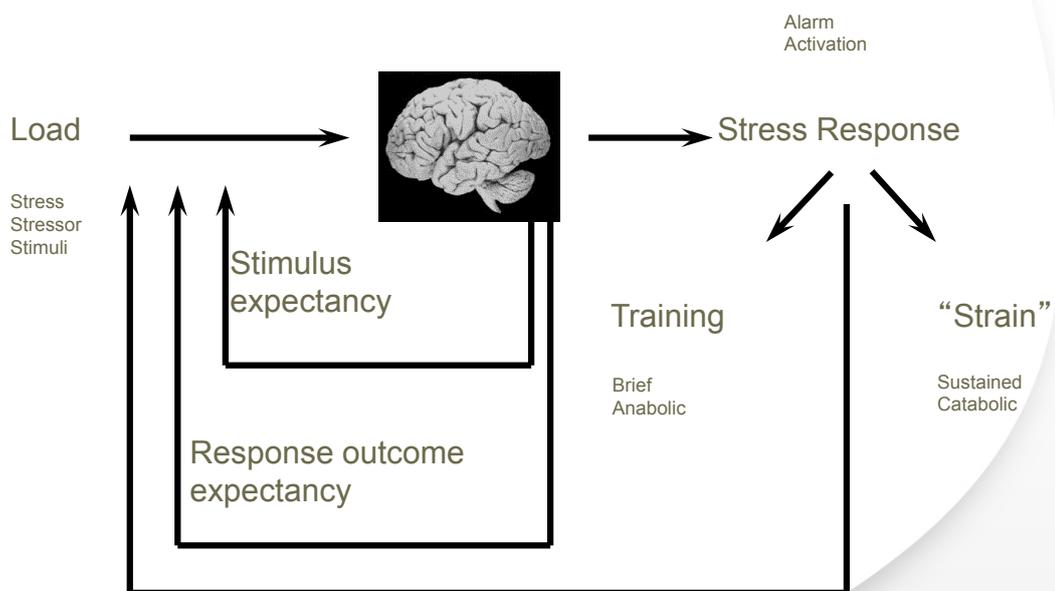


# CATS IN SHORTS

Easy reader of definitions and formal expressions

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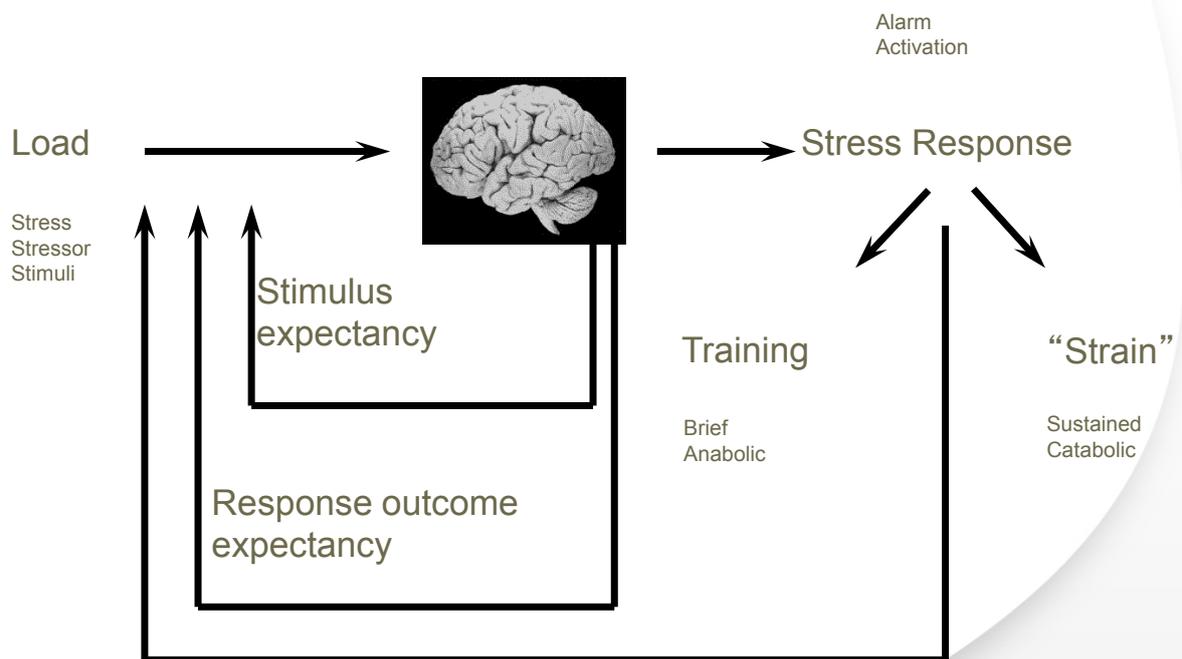


