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ORIGINAL ARTICLE

Cognitive Science Speaks to the "Common-Sense" of Chronic Illness Management

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Abstract We describe the parallels between findings from cognitive science and neuroscience and Common-Sense Models in four areas: (1) Activation of illness representations by the automatic linkage of symptoms and functional changes with concepts (an integration of declarative and perceptual and procedural knowledge); (2) Action plans for the management of symptoms and disease; (3) Cognitive and behavioral heuristics (executive functions parallel to recent findings in cognitive science) involved in monitoring and modifying automatic control processes; (4) Perceiving and communicating to "other minds" during medical visits to address the declarative and non-declarative (perceptual and procedural) knowledge that comprise a patient's representations of illness and treatment (the transparency of other minds).

Keywords Common-sense model · Illness representations · Cognitive science · Patient-centered care

Introduction

The main objective of this brief article is to spell out the relationship between theory and findings in cognitive science and neuroscience and the processes involved in the "Common-Sense Model" (CSM) of self-regulation. Although CSM has a number of "common-sense" features, it would be more accurate to label it a model of the processes underlying the common-sense management of health threats in everyday life. CSM is a dynamic, systems model. An individual's common-sense *representation* or model of a health threat is updated and enriched by actions to promote health, detect risk and prevent illnesses, by behaviors to manage acute and chronic illnesses, and by the expression of preferences and treatment decisions during terminal illness. As CSM is a systems model and is complex, it is a challenge to illustrate how it can be implemented in descriptive and intervention studies. Our task will be simplified by focusing on a particular set of phenomena; how patients and clinicians address and implement the management of chronic conditions. We address these problems in the following sections: I: Common-Sense Management of Health Threats; II: Representations of Procedures and Action Plans; III: CSM and Personalized Treatment; and IV: A Future for Patient-Centered, Translational Research.

Common-Sense Management of Health Threats

CSM translates the perceptions, actions, concepts, and language of the management of health threats in daily life into a cognitive science framework [1]. The translation and cognitive processes involved are best described by examining the following example of an elderly male undergoing an examination by a medical internist after being transferred from the hospital emergency department (ED).

The patient sits quietly, hand on chest, a strained and concerned expression on his face. He describes the events leading him to the ED as follows: "I had sharp chest pains and pressure. My head started to hurt. I felt kind of dizzy. I was scared; thought maybe I'm having a stroke, maybe a heart attack? I took two aspirins, but the headache didn't go

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away. It didn't stop. My wife said we'd better go to the emergency room. She put me in the car and drove us to the emergency room." After this exchange, the internist reviewed the record from the emergency department, conducted a physical examination, diagnosed the likely biological source of the symptoms, and addressed the patient's view of the symptoms prior to prescribing treatment and a life style change. We will first address the cognitive components of the appraisal process by the patient and his wife, and address the actions of the internist afterwards.

The Content and Creation of Illness Representations

The patient's words described key features of his somatic perceptions (symptoms), and the concepts they elicited (stroke and/or heart attack). The experience and concepts define his *representation* of the threat. The *representation* of the threat (at least the verbal description provided by the patient) created a framework for action; it led to the sequence of taking aspirin, discussion with his wife, and finally, going to the ED. The report that, "I took two aspirins, but the headache didn't go away", describes the patient's *representation* of the procedure first selected for management, but says little about the action plan that guided it (getting aspirins, a glass of water, and then swallowing aspirins). The statement about the outcome, "but the headache didn't go away", describes the failure of a match between an expectation embedded in the *representation of the procedures*, that led to the discussions with his wife and driving to the ED. The representations of the threat, the procedure for management and the action plan to implement management, are dynamic; they change over time.

Listening to the patient talk about his experience could lead one to forget that words are highly abstract symbols that provide an extremely limited view of what he and his wife were experiencing and doing during the period preceding their arrival at the ED. The actual *representations* of the illness, the procedures and action plans for implementing the procedures are far more complex; they are integrations of perceptions (symptoms; sight of the aspirins, water glass, etc.), concrete actions (imbibing aspirin; discussing the condition; driving to the hospital – perceptions and actions are non-declarative knowledge) and abstractions (stroke; heart attack; aspirin – declarative knowledge). The verbal statements describe selected features of these *representations* but omit virtually all the details of the perceptual experience and motor performance [2]. Thus, the statement, "She put me in the car and drove us to the emergency room," is based on episodic memory (a component of the declarative system). This statement ignores the details of the non-declarative processes that amplify the sense of urgency and the possible severity of the consequences of the illness threat (e.g., urging and/or helping the patient into the car, their emotional states as the wife drove (perhaps hastily) to the hospital).

Each of the representations of the threat, procedure for control, and action plan involve abstract concepts, and concrete, perceptual experiences and actions. Much of these ongoing processes are automatic, some deliberative and conscious. However, the exact proportion of each is unclear and possibly less important than the degree to which they are integrated and lead to outcomes with health benefits. Examining CSM within the framework of current studies in cognitive science and neuroscience will help to address these important and as yet unanswered questions.

