimentary reflex evoked by the sight of an attractive food in the satiated subject is the example of such reflex (*see* Section VI).

Escape-approach reflex with consummatory stage

A given reflex can have simultaneously two or even three different meanings. The most frequent situation is that a given reflex plays the role of the escape reflex with consummatory stage and the approach reflex with consummatory stage. Escape-approach reflex with consummatory stage often occurs in the alimentary and sexual systems (*see* Section VI). Since the hunger stimulus is tonic, the appetitive stimulus usually appears on the background of the hunger stimulus action Fig. 9). The specific central processes of the preparatory response are facilitated by both hunger and appetite central processes and the pleasant stimulus plays also the role of the antihunger stimulus.

IV. UNCONDITIONED AND CONDITIONED REFLEXES

Lower reflexes are unconditioned. In the majority of higher reflexes conditioned connections are present. They can be located in the emotional component and in the higher specific component (*see* Section II). In the escape conditioned reflex conditioned connections are located mainly in the higher specifis component. In the avoidance and approach conditioned reflexes they are usually present both in the emotional and higher specific components.

V. CHAIN REFLEXES

Higher reflexes are usually in a chain form, i. e. in a given reflex there are several clear cut stages. The escape and approach reflexes with a consummatory stage are chain reflexes by definition. They are composed of at least two stages, preparatory and consummatory (Fig. 4, 8 and 9).

The role of a given stage (except the last one) is usually to provide a definite stimulus, which evokes in turn a next stage, and will be called *means* stimulus (*see* the examples of chain reflexes in Fig. 10–12, and Table II). The role of the last stage is abolishing the evoking stimulus, or providing the goal stimulus, or both. In the reflexes with consummatory stage, however, the penultimate stage also provides the goal stimulus. In