## **I DEFINITIONS OF STRESS: FOUR CONCEPTS REFERRED TO AS “STRESS”**

*Stress is defined and operationalized by stimuli ("stressors"), subjective reports of an experience (humans only), a general non-specific increase in arousal (activation, and the feedback to the brain from this response (Levine and Ursin, 1991).*

- 1. The Stress Stimuli.** Whether a stimulus is pleasant or threatening depends on the individual appraisal of the situation, which is based on previous experience and expectations of the outcome. In CATS this is referred to as *stimulus expectancy*, (next point) and is not dependent by physical aspects of the stimulus. A particular source of information is the feedback from the arousal processes in the body (point 4).
- 2. The Stress Experience.** In addition to the acquired *stimulus expectancy* (what does this stimulus mean to me?) there is also an acquired expectancy to what the individual may do to the stimuli, a *response outcome expectancy*.
- 3. The Stress Response.** The general response to stress stimuli is a non-specific alarm response, eliciting a general increase in wakefulness and brain arousal. *We will refer to this increase in arousal as activation.* The increase in arousal manifests itself in behavior and in many or most organ systems, with individual and situational variance in strength, reciprocal relations, and time parameters.
- 4. The Feedback from the stress response.** The feedback loop from the peripheral changes associated with increased arousal is important for the experience of “stress” in humans. It corresponds to the James-Lange principle in emotional theory. It is an important dynamic principle since this often functions as a positive feedback mechanism. It is also possible to

influence the interpretation of the feedback, and to reduce the arousal itself, through therapeutic maneuvers.



Ursin, H., and Eriksen, H.R. Cognitive activation theory of stress (CATS). *Psychoneuroendocrinology*, 2004, Eriksen et al., CATS; From fish brains to the Olympics, *Psychoneuroendocrinology*, 2005

## **II MEASUREMENT OF “STRESS”**

**1. The stimuli.** This may impress as the most objective way of measurement, number of clients per time unit, work hours, shift work. There are, however, no linear or predictable relations to subjective reports of stress, or any reliable relations to health or physiological factors relevant for health or productivity.

**2. The experience or feeling of stress.** This is particularly relevant in human stress research, by interviews or questionnaires. For animals more indirect methods must be used, by measuring overt behavior, choices, and physiological responses (next point).

**3. The stress response.** Since arousal affects almost all organ systems, there is an abundance of methods available from psychophysiology, psychoendocrinology, psychoimmunology, behavioral analyses, and brain biochemistry. There is a traditional preoccupation with the pituitary-adrenal axis, and in steady increase now due to the easy methods for saliva sampling and analyses. However, there are other indicators as well, they are all reliable for acute and short lasting stress situations, but not for long term challenges. The time axis differ, and reciprocal and homeostatic mechanisms must be taken into account. Evaluation of behavior is also used, but should be used with caution. Stress related behaviors (“coping attempts”) or strategies (“ways of coping”) may be executed under varying degrees of arousal, depending on the expectancy attached to that specific behavior.

**4. The feedback from the arousal.** The feedback from the arousal is used in many questionnaires in human research. It is an essential element of many anxiety scales and questionnaires on health complaints.

