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Cognitive activation theory of stress—how are individual experiences mediated into biological systems?

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The cognitive activation theory of stress (CATS) offers a psychobiological explanation for the relationship between life events, from hassles in worklife to dramatic events, and individual health. It differs from other prevalent stress theories by offering a formal system of systematic definitions, it relies on cognitive formulations within learning theory, it offers a consistent pathophysiological model for health and disease, and it is valid across species and cultures. The aim of this paper was to compare CATS with other prevalent theories with respect to the relationships between worklife and health. The main concern was the comparison with the demand–control theory of Karasek & Theorell. A brief review is presented of interventions based on CATS positions, in particular interventions aimed at modifying patients' expectations, as well as at attempts to prevent illness and disease in the working population.

Key terms coping; expectancy; prevention; rehabilitation; stress theory; therapy; worklife.

The cognitive activation theory of stress (CATS) (1) offers a psychobiological explanation for the assumed relationships between health and external and internal events referred to as "stress". It is a cognitive theory since physiological and psychological consequences all depend on cognitive evaluations of the situation and what a person can do about it. It is an activation theory since the psychobiological consequences of cognitive activity are explained by increases in arousal (activation). It is a psychobiological theory that includes and integrates data from both animals and humans—from fish to Olympic competition (2). It is a theory in that all concepts are given formal symbolic definitions and that it claims to be compatible with the empirical basis in this area of psychobiology (1).

CATS appears to be relevant in the present context since it aims at presenting a consistent pathophysiological model for health and disease, valid across species and cultures (1). The aim of this paper was to compare CATS with other prevalent theories with respect to the relationships between worklife and health among humans. Does the emphasis on formal definitions, individual expectancies, and the link to psychophysiological activation processes add anything, and is this information a useful background for intervention?

Stress as a healthy alarm

The term "stress" is used for four aspects of "stress"; stress stimuli, stress experience, the nonspecific general stress response, and the experience of the stress response (3). The stress response is conceptualized as a general alarm in a homeostatic system, producing general and nonspecific neurophysiological activation from one level of arousal to a higher level of arousal.

This alarm or stress response is healthy and necessary whenever there is a discrepancy between what should be [set value (SV)], and what is [actual value (AV)] with respect to the same variable. The unpleasantness of the alarm is no health threat. However, if sustained, the response may lead to illness and disease through established pathophysiological processes (1, 3).

The level of alarm depends on the expectancy of the outcome of stimuli and the specific responses available for coping. Psychological defense is defined as a distortion of stimulus expectancies. Response outcome expectancies are defined as positive, negative, or none to the available responses (1, 3). These definitions are the basis for formal definitions of coping, hopelessness, and helplessness. The advantage of such definitions is not only precision, as it also makes it much less interesting

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to discuss the relative virtues of words (coping, control, mastery, efficacy) that may, in reality, cover the same dimensions. Another advantage is that these formulations make it possible to operationalize the dimensions for humans and for animals. Finally, when "coping" is defined as positive outcome expectancy and related to psychophysiological activation, the concept acquires predictive power for physiology, pathophysiology, and relations to health and disease (1, 3).

Expectancy

The crucial concept in CATS is "expectancy". Expectancy is an essential element in many reformulations of learning theory from the last few decades (4–6). When a rat learns an instrumental response for food, it typically first learns that certain cues predict food and then learns that certain responses produce food, for instance, pressing a bar in the Skinner operant box. What is stored in the brain may be referred to as "expectancies". When the brain has established that one event precedes another, the brain "expects" the second event after the first event has been presented or the response has been performed. This is also referred to as the "two-process" theory of learning. The brain first establishes that there is a relationship between stimuli, one stimulus preceding the other. Pavlov's dog stored the information that the bell preceded meat. This is stimulus–stimulus learning, most often referred to as classical conditioning. The second stage in learning is to establish the expectancy that one type of action (response) leads to a consequence. This is response outcome learning and is most often referred to as instrumental conditioning. In CATS, these cognitive reformulations of stress theory and learning theory are necessary to explain how the brain determines the health consequences of "stress".