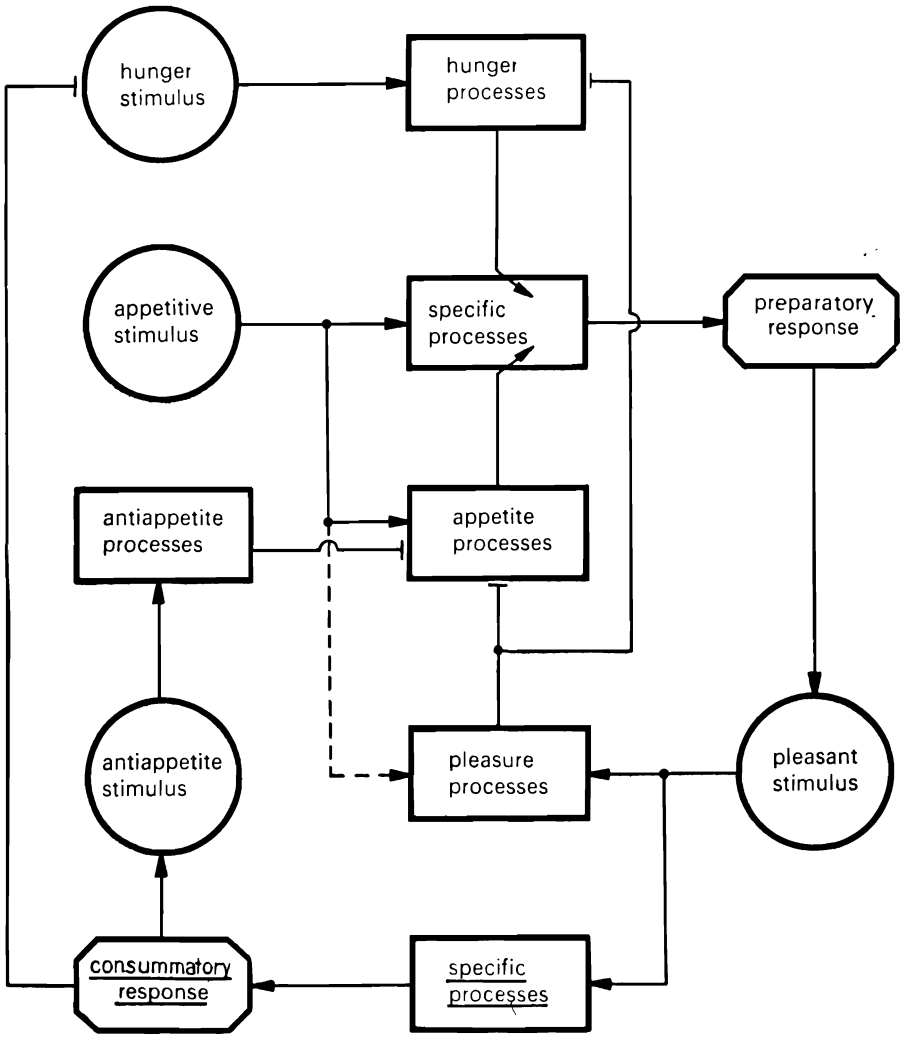

Fig. 9. Escape-approach reflex with consummatory stage. The situation, in which the appetitive stimulus appears on the background of the tonic action of the hunger stimulus, is shown. Note that the pleasant stimulus plays also the role of an anti-hunger stimulus.

the alimentary approach reflex evoked by the sound of metronome, for example, the first stage (running to the food) provides the means stimulus (the sight of food), this in turn evokes the second stage (eating) providing the pleasant goal stimulus (taste stimulus), which finally evokes the consummatory stage (swallowing) providing the antiappetite goal stimulus.

In chain reflexes the central higher specific processes of all stages are facilitated by the drive central processes. In the escape and avoidance

TABLE II

The role of different stages in chain reflexes

Reflex \ Stage	Any but the penultimate and the ultimate	Penultimate	Ultimate
Escape directed to evoking stimulus	→ M or ↓ I	→ M or ↓ I	↓ E
Escape directed to evoking and goal stimuli and without consummatory stage	→ M or ↓ I	→ M or ↓ I	↓ E and → G
Escape directed to evoking and goal stimuli and with consummatory stage	→ M or ↓ I	→ G	↓ E
Avoidance directed to evoking stimulus	→ M or ↓ I	→ M or ↓ I	↓ E
Avoidance directed to goal stimulus	→ M or ↓ I	→ M or ↓ I	→ G
Approach without consummatory stage	→ M or ↓ I	→ M or ↓ I	→ G
Approach with consummatory stage	→ M or ↓ I	→ G	→ G
Escape-approach with consummatory stage	→ M or ↓ I	→ G	↓ E and → G

Symbols: → M, provides a means stimulus; → G, provides the goal stimulus; ↓ I, abolishes the inhibitory stimulus; ↓ E, abolishes the evoking stimulus.

chain reflexes the drive processes are produced only by the evoking stimulus (Fig. 10 and 11). In the escape reflex evoked by a nociceptive stimulus, for example, the pain processes produced by this stimulus facilitate the central processes evoked by the sight of the appropriate tool provided in the course of the reflex. In contrast, in chain approach reflex the means stimulus itself contributes strongly in the production of the emotional central processes (Fig. 12). Its effect is even stronger than that of the evoking stimulus. For example, in the mentioned previously alimentary approach reflex evoked by the sound of a metronome the appetite awakened by this stimulus is obviously weaker than that produced by the actual sight and smell of food.