### III WHEN DOES THE ALARM OCCUR?

*The stress response is a general, unspecific alarm response occurring whenever there is a discrepancy between what is expected or the "normal" situation (set value) and what is happening in reality (actual value).*

**Table 1**  
**When Does Activation Occur?**

For all variables controlled by the brain, at any point in time:

“Set Value” (SV): the value brain is “set” on for that particular variable

“Actual Value” (AV): the real value of that variable.

*Statement 1a:*         $(SV \neq AV) \Rightarrow \text{Activation}$

and

*Statement 1b:*         $(SV = AV) \Rightarrow \text{No activation}$

Statement 1a is to be read: When the set value differs from the actual value this implies ( $\Rightarrow$ ) activation.

Activation will sustain itself until activation affects mechanisms that serve to solve the underlying discrepancy, by changing the actual values, or the set value when possible, or shifting to other motivational systems (other SVs).

*Since (1):*

*Statement 2:*         $(SV - AV \neq 0) \Rightarrow \text{Activation} \rightarrow ((SV - AV) \rightarrow 0)$

Statement 2 is to be read: When the set value differs from the actual value this implies activation which, in turn, may lead to this difference being reduced or abolished.

Comments:

In general, the alarm occurs in all situations where expectancies are not met. It occurs to “novel” stimuli, in situations where there is something missing, or where there is a homeostatic imbalance, or when there is a threat to the organism. This follows a very simple and basic principle from general control theory, and represents a cognitive reformulations of

homeostatic theory. The alarm occurs whenever there is a discrepancy between what should be and what is- between the value a variable should have (set value (SV)), and the real value (actual value (AV)) of the same variable (Statement 1a and 1b).

The alarm continues until the discrepancy is eliminated, by changing the AV, or the SV, when this is possible (Statement 2). The alarm is the “drive” component that is required to make drive reduction theory work since it “drives” the individual to the proper solutions.

## IV EXPECTANCY (Forventning)

All brains store the relations between stimuli, and between responses and stimuli. This stored (learned) information is referred to as expectancy (Table 2).

**Table 2**  
**The Expectancy Concept**

### **Stimulus expectancy: Statement 3**

When the subject has learned that one stimulus (S1) predicts the occurrence of another event (S2) this is referred to as *stimulus expectancy*:

Statement 3:  $_{S1}E_{S2} = (S1 \Rightarrow S2)$

Statement 3 is to be read: The stimulus expectancy S1- S2 means that S1 implies S2. In classical conditioning, S1 is the conditioned stimulus (CS), S2 is the unconditioned stimulus (UCS), and the conditioned response is the response to expecting the UCS.

### **Response outcome expectancy: Statement 4**

When the subject has learned that performance of a response (R1) brings a certain outcome (S2):

(R1  $\Rightarrow$  S2), this is referred to as *response outcome expectancy*:

Statement 4:  $_{R1}E_{S2} = (R1 \Rightarrow S2)$

Statement 4 is to be read: The R1 expectancy of S2 means that R1 implies S2.

*Expectancy* is a particular brain function of registering, storing and using the particular information that one stimulus (event) precedes a second stimulus (classical conditioning, stimulus-stimulus learning), or that one response leads to a particular outcome (instrumental conditioning).

This represents cognitive reformulations of learning theory, and are essential elements in CATS. It is also essential for CATS that it is the perceived relationship that counts for stress responses and stress consequences, not the objectively true contingencies.

## V DIMENSIONS OF EXPECTANCY

*Expectancies are quantified by three dimensions: acquisition strength, perceived probability, and affective value (Table 3).*

**Table 3**  
**Dimensions of the Expectancy Concept**

### **Acquisition strength.**

Acquisition strength is referred to as H (“habit value”), which is assumed to have values between 0 (minimum) and 1 (maximum). Formally, the strength of  $S_1 \Rightarrow S_2$  is expressed by  $H(S_1E_{S_2})$  and has values between 0 and 1:

*Statement 5a*             $H(S_1E_{S_2}) \in (0,1)$ .