The main advantage is that CATS offers a frame of reference for the information processes in the brain and therefore makes it possible and meaningful to compare these functions across species. The information processing in brains follows certain basic principles common to all of us. This similarity opens the possibility to study pathophysiological processes also in animals.

Expectancies—priorities, probabilities and values

The alarm response gives priority to unexpected events and to events in which the reason for the alarm is not eliminated. Since the brain is, above all, an organ designed for multiple, simultaneous tasks, there must be a system for giving priorities beyond simple novelty. Again, we attribute these processes to expectancies and to a system for ranking priorities. Ranking requires quantification, and we quantify expectancies using the following three dimensions: acquisition strength, perceived probability, and affective value (1).

Briefly, the acquisition strength (the H "habit" value) (6) ("the strength") of an expectancy expresses strength according to the general principles of learning theory. This expression depends on the properties of the events ("salience"), the contiguity in the presentation, the number of presentations, and how often the events occur together (the predictive value). The perceived probability (PP) (6) of an expectancy expresses the probability of the expected event, as it is perceived by a person. This is a subjective evaluation of the probability based on learning (the H value). 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, and high levels of perceived probability for response outcomes can be referred to as control. The affective value (the A value) represents the reward value of the expected event (negative, positive, or neutral) (1).

Comparison with other theoretical positions

The demand–control model of Karasek & Theorell

In the analyses of potential psychosocial factors as modifiers or direct causes of ill health, there are essentially two overlapping traditions. One tradition emphasizes formal or "objective" work conditions, and the other focuses more on the stress management potential of each employee. CATS is probably the most extreme in its emphasis on individual factors, the best known and most influential "objective" model being the demand–control model of Karasek & Theorell (7). There is a strong consensus that it is the combination of psychological demands, task control, and skill use at work that predicts stress-related ill health and behavioral correlates of work. Jobs with high demands, low control, and low social support carry the highest risk of illness and disease. Low psychological demands and high levels of control carry the lowest risk. Jobs with high psychological demands and high control, and low psychological demands and low control, carry an average risk. A considerable amount of data demonstrates significant relations to disease, in particular to cardiovascular disease (5). The control dimension is the most robust predictor (8).

In later developments, Theorell places much more emphasis on individual stress management, coping abilities, and subjective feelings of being in control or being able to cope (8). This emphasis is very much in line with the theoretical and empirical background for

CATS and other positions emphasizing the individual variance in responses to "stress". In these later papers, Theorell has studied one important aspect of coping, locus of control (9), which relates to a person's attitude towards his or her own possibility to exert control over his or her environment. An external locus of control means that the person expects the environment to solve his or her problems, while internal locus of control corresponds to the attitude that the person has to take care of the problem himself or herself. Neither the extreme internal nor the extreme external locus is recommendable in all situations (10).

It seems to be a consensus that physical demands and psychological characteristics that produce the stress response have nothing in common (3). Another consensus is that all stimuli are evaluated or filtered by the brain before they gain access to any response system (1, 3). The specific CATS position is that these "filters" are related to response outcome expectancy and stimulus expectancy (6, 11). It is the person's experience of the demands and the expectancies of the outcome that determine whether the demands cause stress responses, which again may cause illness and disease in humans and animals (3). Within this cognitive tradition, and in CATS, coping is defined as positive response–outcome expectancies (11). In other words, the people expect that they will be able to handle the situation with a positive result. The difference from the usual control concept is that it is not enough to have control; instead people must expect that this control leads to a good result with a high degree of probability. If this is not the case, they may develop negative expectancy with guilt, which is referred to as hopelessness in CATS (1).

In order to determine how important individual expectancy is for subjective health complaints, a study was conducted by Eriksen & Ursin (12), who used two questionnaires, one based on the CATS position and one on the model of Karasek & Theorell. One set emphasized the more "objective" control mechanisms available to a person, and the other focused on the more "subjective" type of response outcome expectancies. In both models the health effects depended on the combination with the psychological demands. In the classical demand–control model, high demands may cause illness and disease if a person does not have control in work situations. The results showed that, in this study, "coping" had more impact on all of the subjective health complaints than "control" did. The combination of high demands and low coping turned out to be the worst combination (12).