In some chain reflexes a given stage is not required to provide a means stimulus, but to remove an inhibitory stimulus (Fig. 13, Table II). For example, micturition may be inhibited in the presence of another person; hence, the stage of the micturition escape reflex may be the locomotor

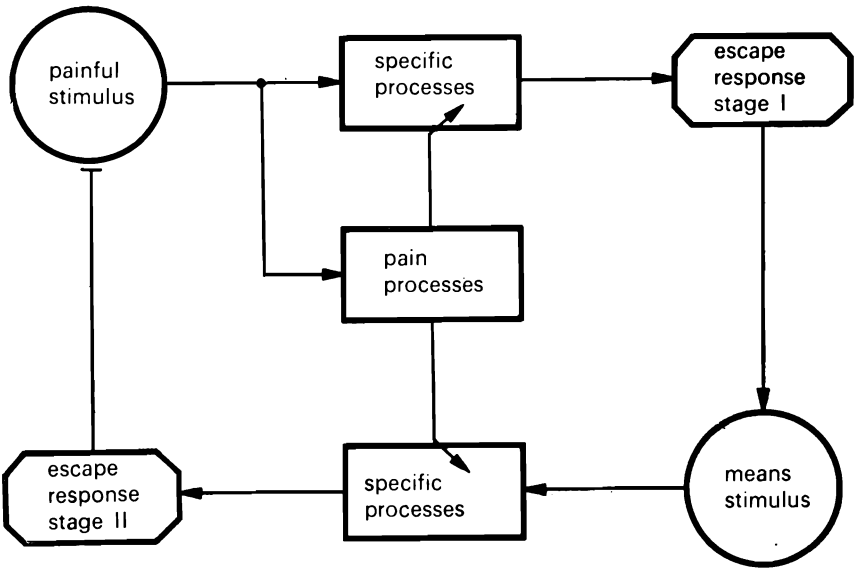

Fig. 10. Chain escape reflex directed to the evoking stimulus. The lower specific component is not indicated.

response eliminating this inhibitory stimulus. The central specific processes of this stage are facilitated by the drive central processes awakened by the evoking stimulus.

VI. SYSTEMS OF HIGHER REFLEXES

Higher reflexes can be grouped in several systems according to the particular functions they perform in an organism. Some important systems will be briefly described (Table III).

Cutaneous nociceptive system

In this system the escape reflex directed to the evoking stimulus and avoidance reflex are in operation.

Micturition, defecation and vomiting systems

Micturition reflex is either the escape reflex directed to the evoking stimulus or the avoidance reflex. The micturition reflex before going to sleep, for example, is often of the avoidance type.

Defecation and vomiting reflexes are the escape reflexes directed to the evoking stimulus.