Risk Detection: Joining Perception to Prototypes

Highly trained and verbally gifted psychologists impressed by the discourse between patient and clinician may seek to capture the essential features of the conversation by asking patients to respond to an instrument such as the Illness Perception Questionnaire, or IPQ [3, 4]. The IPQ can be scored in five broad areas: the *identity* of the condition, its symptoms and label; its *cause*, events perceived to have led to symptom exacerbation; *consequences*, its impact on work, family relationships, etc., *time lines*; its rate of onset, duration, fluctuations, etc.; and *controllability*, is it expected to be and/or has it been responsive to self initiated behavior or medically prescribed treatment. A measurement approach such as this is central for creating multiple regression models to identify the factors that may play a role in initiating management and predicting outcomes. It, however, ignores at least two sets of questions that are fundamental to CSM and central to contemporary cognitive science: (a) the processes involved in the detection of somatic and functional change and (b) the mapping or linking of perceived changes to abstract concepts. Examining the processes involved in these issues is critical both for understanding "common-sense" management and more importantly, for generating interventions, i.e., communications and demonstrations designed to shape behavior and achieve valued health outcomes. As we suggest later, the IPQ can play a valuable role in individualizing these interventions.

Risk Detection

CSM posits multiple routes for risk perceptions; for example, a media figure or family member diagnosed with cancer can activate self-scrutiny. However, the central route in CSM involves a search and detection of deviations from the underlying prototype of the physical and functional self [5, 6]. The prototype of the physical and functional self is

formed from the individual's history of somatic sensations, visual and auditory perceptions, and physical and cognitive function processed by the neural, physical, and physiological architecture of the body. In short, the prototype is elaborated in a prepared system; it has organized sensory and motor representations of the physical self (e.g., coordinating sight and sound with reaching and walking) and less detailed internal sensory and motor systems. Current texts provide detailed outlines of the system [7, 8]. This prototype changes slowly during normal aging, more rapidly in the case of accidents, diseases, and treatments (personal communication, J. Hash-Converse, 2010), and may also change based on observations of others.

CSM has focused on symptoms and dysfunctions that are perceived as disruptions in normal function of the self-system. An excellent example of this appraisal process is seen in the use of medical care by a sample of 111 older individuals interviewed prior to seeing their primary care physician for a self-initiated visit (the group was part of a larger sample all of whom were interviewed at 3-month intervals on four occasions [9]). Not surprisingly, all (100%) of the 111 reported experiencing new or worrisome symptoms. Each of the 111 was matched to someone similar in age, gender, and family size. The matched, "control" participants were also called and interviewed about their health status. Data from their reports showed that 30% had a new or worrisome symptom. Moreover, the representations of the symptoms reported by the 33 matched controls were less fleshed-out than those of the care seekers; control participants' ratings of their symptoms were less serious and disruptive, less often labeled as a specific illness, less often discussed with another person, and when discussed, the control participants were much less likely to be advised to seek care. This and numerous other studies [10] are transparent examples of the role of the detection of somatic and functional change in the elicitation of perceived risk and the effect of risk perception on subsequent behavior.

Linking Experience to Concepts

As Cameron et al. [9] showed, the detection of deviations from the normative self is a first step in the care-seeking process. The perception of the need for care involves the interpretation of the experienced deviations, or a match of the experience to an underlying abstraction, a prototype that defines the symptoms' meaning. Cameron et al.'s [9] 33 "control" participants who reported new symptoms but did not seek medical care, were less likely to have assigned their symptoms a disease label (i.e., they did not connect deviations with concepts), and were less likely to report symptoms as disruptive. In sum, their symptoms had not yet crossed the borderline between "minor" deviations and meaningful symptoms.

The mechanisms involved in the symptom interpretation process are clearly consistent with historical themes in cognitive science and recent neuroscience findings on the formation of memories. Andrews, Vigliocco, and Vinson [11] summarize two philosophical themes that have motivated cognitive science efforts to understand the creation of meaning; both are clearly operative in how people assign meaning to symptoms and dysfunction. One, the experiential tradition [12–15], proposes that the meaning of words and symptoms resides in concrete, perceptual experience. Kahneman and Miller [16] describe the process of joining perceptions (stimuli) to concepts (category labels) by the action of "elements" in specific contexts; they do not however, specify what these elements may be. They propose that the linking process can be initiated by stimuli from the bottom up and by concepts from the top down, the direction depending upon the context. The outcome of this process is the creation of a meaningful whole; a concept and label and its perceptible properties. The distributional tradition, attributed to Wittgenstein [17], argues that the meaning of concepts and/or words resides in their linguistic context. This approach is aptly summarized by a quotation borrowed from Frith [18]: "you shall know a word by the company it keeps" (see p. 11 in [11]). Computer modeling of co-occurrences in text provide the empirical support for this approach. The point to emphasize here is that meaning does not require perceptible referents; the meaning of a concept emerges from its use or placement in language.