The effort–reward imbalance model of Siegrist

Another theoretical model of work stress that has received much attention is the effort–reward imbalance model in which the focus is on reward and contractual fairness in employment (13). This model builds on the notion of contractual reciprocity that lies at the core of the work contract, with respect to which accomplished tasks are reciprocated by adequate rewards (money, esteem, and career opportunities, including job security). The model claims that lack of reciprocity occurs frequently under the following three conditions: (i) "dependency" (due to a lack of alternative choice in the labor market); (ii) "strategic choice" (anticipatory investments in order to increase future promotion prospects); (iii) "overcommitment" (a motivational pattern of excessive work-related performance and achievement that may be part of a person's psychological profile or result from a competitive work environment). The model further suggests that failed reciprocity in terms of "high cost" and "low gain" elicits strong negative emotions and sustained stress reactions. As with the demand–control model, the effort–reward model also deals mostly with cardiovascular disease, and not with musculoskeletal problems, even though the latter account for most long-term sickness compensation and permanent disability (14).

The potential contribution from CATS is to offer a pathophysiological model for these findings. Within CATS, effort–reward imbalance is clearly a discrepancy between set values and actual values, the result being sustained activation that, again, may result in pathophysiological consequences. No pathophysiological consequences are to be expected if this imbalance is of short duration; it is long-lasting imbalance that matters, and only if the reward has a high affective value.

Other stress models

Coping is often defined as the acts or strategies chosen [Ways Of Coping, a very important questionnaire (15)]. However, the strategy chosen does not predict the result or the internal state; it can be executed in high, as well as low, arousal; therefore, it does not predict health effects (1, 3).

The concept of "control" is found in many other models than the original demand–control model. The generalization of the expectancy from one situation to all situations is an important aspect (16) for the response–outcome expectancies in CATS (1, 3) and in the Rotter "locus of control" (9). Self-efficacy (17) is another related concept, defined as the belief that a person can act in a way that leads to a particular goal. When this expectancy is generalized and related to an event with high affective value, it becomes close or even identical to the CATS coping concept. The generalized self-efficacy (and coping) concept relates to self-esteem and neuroticism, as measured with standardized questionnaires (18). There are also other related and overlapping terms. Toughness, an increased ability to

deal with a stressor (19), develops through repeated exposures to a variety of stressors. Other related concepts are hardiness (20), high self-esteem, affective stability (21), mastery (22), sense of coherence (23), and older concepts like the "instinct of mastery" of Hendrick (24) and the effectance concept of White (25).

In recent works, Theorell has defined "covert coping". When difficulties are met that cannot be dealt with, one possible strategy is to establish success in other fields of life. This strategy relates to depression, passive avoidance, and defensive behavior (26) and is related to illness and disease risks. One particularly unfortunate strategy available to humans is to "take it out" on family members when the job situation is intolerable. This phenomenon is similar to "displacement" strategies in animals. Frustrating important behavior patterns may lead to strange or inadequate responses like meaningless pecking on the cage (27). Within CATS, this shift from one motivational system or behavior to another is related to the hierarchy of motivational systems, which, in CATS, is related to the probability of correcting the set value or actual value imbalance attached to each motivational system (1).

Interventions based on individual coping models

Prevention

Tone Morken (28) and her collaborators have performed a large study involving a general training program intended to reduce musculoskeletal complaints and sickness absence, improve psychosocial factors, and improve the way people cope with their complaints in the aluminum industry in Norway. The project took 4 years and included the interventions and a 1-year follow-up. The study was a randomized intervention study. The participants demonstrated an increased use of coping strategies to handle their complaints, and they also reported a tendency towards increased social support. However, this large intervention did not give any significant changes in musculoskeletal complaints or in sickness absence.

Eriksen and her collaborators (29) tried a larger intervention with three intervention groups, one stress management training group, one physical exercise group, and a combination of physical exercise and stress management information. This was a randomized controlled trial comparing the three intervention groups with a control group. The total material comprised 860 persons, and the effects were followed for 1 year. There were no significant effects on subjective health complaints, job stress, or self-reported sick leave. However, there were significant effects on the self-reported feeling of improved knowledge, increased subjective health, and increased physical fitness. The participants also reported significant improvements in their muscle pain. Those randomized to receive either stress management training or the combined program also reported an improved ability to cope with stress and challenges in daily work. The odds ratios for these findings were very high, from 4 up to 25.