Or, in more detail:

*Statement 5b*             $\forall S_1E_{S_2} \exists H(S_1E_{S_2}) \in (0,1)\{0\}$ .

Statement 5b is to be read: For all  $S_1E_{S_2}$  there is a H-value between 0 and 1. When the H value is close to zero, there is no expectancy (  $\{0\}$  ).

The same is true for  $R_1E_{R_2}$ :

*Statement 6*             $H(R_1E_{R_2}) \in (0,1)$ .

### **Perceived probability:**

The subjective predictability and control which is referred to as “perceived probability” (PP) will also be attributed values between 0 (very low perceived probability) and 1 (very high perceived probability). Formally, for stimulus expectancies:

*Statement 7*             $PP(S_1E_{S_2}) \in (0,1)$

For response expectancies:

*Statement 8*             $PP(R_1E_{R_2}) \in (0,1)$ .

### **Affective value:**

The reinforcing or attractive/aversive value of the expected outcome or stimulus event will be referred to as the *affective value* (A) and will be allocated values from -1 (highly unattractive) to +1 (highly attractive). Formally:

*Statement 9*             $A(S_1E_{S_2}) \in (-1, +1)$ , and  $A(R_1E_{R_2}) \in (-1, +1)$ .

The affective value of an expectancy depends on (is a function ( $f$ ) of the expected event  $S_2$ ). Therefore:

*Statement 10*                     $A(S_1E_{S_2}) = f(A(S_2))$  and  $A(R_1E_{S_2}) = f(A(S_2))$ .

*The acquisition strength (H- "habit value")* of an expectancy expresses how strong the habit is. Expectancies are acquired, according to the general principles of learning theory. Whether learning will occur or not, and how strong the learning will be, depends on properties of the events, the contiguity in the presentation, the number of presentations, and how often the events are occurring together.

*The perceived probability (PP)* of an expectancy expresses the probability of the expected event, as it is perceived by the individual. This is a subjective evaluation of the probability. It may differ considerably from the true or objective probability. For the stimulus expectancies a high level of perceived probability is often referred to as predictability, high levels of perceived probability for response outcomes may be referred to as *control*.

*The affective value (A)* of an expectancy covers the "hedonic" value of the expected outcome, i.e. whether the expected outcome is attractive, aversive, or neutral. This decides the reinforcing properties of the expected event.

## VI COPING: POSITIVE RESPONSE OUTCOME EXPECTANCY

*Coping is the acquired expectancy that most or all responses lead to a positive result. This leads to a reduced arousal level (Table 4).*

**Table 4**  
**Coping defined as positive response outcome expectancy.**

### **Coping is a positive response outcome expectancy**

(Approach learning:  $A(S2) \rightarrow 1$ ):

*Statement 11:*  $H_{(R1 E_{S2})} \rightarrow 1, PP_{(R1 E_{S2})} \rightarrow 1, A(S2) \rightarrow 1$

Statement 11 is to be read: The habit value of R1 leading to S2 is high, the perceived probability of R1 leading to S2 is high, and the affective value of S2 is high.

(Avoidance learning:  $A(S2) \rightarrow -1$ ):

*Statement 12:*  $H_{(R1 E_{\bar{S}2})} \rightarrow 1, PP_{(R1 E_{\bar{S}2})} \rightarrow 1, A(S2) \rightarrow -1$   
*Since  $A(S2) \rightarrow -1$ , R1 is abolishing a negative event, therefore*  
 $A_{(R1 E_{\bar{S}2})} \rightarrow +1$ .

Statement 12 is to be read: The habit value of R1 leading to the abolishment of S2 is high, the perceived probability of R1 leading to the abolishment of S2 is high, and the affective value of S2 is low. Since the affective value of S2 is negative, R1 is abolishing a negative event, therefore, the affective value of R1 abolishing S2 is positive.