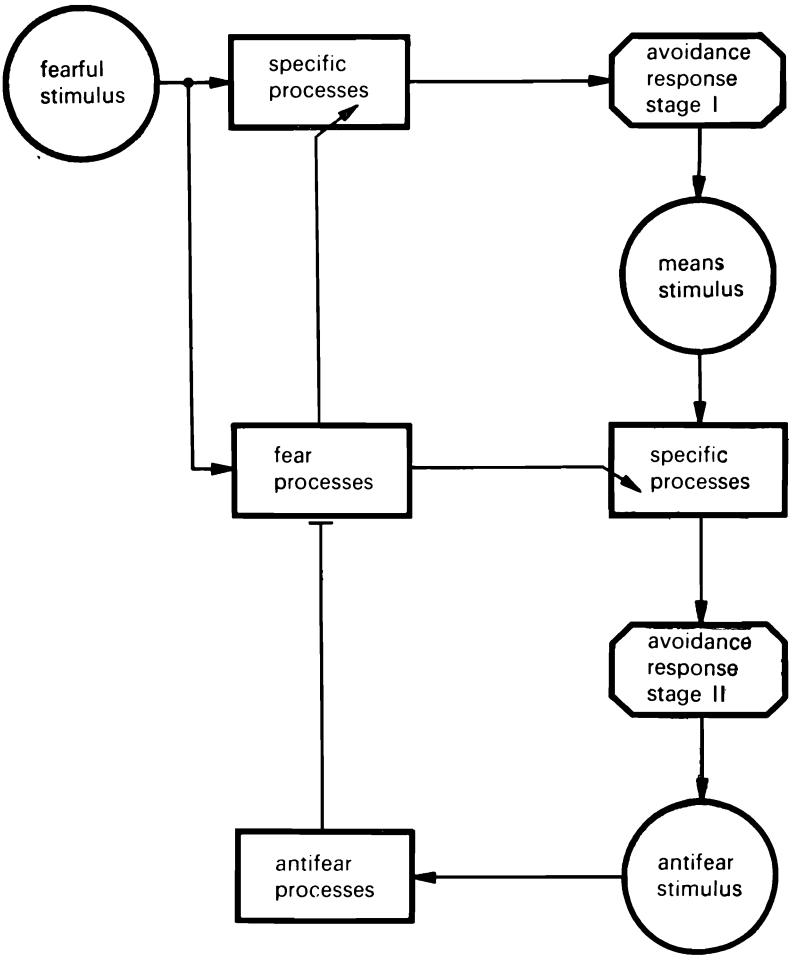

Fig. 11. Chain goal directed avoidance reflex.

Respiratory system

When the appropriate humoral stimulus is weak, the lower respiratory reflex occurs; then only the respiratory muscles are in operation. The strong stimulus evokes the escape reflex, which is directed probably to both the evoking and goal stimuli: fresh air in lungs restores the proper carbon dioxide content in blood and probably is the goal stimulus inhibiting respiratory hunger central processes. In the escape reflex the higher specific component may involve the respiratory muscles (strong action) and other effectors (the subject opens a window, for example).

Under normal conditions of life the avoidance respiratory reflex occurs

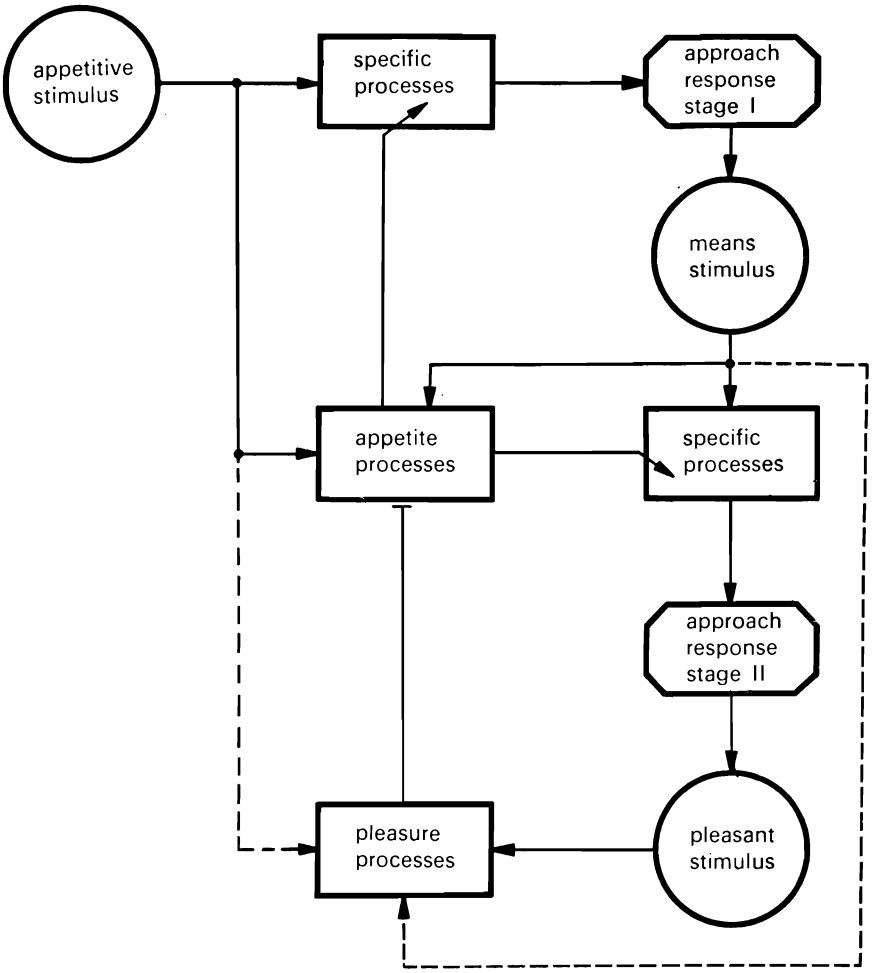

Fig. 12. Chain approach reflex without consummatory stage.

rarely. It is important, however, in special stituations, for example, in the work of a diver.