These and other studies demonstrate that good healing and positive results are easily obtained from interventions as long as only subjective statements from the participants are relied on. However, if one compares the actual reports on subjective health complaints with respect to prevalence and intensity, or sickness absence, there are no significant effects. There is an increase in the market value of the interventions but no real significant economic effects for society or the company. However, the interventions in the mentioned studies might lead to lifestyle changes, which may be beneficial in the long run. A reduction in musculoskeletal complaints, for example, generally not only requires very large samples, but also a long follow up. Effects in terms of keeping people in worklife and effects on individual health are both possible long-term effects of the interventions that might not be demonstrable from short-term effects (28, 29).

Therapy

The most important reason for sick leave in Norway is musculoskeletal pain, half of which is long-lasting low-back pain. The second most important reason is psychiatric diagnoses; a substantial portion of which appears to be light conditions like moderate depression and fatigue. For all these conditions, a cognitive behavioral approach seems to be efficient treatment (30, 31). Two intervention programs with cognitive elements have been tried in large randomized, controlled studies. Both had individual coping skills as a main element, and both were compatible with positions that can be derived from CATS.

Brief intervention. Our starting point was a study by Aage Indahl and his colleagues (32) in which people with sickness compensation for more than 8 weeks for low-back pain were either given a brief intervention, or were merely left with the ordinary treatment given at the time. The material comprised 463 in the brief-intervention group and 512 controls. The average age was 44 versus 41 years in the two groups, respectively. The brief intervention ("Indahl treatment") consisted of a medical examination that emphasized information and feedback to the patient about the findings. The aim was to reduce fear and inactivity. The patients were advised not to pay attention to their back and were informed that there was no reason to be cautious or careful and that

they must stay active. They were followed and given the opportunity to contact a therapist at any time. The results of the study showed a significant effect. After 200 days, 60% were still on sick leave in the control group, compared with only 30% in the brief-intervention group. The effect was present even after 5 years in that 81% in the brief-intervention group were then working, while the respective proportion of the control group was only 66% (33). The same type of intervention was tried in a later study (34) in a randomized control trial. After 3 months, 52% of the patients in the brief-intervention group, but only 36% in the control group, had returned to full duty. The differences between the groups showed a slight decline, but they were still significant 12 months after the intervention (34).

Multimodal, cognitive behavior treatment. In another, very large randomized study, a program involving multimodal, cognitive behavior treatment was tried for patients sick-listed because of musculoskeletal pain (35). This program was extensive, lasting 4 weeks, 5 days a week, and 6 hours a day. The program was carried out by a multidisciplinary team. It included physical training, cognitive behavioral modification, education, and an examination of the work situation for each patient. The treatment emphasized the patient's responsibility for his or her own health. The program focused on function and not on pain, diagnoses were discussed, and information and feedback were given (35). This program seems to have been too extensive in that no significant differences between the treatment group and the control group were detected (52% versus 53% back to work). There was a slight tendency towards improvement for those with general muscle pain, but none in the other groups of musculoskeletal pain patients.

This large experiment was followed by comparing this extensive program with a light brief-intervention program and treatment as usual. The patients were at first divided according to prognosis (light, medium, and serious) on the basis of a simple questionnaire asking about general pain and the patient's own optimism and willingness to participate in treatment. In this case, those with a very poor prognosis benefited from the extensive program, but there was no point in providing such an extensive program for the other patients (36).

Cognitive behavioral treatment. In the European guidelines for low-back pain (30), cognitive behavioral treatment is among the recommended therapeutic methods, along with brief intervention; multimodal, cognitive behavior treatment; and supervised exercise. Both the brief intervention and the multimodal, cognitive behavior treatment contain important elements of cognitive behavioral treatment and both are compatible with positions from CATS.

There is, however, a need for more precision and an evaluation of the different methods within cognitive behavioral treatment, as also stated by the European guidelines (30). This need can be met by basing cognitive behavioral treatment on a consistent theoretical framework. CATS may offer such a framework.