The contribution of referential and co-occurrence processes in creating representations of health threats and treatment procedures is clear in studies of adherence to treatment. Two early qualitative studies of patients with hypertension, an asymptomatic disorder, found that patients treated hypertension symptomatically. Thus, although hypertension is a silent disease and study participants cannot accurately judge when their pressure is high [19], they believe they can tell when their pressure is elevated and use symptoms as indicators of elevated pressure and guides to adherence. The symptoms, "tension", "feeling hyper", etc., were perceived as valid because of their co-occurrence and overlap with the disease label "hypertension." As tension and feeling hyper are typically reported during psychological and physical stress, they were seen as valid indicators of hypertension [10, 20, 21]. Quantitative data by our group confirmed the qualitative observations; patients who had been in treatment for years and were adherent, reported that medication alleviated their symptoms [22]. Although they believed that *they* could tell when their pressure was elevated, they did not believe that held for others as they strongly agreed that "people" cannot tell when their blood

pressure is elevated [22]. Meyer et al. [22] also found that 60% of a sample of newly treated patients dropped out 9 months later if they told their doctors they could monitor their blood pressure symptomatically when they began treatment. "Co-occurrence" in language could establish the validity of these "symptoms" because hypertension is a "silent" disease.

The symptom-driven use of medication is not restricted to hypertension. The majority (80%) of 198 patients hospitalized because of a severe attack of asthma agreed that they will definitely or probably always have asthma, but 57% also believed they had asthma only when symptomatic. The episodic representation, reinforced by the episodic nature of asthma (symptomatic episodes preceding attacks separated by periods of quiet), is associated with less-frequent use of prescribed medication (45% of patients with episodic representations were adherent versus 70% of patients with chronic representations). The episodic representation is also associated with less-frequent routine visits and less-frequent use of peak flow meters to evaluate pulmonary status [23]. Similar symptom-driven behavior has been reported for patients managing hemophilia [24] and HIV AIDS [25]. In these and other similar cases, referential and linguistic co-occurrence work together to encourage a symptom-based definition of risk; the relative importance of each depending upon the degree to which the disorder is silent, episodic, or consistently symptomatic.

Specific Elements and the Need to Define Words in Reality

If the nervous system is designed to anchor abstractions in perceptible events, as Locke and others have proposed, the specific factors involved in the linking process might be partly innate and function automatically and largely outside of awareness [26]. We initially used the term "symmetry" to describe how symptoms were matched to disease labels when patients were diagnosed with hypertension [5]. Symmetry seemed to be a heuristic similar to other generic processes, such as availability and representativeness. "Generic" heuristics are far less informative of process than generics in medicine, as unlike the latter, they do not have known properties and they lack clear pathways and targets for action and fail, therefore, to answer specific questions such as: What is the event representative of? What makes it available? And what makes a disease and label symmetrical?

CSM has begun to address these questions by identifying the elements involved in creating and linking experience to concepts. Specifying these elements also opens a window to understanding failures in interpersonal communication and why messages from medical and public health practitioners often fail to achieve their goals in patient and public behavior. Two studies, one a quantitative analysis of delay in care seeking following myocardial infarction (MI) [27], the second a qualitative analysis of the use of treatment for congestive heart failure (CHF) [28], provide excellent examples as to how the content of the elements affect their operation in the linking process. The studies identify four sets of elements: (1) *location*, (2) *stimulus pattern*, and two *time lines*, (3) *rate of onset* and (4) *duration*. Patients with MI experience chest pain, pain radiating to the shoulder (location near the heart and its felt beats), and pressure (also a sign of over exertion), and have rapid onset and rapid increases in severity of symptoms (time lines). These elements map to heart and each of them is positively and independently associated with more rapid care seeking [27]. The location of symptoms experienced by patients with CHF, e.g., problems breathing, swollen legs, and the time frames of these symptoms, e.g., chronic, slow changes before catastrophic changes, lack the pattern and rate of change for attribution to the heart [28]. Patients with CHF are confused, "When you hear about having heart problems, –- you're supposed to feel maybe a pain in your left arm, maybe a pain in your chest, or pressure. If I had chest pain, then I would have said, okay, I'll call [the doctor]." In sum, specific elements make the label "heart attack" available, these elements define the search for an available prototype and the match activates the representation of a heart attack.

The evidence respecting the linking of abstractions (words and symbols) to experience suggests that both experience and use are critical for enriching the meaning of concepts. *Indeed, we will advance the proposition that concepts can only lead to and create behavioral patterns that generalize across illness labels if they have experience and behavioral underpinnings that can be joined and implemented across contexts.* CSM's analysis of the elements involved in joining somatic experience to underlying schemata or prototypes for the creation and activation of illness representations parallels animal findings which have linked the activation of specific neural clusters to specific concepts [29].

Representations of Procedures and Action Plans

Illness representations create a framework for action, but a sophisticated user of CSM would not attempt to predict action from an illness framework alone. The predictive power of a valid measure of illness representations, such as the Illness Perception Questionnaire [3, 4], will be large in studies that include both well and ill participants as the measures will differentiate the two groups. Illness perceptions will have limited predictive power, however, when all study participants have been diagnosed and see themselves

as ill from or at risk for the same disease unless there is variability in how the illness is perceived and/or understood (e.g., some see it as symptomatic, others do not). When study participants have relatively homogeneous representations of the same condition, their representations of treatment (or life style change) and the presence of action plans will be far more robust predictors of individual differences in behavior. However, the variance attributable to procedures and action plans will be limited by external constraints on behavior, for example, social and economic factors that reduce the variance accounted for by individual perceptions and beliefs. It is important to recognize that neither illness nor treatment representations are static traits; they are changeable and sudden shifts in these representations may lead to major changes in behaviors, including treatment adherence.