#### *Comments:*

It follows from Statement 12 that discussions on whether avoidance behavior is maintained by «safety» or «residual fear» are a sham problem. Since  $-(-1) = +1$  there is no logical reason to prefer one of the two expressions, it is really the same whether one deals with the negative affect of S2, or the positive affect of  $\bar{S}2$ .

Given that SV is obtaining a highly attractive stimulus (S2 with a high A value), it follows from Statement 1b that the arousal level is expected to be low when coping exists.

#### Comments:

The most adequate way of reducing arousal to a threat is to reduce or eliminate the threat itself by action. This is the simplest definition of coping, the coping act. The CATS definition

is not for the actions, but for the acquired expectancy of being able to cope. In man and animals an acquired expectancy of being able to cope is followed by a marked reduction in arousal (“stress”). *In CATS we suggest that this low level of arousal is due to an expectancy of future events, tied to the expectancy of a positive outcome of the performance.*

## VII HELPLESSNESS

*Helplessness is the acquired expectancy that there are no relationships between responses and reinforcement (Table 5).*

**Table 5 a**  
**Helplessness Defined as Response Outcome Expectancies.**

### **Helplessness exists when:**

*Statement 13:*  $H_{(R1 E \bar{S}2)} \rightarrow 1, PP_{(R1 E \bar{S}2)} \rightarrow 0, A(S2) \rightarrow -1,$   
 $PP_{(R1 E \bar{S}2)} \sim PP_{(\bar{R}1 E \bar{S}2)}$

Statement 13 is to be read: Helplessness exists when the perceived probability of avoiding an unpleasant stimulus approaches zero.

The habit value of R1 relating to abolishing to S2 is high, the perceived probability of R1 abolishing S2 is low, and the negative affective value of S2 is high.

### *Comment:*

From Statement 1a the arousal level is expected to be high. For prolonged states Statement 15 may predict low arousal.

### Comments

Formally, in this case, the expectancy is that there is no relationship between anything the individual can do and the outcome. The perceived probability of avoiding the aversive stimulus with a response is the same as for no response. In other words, the response is without any perceived consequence for the occurrence of the aversive event. The organism has no control.

When the “helplessness” expectancy is truly approaching zero, the individual may accept that there is no solution, and the arousal may be reduced. Arousal may also be reduced if the helplessness leads to secondary gain and support from society.

## VIII HOPELESSNESS: NEGATIVE RESPONSE OUTCOME EXPECTANCY

*Hopelessness is the acquired expectancy that most or all responses lead to a negative result*

*Table 5).*

**Table 5 a**  
**Hopelessness Defined as Response Outcome Expectancies.**

### **Hopelessness exists when:**

*Statement 14:*  $H(RI E_{S2}) \rightarrow I, PP(RI E_{S2}) \rightarrow I, A(S2) \rightarrow -I.$

Statement 14 is to be read: Hopelessness exists when there is a very high probability that available responses bring results of high negative affective value.

*Comment:*

Statement 1a predicts high arousal levels.

Comments

Hopelessness is more directly opposite of coping than helplessness, since it is a negative response outcome expectancy. There is control, responses have effects, but they are all negative. The negative outcome is his or her fault since the individual has control. This introduces the element of guilt, which may make hopelessness a better model for depression than helplessness. Depression defined as a generalized negative expectancy is now an important part of the cognitive tradition in the “hopelessness theory of depression”.

## **IX PREDICTABILITY, FEAR, AND ANXIETY**

*Predictability is used both for the true relations between events, and the subjective or learned (perceived) relation. Only the acquired (learned) relation is related to internal state of the organism. Perceived predictability offers formal definitions of fear and anxiety.*

A highly probable as well as a highly improbable event are both predictable, and are concurrent with low arousal. Uncertainty produces high arousal. However, *predictability in itself is not enough to predict the internal state, or the behavioral consequences.*

### **Fear:**

In situations where the affective value of the expected event is highly unattractive, high perceived probability leads to high arousal rather than low. This is a reasonable definition of *fear*.