A consistent finding in the literature on low-back pain is that patients with chronic and nonspecific low-back pain have established a negative expectation of personal abilities to gain control of the condition. This expectancy is a significant predictor of poor prognosis (36, 37). Patients that have acquired negative outcome expectancies do not dare move and struggle with fear of pain and catastrophic consequences of activity and movement (38). Even if cognitive behavioral treatment, as well as programs with brief intervention or multimodal, cognitive behavior treatment, is directed towards these fears and avoidance, we believe that a detailed protocol with cognitive behavioral treatment based on CATS positions may be an interesting approach. We are currently testing this possibility in a large randomized controlled study.

Rehabilitation

One-third of all disability pensions are due to musculoskeletal disorders (39). Among disability pensioners, low-back pain is the most frequent condition, alone leading to 13–17% of all sick leaves and disability pensions (40). Low-back pain generally has a benign course, as most of those affected recover within a few weeks (41). However, some will develop chronic pain and disability, which in turn may lead to absence from work and isolation from social life. Prolonged unemployment is associated with poorer physical and mental health (42, 43) and lower life expectancy (44–46). For these people, low-back pain has a serious impact on quality of life.

Long-term sick leave, vocational rehabilitation, and disability pensions due to back pain also represent an economic burden for society. Disability pensions alone had a cost of more than NOK 44 billion, which is about 5.6% of the Norwegian gross domestic product (GPD), in 2004. There is increasing concern in Norway, as well as in other Western countries, about the ever-increasing number of disability pensioners leaving worklife before the time of retirement. In the years to come, a decreasing number of employees will have to carry the increasing expenses of the pensions, to a point at which it will no longer be possible to cover the costs after the year 2050.

Magnussen et al (47) conducted a study in which the main goal was to investigate the effect of a brief vocationally oriented intervention, aimed at helping

disability pensioners with low-back pain return to work. Primary outcome measures were return to work or having entered a return-to-work process. The intervention had no significant effect on these outcome measures. Magnussen et al (47) further explored the issue of perceived barriers for returning to work through a focus-group-based qualitative study. The study was part of the aforementioned study of disability pensioners with low-back pain. The barriers that appeared were related to earlier negative experiences, poor self-judgment of work ability and low self-esteem, a lack of support from social security authorities, and unsuitable economic arrangements (48).

The studies conducted by Magnussen et al (47) confirm that the effort of returning disability pensioners with back pain to work is a challenging task. Because of the large economic implication of returning disability pensioners to work, the modest effect of the intervention used in the present study may still be of clinical and economic relevance, at least for a selected group of pensioners. Candidates for vocational rehabilitation seem to be more likely to succeed if they have a positive attitude towards returning to work, have less pain, and are not severely physically impaired. Candidates in future rehabilitation programs should probably be selected on the basis of these criteria. They seem also to need very close follow-up from all parties involved in the return-to-work process (47).

Concluding remarks

CATS differs from many other approaches to "stress" in the emphasis on the positive health consequences of the normal alarm response, occurring whenever the organism lacks an essential factor. CATS is an expansion of the general arousal and activation theory from neurophysiology. The stress responses are normal activation responses that lead to an increase in arousal and corresponding changes in behavior, as well as in most or all parts of the body. These somatic changes are mediated through well-described and well-understood mechanisms in psychophysiology, psychoendocrinology, and psychoimmunology.

CATS differs from more organizational and social theories in its extreme reliance on individually acquired expectancies to future events. When these expectancies are positive, there is no health risk in a healthy organism. Ill effects occur only when there is a lack of positive outcome expectancy (coping). CATS offers strict definitions for two different expectancies that occur when there is no coping, helplessness and hopelessness. Both states can lead to somatic disease through sustained arousal. Both states can also lead to somatic disease and illness through a lack of motivation to engage in a positive lifestyle. CATS, therefore, offers a new and alternative explanation for social differences in health, based on social differences in the reinforcement contingencies for the development of coping.

CATS offers formal definitions that can be expressed in symbolic terms that make it possible to arrive at clear definitions and a consistent use of language. The formal definitions also permit comparisons across species, without reference to nonverifiable assumptions of "mental" activities beyond the assumption that brains handle information according to basic logic principles.

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