Selection of Treatment or Preventive Procedures

Selecting and performing a treatment or preventive behavior, whether done automatically or deliberatively, assumes an implicit or explicit match between the procedure and the illness representation and an action plan; it assumes coherence [3, 4]. The match assumes that the procedure targets the identity of the threat (its symptoms and underlying causal process), its anticipated efficacy (control) in a given time frame (implicit or explicit), with its own set of consequences (side effects). The perceived and/or expected features of a procedure can be assessed in each of the five domains that characterize the representation of the illness. A differentiated approach to the assessment of representations of treatment is not essential. Instruments have been developed to assess two general facets of medications, perceived benefits and concerns about medications in general and benefits and concerns about one's own medication for a particular condition [30]. Many items specific to the five domains are nested in each of these four scales and though total scale scores are typically used in regression analyses, item-specific information can be useful for identifying targets for interventions.

A number of investigators have used measures of illness representations and measures of coping strategies to predict behavior; this approach is inconsistent with CSM. Illness representations combine with specific procedures and not with coping strategies. For example, patients diagnosed with colon or breast cancer may prefer surgery to radiation as they see surgery as removing the tumor. Coping strategies, for example, avoidance versus problem-focused strategies, can however, moderate preferences for one or another procedure or moderate the speed with which a preference or decision is expressed. Thus, both illness and treatment representations are nested under and moderated by strategies for self-regulation.

Action Plans and Situated Behavior

Two developments in cognitive psychology helped to introduce *action plans* into studies of health behavior; Miller, Galanter and Pribram's [31] volume on “Plans and the structure of behavior”, and Milner's [32] classic empirical work that supported Ryle's [33] distinction between declarative and procedural knowledge. Milner [32] describes how surgery eliminated both HM's epileptic seizures and his ability to form new memories, with one important qualification: although he could neither recall practicing drawing within the narrow, double borders of a star pattern nor recognize the person instructing him, his performance improved over trials as his procedural memory was intact.

Procedural control systems, i.e., *action plans*, were introduced in studies of behavioral health during the 1960s [34, 35]. Decades of research have consistently shown that action plans are mediators of health behavior change [36]. Implementation intentions, a minimalist version of action plans introduced by Gollwitzer [37] into the model of planned behavior, have also proven their efficacy in mediating the gap between intentions and action [38]. Unlike implementation intentions, action plans consist of two, separable sets of elements: a unit for behavioral control and the perceptual representation of the context (social and physical ecology) in which the control unit is situated [35]. The control unit is at the center of the plan. It consists of cues defining a discrepancy from a set point, a procedure or action, an expected to be observed outcome, and a post appraisal of response efficacy, that is, whether the procedure reduced the discrepancy. The initiating cue (the discrepancy defined by a symptom or an objective reading) is defined by the illness representation, the procedure is selected from a potential set of treatment or lifestyle actions, the outcome is the removal of the discrepancy defined by the representation (a symptom, dysfunction, or objective indicator) within a defined time frame. The representation of both the illness and the procedure identify necessary features of the control unit, but they are not sufficient for the creation and implementation of an action plan. Most importantly, they are not sufficient for transitioning from a conscious deliberative act to an automatic act.

The second, essential set of elements for the formation of an action plan is the representation of the social and physical context in which the control unit operates. This facet of action planning was based on Gibson's [39, 40] analysis of perception in natural environments, Lewin's [41] representation of pathways to perceived goals, described more recently by Greeno [42] in his elegant elaboration on the nature of “situated” theory, and by the division of non-declarative memory into perceptual and procedural learning

[2]. The representation of the context at both the perceptual experiential and abstract levels, defines the affordances or pathways in which the control unit is situated and performs. For example, half of the college student participants in each of the groups in the studies of the effects of fear levels on taking preventive inoculations against tetanus were given maps of the university campus with the student health center clearly marked. This information was not new. The key was the instruction to review their daily class schedules and identify specific times when they would pass near the health center. The review inserted dropping in for a tetanus inoculation into an ongoing, and well-structured daily behavioral pattern in their perceptual worlds [35]. *In short, the control unit was situated in their behavioral environment*. The planning process makes clear that CSM is a situated theory [42].

Feedback and Feed-Forward Properties of Procedures and Action Plans

Both lay persons and investigators are inclined to view behavior as an outcome of a process beginning with sensation and perception through cognition to action; the evaluation of the action, which is, whether one is closer or further from the goal (negative or positive feedback), provides the feedback to close the loop. *The degree to which procedures and action plans have feed-forward properties is less often appreciated. The feed-forward process is the search for triggers to activate the control system: the readiness to search is embedded in the control unit.* In everyday terms, "If you have a nice, new hammer, everything looks like a nail." The feed-forward and feedback cues (outcome expectations) are typically mirror images of one another. Attention to cues to activate (or justify) a behavioral plan is involved in behavioral syndromes such as the "worried well"—individuals who seek medical care to reduce their anxiety about life stresses. These patients search for, find and interpret minor and stress-related somatic cues as signs of disease risk [43]. The studies of patients who search for and interpret every chest pain as a sign of cardiac risk provide a likely example of the feed-forward effect [27].