### **Safety:**

When the perceived probability of the unattractive event is low, the arousal is low, this is safety.

### **Anxiety:**

If the perceived probability of an unattractive event is at chance level, that is, the perceived probability is close to 0.5, the arousal is high, this is uncertainty. This is a reasonable definition of *anxiety*.

## X ACCESS TO THE ACTIVATION OF THE AROUSAL SYSTEM

*Stress (alarm) occurs when something is missing, i.e. when there is a discrepancy between goals (SV) and reality (AV). The probability of eliminating such discrepancies influences access to the arousal system (Table 6).*

**Table 6**  
**Access to the Activation System**

Access to the activation and arousal system depends on the perceived probability of success

### **Low probability:**

*Statement 15*                      *Activation  $\rightarrow 0$  if  $SV_1 \neq AV_1$ , and if  $PP((SV_1 - AV_1) \rightarrow 0) \rightarrow 0$*

Statement 15 is to be read: For any particular motivational system with a difference between the set value  $SV_1$  and actual value  $AV_1$ , the arousal is reduced by low or eliminated activation if there is a low (perceived) probability that the difference between the set value and the actual value will be eliminated.

### **High probability:**

*Statement 16*                      *Activation  $\rightarrow 0$  if  $SV_1 \neq AV_1$ , and if  $PP((SV_1 - AV_1) \rightarrow 0) \rightarrow 1$*

Statement 16 is to be read: For any particular motivational system with a difference between the set value  $SV_1$  and actual value  $AV_1$ , the arousal is reduced by low or eliminated activation if there is a high (perceived) probability that the difference between the set value and the actual value will be eliminated.

### **These processes contribute to the hierarchy of motivational systems:**

*Statement 17*                      *If  $SV_1 - AV_1 \neq 0$  and  $SV_2 - AV_2 \neq 0$ ,*  
*and if  $PP(R_1 \Rightarrow (SV_1 - AV_1) \rightarrow 0) > PP(R_2 \Rightarrow (SV_2 - AV_2) \rightarrow 0)$ ,*  
*and if  $A(SV_1) \sim A(SV_2)$ ,*  
*then*  
 *$P(R_1) > P(R_2)$*

Statement 17 is to be read: When an organism is faced with two problems, and the perceived probability of solving problem 1 is greater than for the second problem, the probability (P) of the behavior ( $R_1$ ) involved in the solution to the first problem will be greater than the behavior involved in the second problem ( $R_2$ ).

## Comment

Rats trained to barpress for water on continuous reinforcement (CRF) have higher values if shifted to a variable interval (VI) schedule, while VI trained rats have lower values if shifted to a CRF schedule. Predictability, therefore, is important for arousal.

The affective value of the expected event also counts. Cues signaling positive events (e.g. food to hungry rats) produce a decline in the corticosterone response. Thirsty or hungry rats have high levels of plasma corticosterone when there is uncertainty about whether food (or water) is coming or not, and low levels when there is a very high or very low probability that food (or water) is coming. The perceived probability of success, therefore, has a decisive influence on the arousal level. Increased arousal, or “stress”, is not a direct function of deprivation unless there is some probability that the missing item may be available. From a biological point of view it would be inadequate if, for instance, the food or water-deprived animal kept running around in its cage when food or water is not available. Instead, they are quiet until some cue signals that the deprivation period may be over.

CATS proposes that the probability of success have consequences also for the hierarchy of set values. This is an important psychological function. At any point in time, the brain monitors many set values, and selection mechanisms must be operating.

## **XI ACTIVATION AND AROUSAL THEORY – OTHER CONCLUSIONS**

*Stress is an adaptive response.*

*Stress may be reduced by distortion of stimulus expectancies*

*Only sustained high arousal levels constitute a potential health risk.*

*Social order is related to expectancies, coping, and health*

*A prerequisite for the CATS position on stress is a general, non-specific brain stem activation concept.*