Since there is no respiratory pleasure, the approach respiratory reflex does not exist.

Body temperature system

This system should be distiguished from the cutaneous nociceptive system. Two subsystems serving, respectively, for decrease and increase body temperature can be distinguished. The escape reflex directed to the evoking stimulus and to the goal stimulus and avoidance reflex are in

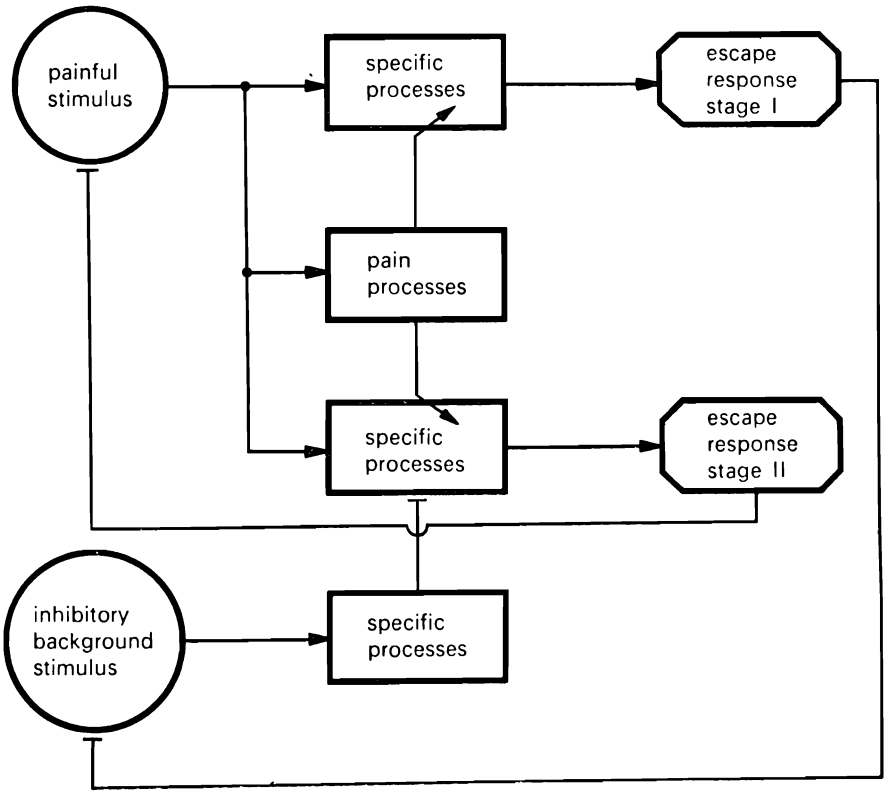

Fig. 13. Chain escape reflex, in which the first stage is devoted to the removal of the inhibitory background stimulus. The lower specific component is not indicated.

operation. The escape reflex has not usually the consummatory stage, for example, a subject takes cold bath during a hot day. When cold water is taken in the mouth, however, the consummatory stage is present. Then the body temperature and water reflexes collaborate closely (*see* below).

Alimentary system

In this system escape, approach, and escape-approach reflexes are mainly in operation. In all these reflexes the consummatory stage is present.