Many feed-forward effects occur implicitly and automatically, slipping beneath the "radar" of conscious awareness and are slow to be discovered. Neuroscientists have uncovered linkages between words and motor areas (words referring to body action activate the pre-motor cortex [44] and words with "motor associations" activate localized motor areas) suggesting the representations and readiness to act are mutually activating. All of these processes, such as the automatic assumption that sharp, chest pain of sudden onset reflects a heart attack, to more subtle feed-forward processes, can be reframed or integrated into new and more valid, abstractions. Symbols and words, highly abstract concepts, play a critical role in linking seemingly unrelated experiences and making sense of behaviors targeting goals at different points over lengthy time spans.

CSM is a Multi-Component, Multi-Level Model

The model of a control system in context defines the ground level mechanisms in CSM. Critics of control system approaches argue that they are "machine like" and focused on reducing discrepancies (current and sought outcome) set by the machine's manufacturer, ignoring the creation and goal setting by the actor [44]. If control models were constructed in this manner, the criticisms would be correct as a thermostat like control system is insufficient to account for preventive or treatment behaviors. CSM has addressed this concern by postulating the presence of multiple processes, possibly hierarchically arranged and consistent with current findings in cognitive science.

Four Components or Levels of CSM

In addition to the control system defined by representations of illness, procedures for management and action plans, CSM specifies three additional components in the behavioral system. They include: (1) underlying prototypes of self and diseases (previously discussed); (2) strategies for self-regulation; and (3) executive functioning. Although prototypes and executive function have been in the background of the description of the of CSM's control system, additional properties and functions need to be spelled out to fully understand how CSM operates. As strategies moderating management, such as conservation of resources [45] or stable outlooks such as optimism [46], are less relevant to understanding CSM, they will not be discussed further.

Prototypes

Goal setting emerges from deviations of experience from the prototype of the physical and functional (cognitive; social) features of the "normal" (healthy/arthritic/etc.) self and the subsequent match of these deviations to prototypes of illness threats. Self-prototypes are acquired over time and are assumed to change slowly in the absence of accidents or severe illness. Most studies examining the contribution of the self to health outcomes have used generic measures; self-assessments of health (SAH) made on a five-point scale (excellent, very good, good, fair, poor) a prime example. Two important findings have emerged from these studies. First, SAH are powerful predictors of the future onset of major illnesses and mortality [47, 48].

These findings appear in many studies of community samples in multiple countries and in clinical samples, such as terminally ill cancer patients [48]. Second, self-appraisals of function (ability to perform everyday tasks) and not reports of emotional states, are the factors that contribute to, drive changes in, and create the criterion validity of SAH [49]. With the exception of the assessments of specific components of quality of life [50], self-assessment of specific functions (social; cognitive; etc.) of the prototype of the "normal" self, that are salient in the search for detecting health threats, are not well defined or integrated into CSM. For example, the extensive empirical work on cognitive function and its changes over the life span has focused primarily on objective measures of function in different domains [51, 52] rather than an individual's perception of cognitive function and functional decline. Person-based assessments are critical for understanding the detection of deviations leading to health behavior and how perceptions of declines in function may lead to loss of social roles and depressive symptoms [53].

Assessment of the other major set of prototypes, illness prototypes, has relied on various forms of multi-dimensional scaling in which prototypes emerge from analyses of participants' ratings of similarity or categorization of symptoms or illness labels [54, 55]. What is missing from assessments of prototypes of self and illness is the examination of the "slots" ([56]; analogous to biological receptor sites), and processes for "binding" perceptual experience and action outcomes to illness prototypes. In addition, only now are studies underway that examine the change of and variability in prototypes over time. Addressing these issues will be important for understanding the dynamic features of CSM.

Executive Functions

Executive function (EF) is involved in surveillance, assigning utilities, expressing preferences, making decisions, and selecting, regulating and evaluating action. The executive system is far more "open" than the base-level control units it monitors and attempts to shape and control. That is, EF is involved to some degree at every step of the control process and can help or hinder development of automatic, health promoting behaviors. Although the executive can express preferences, set goals, select procedures for goal attainment, etc. (it is an open system), EF is limited by the capacity of working memory, and most importantly, by its knowledge base (available prototypes and skills) and social and physical contexts. Understanding how EF affects the control processes involved in everyday management will be critical for CSM.

Surveillance includes the selection of cues for initiating action, the selection of targets (goals) and time frames for action and for evaluating outcomes (set points in control systems: [57]). The abstract and "syntactical" skills of EF are clearly central to the construction of goal sequences or scripts [58] and the generalization of action control systems to new contexts and re-framing contexts in which control units operate. For example, initiating medication use in the management of asthma, hypertension, and CHF requires the isolation of somatic cues that are valid indicators of disease progression and ignoring those that are not. It also requires establishing time frames for action and evaluating outcomes (time of day to initiate action; time post action to evaluate efficacy outcomes; magnitude of change; etc.), and focusing on objective indicators for initiating and evaluating outcomes and ignoring subjective cues that are invalid and/or nonexistent. Patients face several challenges in evaluating whether a treatment or life style change is working if they are given multiple criteria for evaluating efficacy that are not clearly related to one another. For example, patients with type 2 diabetes are often bewildered by the seeming non-correspondence between serum monitoring of blood glucose (taken 2 h after eating and reported in three-digit numbers) and the longer term indicator of diabetes (HbA1c—taken by the physician at 3-month intervals and reported as a one- or two-digit percentage) and either stop monitoring blood glucose or monitor but fail to use the results to modify food intake and physical activity [59].

The steps in surveillance, performance and evaluation that involve the dynamic processes specified by CSM, parallel neuroscience findings for responding to the Stroop Task [60]. The first step in such tasks is to identify the properties of the stimulus (e.g., color rather than semantics) called for by the task. A simple parallel would be to focus on a blood pressure reading or time of day for taking medication and ignore symptoms such as heart beating and tension as signals for medication use. The second step, both the selection of a response and the evaluation of response outcomes, involves neural activity in specific brain regions. Specifying the processes or "rules" required to transition from deliberate to automatic control and for bringing automatic processes under deliberative control is a critical issue for CSM. Three literatures point to overlapping factors likely to play an important role in these transitions. For example, inhibition in neuroscience [60] and the slowing performance and deliberate construction and revision of action plans in CSM. Parallels also exist in current approaches to cognitive behavioral therapy (e.g., [61]).

The Transition Between Automatic and Deliberative Function

One way that EF may be able to control the transition from deliberative to automatic and from automatic to deliberative

function, is by searching for and creating connections between the perceptions and actions of the lower level control units that are active at different points in time (e.g., identify valid start cues; perform the control response; observe specified outcomes at a given point in time, shared by two or more units). A deliberative examination of the physical and social context for action, locating a niche for inserting the control unit and testing its fit, is a critical step for automation. For example, placing lipid and hypertension medications adjacent to objects used in morning rituals, e.g., a toothbrush or coffee pot, etc., is a step toward embedding medication use into ongoing activity. A central rule for transitioning from volitional to automatic action and for controlling automatic action through volitional effort, is to "*go slowly, observe and shape and control behavior*!" Therefore, EF must also have "behavioral heuristics", or generic tools for manipulating the eliciting cues and fundamental contours of specific behaviors. Slow performance is a tool used by the executive in learning and shaping actions ranging from playing a musical instrument, performance in sports to organizing and automating action plans.

In summary, the task for EF is to generate or select an existent, abstract, conceptual framework to inter-relate goals and performances. Unlike the elements such as location, sensory pattern, time line, etc., that link experience to prototypes, EF depends upon tools or cognitive and behavioral heuristics (availability; representativeness; slow action) that make limited demands on processing capacity and reveal the contours of action that can be used to handle a wide range of problems. Thus, the executive can question the fit of selected features of somatic experience to alternative prototypes that are highly available or appear representative of key features of experience. *The framework will be effective for regulating behavior however, only if concrete experiential and performance processes are embedded in its concepts and linked to one another. Strings of "empty" words (not enriched with perceptions and actions) do not lead to action.*

CSM and Personalized Treatment

Patients and practitioners bring different knowledge bases when they meet to diagnose and treat new or previously diagnosed symptoms or functional complaints. The physician brings a bio-medical compendium and a history of skills in observing, history taking and physical examination to diagnosis and treatment of specific clinical problems. The patient brings his or her complaint, a new or unresolved symptom or dysfunction. Patients will seek a diagnosis for a new complaint, but their likely primary goal is to find a treatment to control or eliminate symptoms and correct dysfunctions. The complaint is also likely to be connected to the patient's history of illnesses, strategies for management and both self and response efficacy. Social context, such as family members and friends, TV dramas, and discourse in Internet chat rooms also affect the complaint. Patients may not articulate or be fully aware of the array of vague ideas that underlie their complaints and the worries they have about how it will impact their lives. These latent concerns can interfere with hearing and retaining information essential for adherence to effective treatment protocols.

Awareness of the disparity between practitioner and patient and the array of cultural and emotional factors affecting care, has led to the examination of factors ranging from access to care to the effects of education, ethnicity, literacy, trust, etc., on the encounter and treatment outcomes. These factors, or moderators, affect three processes essential for the creation of effective management after termination of the clinical encounter: (1) *Information sharing:* the patient presents the complaint and collaborates with the clinician by reporting its history and answering questions about related conditions, and participating in a physical examination; (2) *Diagnosis:* definition of the biological nature of the complaint and diagnosis of its meaning to the patient; and (3) *Recommendations for management:* a treatment protocol is specified. In a successful encounter, steps one and two lead to a common representation or model of the condition and step three establishes a procedure for management. If the protocol is followed, one can expect resolution of the complaint as assessed by subjective and objective indicators. Many investigators have examined specific factors that affect whether the encounter achieves these objectives (e.g., patients are more likely to provide information if asked whether there is *something* else of concern than when asked whether there is anything else of concern). Others have intervened outside the encounter in the hope of achieving similar ends. The processes articulated in CSM are involved in both the encounter and its consequences and as a result suggest a number of approaches for their integration.