Escape reflex. The appropriate humoral stimulus evokes the hunger central processes facilitating the specific central processes (*see* Wyrwicka 1952, 1960) [2]. The antihunger stimulus is a tasteless food in the mouth,

[2] The hunger stimulus is not simply the lack of appropriate molecules of a nutritive substance in blood, but such molecules evoke satiation central processes inhibiting the hunger central processes.

which inhibits the hunger central processes, as shown by the usual stopping of food intake during the presence of food in the mouth, and evokes the consummatory stage consisting in swallowing (*see* Sołtysik 1960, Konorski 1967, Konorski and Gawroński 1970*abc*).

When food is solid, it evokes in addition the masticatory movements and salivation. These responses seem to depend only partially on hunger. In other words, mastication and salivation may be partially the last stage of the higher specific component, and partially the consummatory component.

When food is swallowed, the higher component of the escape reflex is released from inhibition and the second portion of food is taken into the mouth. Ultimately, when a sufficient amount of food is swallowed, the hunger stimulus is eliminated (the subject is satiated).

Approach reflex. Tasty food can be approached in the absence of the hunger stimulus. This is the normal mechanism of eating a dessert. The extra amount of food swallowed gradually produces the antiappetite stimulus inhibiting the approach reflex.

Escape-approach reflex. This reflex is usually evoked by the appetitive stimulus on the background of the hunger stimulus, which itself is ineffective (*see* Fig. 9). The higher specific central processes are facilitated by both appetite and hunger central processes [3].

Water system

Everything said about alimentary higher reflexes seems to be also valid for water higher reflexes. The hunger stimulus for water is called thirst stimulus. Tasteless (pure) water is provided by the escape reflex, whereas tasty water (e. g., soda water) is provided by the escape-approach reflex and occasionally by the pure approach reflex [3].

Sexual system

In man under normal conditions of family life, approach reflex with consummatory stage is in operation. The evoking stimulus is usually the sight of a member of the opposite sex. Tactile stimuli acting during caressing and coitus have a *double* meaning. In the beginning they play a role of an appetitive stimulus, i. e. they evoke appetite and secondary pleasure. However, when they last long enough, they become rapidly the pleasant goal stimulus (orgasm), then the pleasure processes become very

[3] Food and water intake play also an important role in the temperature system (*see* above). Food and water, only if of body temperature, have pure alimentary or "water" meaning.

TABLE III

The role of different higher reflexes in some systems

System \ Reflex	Escape directed to evoking stimulus	Escape directed to evoking and goal stimuli and without consummatory stage	Escape directed to evoking and goal stimuli and with consummatory stage	Avoidance	Approach without consummatory stage	Approach with consummatory stage	Escape-approach with consummatory stage
Cutaneous nociceptive	+	0	0	+	0	0	0
Micturition	+	0	0	+	0	0	0
Defecation	+	0	0	0	0	0	0
Vomiting	+	0	0	0	0	0	0
Respiratory	0	+	0	+	0	0	0
Body temperature	0	+	+	+	0	0	0
Alimentary	0	0	+	0	0	+	+
Water	0	0	+	0	0	+	+
Sexual	0	0	0	0	0	+	+
Visual pleasure	0	0	0	0	+	0	0
Auditory pleasure	0	0	0	0	+	0	0

Symbols: +, important; 0, absent or insignificant.

strong and fully inhibit the appetite processes. At the same time, the consummatory stage provides the antiappetite stimulus inhibiting the reflex.

When a man is deprived of sexual life for a considerable time, the hunger sexual stimulus appears. Then, the escape-approach sexual reflex is in operation. This reflex, of course, occurs in animals when in estrus state.

Visual and auditory pleasure systems

In these systems the approach reflexes without consummatory stage are in operation. The examples of pleasant visual and auditory stimuli are, respectively, a beautiful picture and good music.

VII. NEURAL LOCALIZATION OF HIGHER REFLEXES

In different types of higher reflexes there are by definition different emotional components and often different specific components. For example, in the escape and avoidance reflexes of the cutaneous nociceptive system different groups of specific effectors are often involved. Furthermore, in different systems the emotional and often the specific components of the reflexes of a given type are different. For example, there is a tremendous difference between the escape reflexes involved in the cutaneous nociceptive system and those involved in the alimentary system. All these differences must be, of course, reflected anatomically. It is beyond the scope of this paper to discuss the neural localization of reflexes in detail. We will only shortly describe the anatomical aspect of the alimentary system as an example.