CSM: A Cognitive Science Model for Communication

A key insight generated by CSM is that the elements that link deviations in somatic experience to prototypes in the mind of the patient connect the patient's mind with the social environment. This is most evident in the interaction between patient and physician; the physician's "Hello" and "How are you?" opens the door for the exploration of a presenting complaint. Questions exploring the complaint focus on the elements: "What has been bothering you? What does it feel like (identity)? Where is it (location)? When did it start (time lines)? What were you doing before

it started (cause)? How has it been constant or varied (time and identity)? Did you do something to treat it (control)? What happened (control outcome)?" This process is at the core of CSM approaches to intervention whether it is a "pre-packaged" intervention, performed in the encounter, or involves an integration of the two.

CSM and Communication in the Clinical Encounter

Cognitive science research has influenced investigations of communication processes in medical settings for over 50 years. An early and fine series of studies examined patient comprehension, retention of information, and adherence to treatment when information was presented in specific clusters such as the treatment routine, how to conduct it, the symptoms related to the condition, responses treatment, etc. [62, 63]. A recent study compared outcomes 1 month following primary care visits for patients who reported, when interviewed the day after their visit, that their practitioner had told them, "What they were looking for during the physical examination", "How long it would last and what to do to treat it", "What to expect from treatment", "How to work treatment into their daily routine", etc., to outcomes for patients who did not report these experiences (Phillips et al., unpublished manuscript). The patients who gave a detailed coverage of the representations of illness, treatment, and action plans the day following their visit were more likely, on 1-month follow-up interview, to report adherence to treatment and resolution of their medical problem. Additionally, none of these patients were among the 14 who reported making a return visit because their problem did not resolve. Interestingly, patients reporting that their practitioners had high levels of psychosocial skills reported high levels of satisfaction with the encounter on the day following the visit, but satisfaction was negatively related to reported improvement on interview 1 month later. In addition, the 14 participants who required follow-up treatment during the following month were just as likely as not to report high levels of practitioner psychosocial skills and satisfaction with the visit. The data provide a view of the effects of addressing representations and action plans by practitioners not instructed to make use of CSM.

Perceiving and/or Assessing Patients' Representations

A central issue from the perspective of CSM, is whether a practitioner can infer a patient's illness and treatment representations during the typical clinical encounter. It is a genuine challenge to do this in the 30 to 45 min of a first visit or in the 15 min of a repeat visit. Given the time constraints and the multiple biomedical issues facing the practitioner, is it realistic or necessary to take on this burden? We suggest that attention to behavior is a necessary consequence for clinical practices that are increasingly focused on improving health outcomes for patients managing chronic conditions. It is essential however, to differentiate the CSM aspect of practice from the psychosocial component. Though both are important, they differ in content and approach to communication. The CSM's differentiation of the performance aspect of management (perception and action) from symbolic word-based communication is crucial for the formation and effective team (physician; nurse; patient and family) management of chronic conditions.

An early study suggested the value of training physicians to address patient models to improve adherence to medication for the control of blood pressure [64]. Training focused on addressing the meaning of symptoms, consequences, etc., from the framework of the Health Belief Model (HBM); the concrete features of the HBM overlap with many features of CSM. Patients seen by trained physicians did significantly better than those in "standard care" (69% in the intervention were in the recommended range of blood pressure control in contrast to 36% in standard care). A detailed analysis of doctor–patient interaction before and after 6 h of training sessions focused on illness representations (for five of ten practitioners) and action plans (for the other five), showed substantial increases in factors such as patient contributions and focus on patient concerns.

A systematic approach to evaluating patient models has been developed by Ward et al. [65] and Donovan et al. [66] for pain management in cardiac patients. Their approach to patients' representations of coronary disease and pain management focuses on shaping concepts rather than teaching specific responses as suggested by Posner and colleagues [67]. The program is designed to develop shared treatment preferences among patients and proxies (typically a family member) prior to complex cardiac surgery. The first step is a formal assessment of pain representations (cause; time line; consequences cure/control; identity) followed by the exploration (step two) of misconceptions uncovered at step one. Step three is a discussion of the deficits created by these misconceptions followed by step four, which provides information to reshape and replace these misconceptions. The final step, step five, involves clarification and a summary discussion. The intervention led to impressive gains in shared treatment preferences in comparison to patients and proxies in the standard care control group (81% versus 19% complete congruence [65]). It also reduced barriers to analgesic use and lowered ratings of usual pain severity; it did not however, improve coping and well being. This promising approach could be strengthened by constructing action plans with attention to the time and quantity of changes in pain and the social and psychological context for action.

CSM suggests additional steps for inferring and addressing patient representations to improve communication in clinical encounters. A suggestion central to the model is that personal warmth and acceptance can be established by exploring the experiential and behavioral basis of the complaint. In this way the practitioner is drawn into the patients' lived environment, which reveals the sources of uncertainty, emotional distress and social cultural issues in the acceptance and management of a medical problem. Listening and exploring the various facets at the behavioral level communicates the clinician's interest in and readiness to make suggestions to assist with the everyday details of management; it creates trust. The discourse can be facilitated if the clinician has a "dictionary" of prototypes likely to underlie the patient's representations. The number of prototypes in the compendium is constrained by context: the location and nature of symptoms and dysfunctions, how these are represented in the patients' culture and community, and by the range of procedures (family nostrums) and type of help they used for self-treatment prior to seeking medical care. Diagnosing diseases and the prototypes underlying illness representations is inductive: going back from symptoms, dysfunction, prior treatments, etc., to the models and uncertainties driving both the condition and its representation.

Transparency of Other Minds

Cognitive scientists focused on how we "see and understand other minds" have identified a number of features of this inductive process. Malle [68] argues that many subjective states of others are revealed in overt behaviors. For example, the facial expressions, postural changes, etc., when a patient is in pain are "transparent" as they directly reflect this internal state [68]. The transparency of behaviors and their value as cues for inferring states is enhanced by context and facilitated by the range of prototypes available to the clinical practitioner. Knowledge of culturally defined prototypes underlying presenting complaints, such as the prototype for hypertension (feeling tense), risk of MI (chest pain, etc.), cancers (a male patient report of difficulty with urination), Alzheimer's disease (memory problems), and others provide a compendium for inferring a patient's representations. Both context and the details of the complaint allow one to infer "fear of heart attack" for a patient who has rushed to a hospital emergency room complaining of chest pain. A patient's asking to see a cancer expert and/or asking questions and seeking examinations for lumps sees evidence for a possible cancer [69]. One can infer a patient's "effect state", that is, that a presenting complaint is perceived as serious and perhaps life threatening, when the symptoms reported match those for commonly viewed life threatening conditions, multiple actions have been taken and failed to control the symptoms, and the patient appears "concerned" (see p. 31 in [68]). Inferring the patient's models can serve as the basis for correcting self-misdiagnoses and ineffective or potentially harmful treatments. In summary, practitioners prepared with both bio-medical and psychological prototypes can interpret or diagnose patients' descriptions of symptoms and dysfunction in both frameworks.

A Future for Patient-Centered, Translational Research

The parallels in concepts and findings of CSM with the concepts and findings in cognitive science and neuroscience can be seen as historical accidents or they can be seen as an expected outcome of conducting behavioral research in the arena of somatic self-appraisal as it is an arena where cognitive science and neuroscience processes are clearly expressed in words and overt action. The studies that led to the "parallel processing model" that represented the control of fear and objective danger as parallel interacting processes, and "representations of threat" as separate from "action plans" [66], were conducted in health contexts that required attention to social, behavioral and biological factors. It was evident from the start therefore, that the models mapped onto the parallel anatomical interactive features of the pain system [65] and that the division between representations of threat and action plans paralleled findings in perception research [70]. The investigation of the content and function of "representations" of illness and treatment paralleled a very large body of research in cognitive science (e.g., [16]) and the current focus on the practitioner–patient encounter addresses a range of issues of direct concern to investigators examining how people "bridge the divide" between their personal perspective on situations and that held by another person [68]. This expansion in the focus of investigations of the cognitive-affective processes underlying how people manage health and illness in everyday life (CSM) is a natural outcome of conducting research in the specific context of health and illness. Indeed, as is the case with other "situated" models, the context demands attention to an expanding array of factors.

We believe that improvements in the behavioral education of patients in practice settings will require the introduction of many of the premises of CSM, if not the model itself. Models focused on the patient's performance world will be central for evidence-based research and preparing practitioners to improve clinical outcomes. Models are essential for practitioners facing the dual tasks of diagnosis and treatment on the one hand, and cognitive/behavioral management on the other. Acceptance of the reality of patient experience will be critical. That a patient reports a diverse array of symptoms that are medically non-diagnostic, does not mean they are not accurate in reporting

the distress related to the effect of an inoculation [71], symptoms specific to chemotherapy, [72] or symptoms that relate to changes in bone density during a tamoxifen toxicity trial [73]. These experiences are real, central to patient models that drive behavior, and need to be understood.

Creation and dissemination of evidence-based findings to produce health gains can occur only if research is pursued in a systems-oriented theoretical framework that allows investigators and practitioners to anticipate how contextual factors will impact perceptions, thoughts, and feelings of individuals attempting to manage health threats in a social context. The need for a systems approach suggests that it is premature to rely on a single methodology, such as the clinical trial. Clinical trials testing behavioral interventions are important for generating proof of concept, that is, that a behavioral intervention can work (for a review see [74, 75]), though they may not be optimal for identifying the factors in pathways to achieve desired behavioral outcomes. Identification of pathways and testing causation will require a mix of qualitative, descriptive, quantitative, and experimental studies that manipulate and test the effects of specific factors on proximate and intermediate outcomes as well as final endpoints. A mix of methods can more effectively address the components and assemble a model of the system that is both implicit and explicit in CSM. Behavioral health research offers enormous opportunities for developing theory and refining methods for understanding how people prepare for and respond to crises. The opportunity exists as all people in all societies at all times acquire prototypes of the healthy, functional self, experience and interpret deviations, and respond to alleviate symptoms, pain and distress and do so in a social context.

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