Although in the decerebrate cat the mastication and swallowing are preserved, the consummatory stage of the alimentary reflex is not integrated and the animal must be fed by a stomach tube. A chronic thalamic cat can be fed by hand, and a chronic striatal cat can find food placed on the floor but with some difficulty (Wang and Akert 1962, Emmers et al. 1965). These acts are perhaps the abortive forms of the escape reflex.

A great deal of evidence based on the effects of electrical stimulation and lesions show that in both the hypothalamus and amygdala there are drive and satiation alimentary central processes localized. So far, however, the different localization of the hunger, appetite, antihunger and pleasure alimentary central processes have not been shown. This may be because of two reasons: (i) Different units are intermixed; the stimulation of the lateral hypothalamus, for example, evokes probably both the hunger and pleasure central processes *(see* Fonberg 1969). (ii) During experiments the

animals are usually very hungry while the taste of food reward is rather moderate; hence, the possible deficit in the appetite may be easily overlooked.

The higher alimentary reflexes are also impaired after ablation of the gustatory cortex (Żernicki and Santibañez-H. 1961, 1971). This is probably due to the impairment of the alimentary pleasure processes, and the following decrease of appetite.

VIII. SUMMARY

1. The term reflex is used in a wide sense and denotes the neural processes and the effector (behavioral) responses controlled by the evoking stimulus and the feedback stimuli.

2. Five reflex components are distinguished: lower specific component, orienting component, arousal component, emotional component, and higher specific component.

3. Pain, fear, appetite and pleasure emotional central processes are distinguished. Pain, fear and appetite processes are negative (or drive) emotional processes.

4. The essential difference between the lower and the higher specific components is that the latter is facilitated by the drive emotional processes.

5. The specific effector response can play two roles: (i) it can abolish the stimulus evoking the reflex, and (ii) it can provide a goal stimulus (antidrive stimulus) inhibiting the drive emotional processes.

6. Higher and lower reflexes are distinguished, the higher reflexes containing the higher specific component.

7. Three types of higher reflexes are distinguished: escape, avoidance and approach. These reflexes contain, respectively, pain, fear, and appetite and pleasure central processes.

8. The escape, avoidance and approach reflexes are subdivided by the direction of the specific response to the evoking stimulus or to the goal stimulus, and by the presence or absence of the consummatory stage.

9. Higher reflexes are usually in a chain form. The usual role of a given stage (except the last one) is to provide a means stimulus.

10. Higher reflexes are grouped in several systems according to the particular functions they perform in an organism.

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GLOSSARY

antiappetite central processes: central processes evoked by an antiappetite stimulus and inhibiting appetite central processes

antiappetite stimulus: a goal stimulus in the approach reflex provided by the consummatory stage [distension of stomach] [4]

antidrive central processes: central processes evoked by a goal stimulus and inhibiting drive central processes

antidrive stimulus: *see* goal stimulus

antifear central processes: central processes evoked by an antifear stimulus and inhibiting fear central processes

antifear stimulus: a goal stimulus in the avoidance reflex [safe place]

antihunger central processes: central processes evoked by an antihunger stimulus and inhibiting hunger central processes

antihunger stimulus: a goal stimulus in the escape reflex [tasteless food in mouth]

appetite: secondary unpleasant emotion signalling pleasure

appetite central processes: central processes manifested by appetite

appetite stimulus: a stimulus evoking appetite and secondary pleasure [sight of food, small amount of food in the mouth]

approach reflex: a reflex with higher specific component facilitated by appetite central processes [approaching a tasty food by an unhungry animal]

approach response: effector (behavioral) part of approach reflex

avoidance reflex: a reflex with higher specific component facilitated by fear central processes

avoidance response: effector (behavioral) part of avoidance reflex

chain reflex: a reflex consisting of at least two stages; the stages can be produced successively by the stimulus evoking the reflex, by means stimuli, and by the goal stimulus

consummatory stage of reflex: the last stage of reflex evoked by the goal stimulus; the consummatory stage belongs to the lower component, it is present in some escape and approach reflexes [swallowing in alimentary reflex]

drive central processes: central processes manifested by a drive emotion (pain, fear or appetite); the drive central processes facilitate the central processes of higher specific component

drive emotion (negative emotion): unpleasant emotion (pain, fear and appetite)

drive stimulus: a stimulus evoking drive emotion

emotion: an unpleasant or pleasant psychic response

emotional component of reflex: a component of reflex manifested introspectively by emotion

escape-approach reflex: a reflex with higher specific component facilitated simultaneously by pain and appetitive central processes [approaching a tasty food by a hungry animal]

escape reflex: a reflex with higher component facilitated by pain central processes

escape response: effector (behavioral) part of escape reflex

fear: secondary unpleasant emotion signalling pain

fear central processes: central processes manifested by fear

[4] Some terms are illustrated by examples given in square brackets.

fearful stimulus: a stimulus evoking fear

feedback stimulus: a stimulus provided by a reflex and controlling this reflex (*see* reflex evoking stimulus) [kinesthetic and visual cues received during approaching food]

goal stimulus (antidrive stimulus): a feedback stimulus provided by the ultimate or the penultimate stage of a reflex and evoking the antidrive central processes and in some escape and approach reflexes also the consummatory stage

higher reflex: a reflex containing specific component

higher specific component of reflex: specific component facilitated by drive central processes

hunger: pain in the escape reflex directed to the evoking and goal stimuli [alimentary hunger, thirst]

hunger central processes: central processes manifested by hunger

hunger stimulus: a stimulus evoking hunger; the hunger stimulus is humoral [dehydration of body]

lower reflex: a reflex devoid of a higher specific component [light reflex]

lower specific component of reflex: a specific component of a reflex which is not facilitated by drive central processes

means stimulus: a feedback stimulus provided by a stage of the reflex and evoking the next stage except the consummatory one (*see* goal stimulus) [sight of food, sight of an appropriate tool]

negative emotion: *see* drive emotion

pain: primary unpleasant emotion (*see* fear)

pain central processes: central processes manifested by pain

painful stimulus: a stimulus evoking pain

pleasant stimulus: a stimulus evoking primary pleasure (a goal stimulus in the approach reflex) [tasty food in mouth]

pleasure (positive emotion): pleasant emotion

pleasure central processes: central processes manifested by pleasure; these processes are evoked by pleasant and by appetitive stimuli and they inhibit appetitive central processes

positive emotion: *see* pleasure

preparatory stage of reflex: in the escape and approach reflexes with consummatory stage, any stage except the consummatory one

primary pleasure: pleasure not signalling another pleasure (*see* secondory pleasure) [pleasure evoked by tasty food in mouth]

reflex: neural processes and effector (behavioral) responses controlled by the evoking stimulus and by feedback stimuli

reflex evoking stimulus: a stimulus initiating the reflex and usually controlling its general course (*see* feedback stimulus)

satiation: the state when a hunger stimulus is not acting

satiation central processes: central processes inhibiting tonically hunger central processes; their existence is well documented in the alimentary system, where they are evoked by nutritive substances

secondary pleasure: pleasure signalling primary pleasure [pleasure evoked by the sight of an attractive member of the opposite sex]

specific components of reflex (higher and lower components): essential parts of reflex which should be distinguished from the arousal, orienting and emotional components

stimulus: a physical event eliciting the activity of receptors or higher levels of the afferent part of the nervous system [light, body dehydration, decrease of carbon dioxide content]

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