Type 2 Diabetes Self-Management: Controlling a Dynamic System

Helen Altman Klein
Katherine D. Lippa
Wright State University

Abstract: People with type 2 diabetes risk disability and early death when they fail to control their blood glucose levels. Despite advances in medicine, pharmacology, human factors, and education, dangerous glucose levels remain endemic. To investigate cognitive barriers to control, we observed American Diabetes Association (ADA) certified training programs; reviewed ADA and National Institute of Health diabetes Web sites; and interviewed patients with type 2 diabetes using a critical decision method. A consistent picture emerged. The prevailing rules and procedures approaches are not preparing patients for the dynamic control task they face. Patients are often unable to understand and use the rules and procedures provided. They are unprepared to detect problems, make sense of dynamic relationships, and manage complex situations. Our results suggest that glucose self-regulation is better conceptualized as a dynamic control challenge requiring complex processes, including problem detection, sensemaking, decision making, and planning/replanning. The mismatch between most patient training and the dynamic demands of glucose regulation helps explain limitations in existing training and poor patient outcomes. We argue that constructs gleaned from naturalistic decision-making research in other complex domains can help many but not all patients develop the cognition necessary for effective blood glucose self-management.

Introduction

For most people, blood glucose regulation is automatic. The pancreas maintains healthy blood glucose levels whether a person feasts or fasts, exercises or rests, is stressed or is sick. The body achieves this precise regulation by producing and releasing insulin, a hormone that regulates fuel metabolism while lowering blood glucose levels, based on the dynamic needs of the body (Codario, 2005).

Type 2 diabetes is a disorder in which glucose accumulates in the blood, increasing the need for insulin. The pancreas gradually loses its ability to regulate glucose, causing cells to starve while excess glucose disrupts metabolic homeostasis. Patients must control their blood glucose levels with medication, diet, and exercise. Even when they adhere to prescribed regimens, patients may fail because illness, stress, and age-related changes affect blood glucose levels. To maintain

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ADDRESS CORRESPONDENCE TO: Helen Altman Klein, Department of Psychology, Wright State University, Dayton, OH 45435, helen.klein@wright.edu. Visit the *JCEDM* Online Companion at *http://cedm.webexone.com*.

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control, patients must anticipate disturbances, monitor blood glucose levels, and accommodate internal and external variations. When people with type 2 diabetes fail to maintain safe glucose levels, excessive glucose can, over time, cause irreversible organ damage, including nervous system damage, retinopathy, renal disease, heart disease, and stroke (American Diabetes Association, 2005; Ferrannini, 2000).

In response to the prevalence and severity of these problems, medical researchers have developed effective and easy-to-use medications. Human factors specialists have developed innovative technologies, including glucose monitors (i.e., Rogers, Mykityshyn, Campbell, & Fisk, 2001) and electronic support systems (i.e., Farmer, Gibson, Tarassenko, & Neil, 2005). Diabetes educators have created a plethora of books, classes, and Web sites to make it easier to adhere to diet, exercise, and medication recommendations (e.g., Clement, 1995; Magee, 2004). Despite these advances, self-management efforts remain inadequate. In a sample of more than 157,000 type 2 diabetics, the American Association of Clinical Endocrinologists found that two thirds failed to maintain safe glucose levels (State of Diabetes Health, n.d.).

For some people, the disease is inherently unstable, and failures may be unavoidable (Higgins, 2000). For others, cognitive and emotional problems interfere with adherence. For most people, however, self-management can result in safe glucose levels and long-term health. It is tempting to blame failures on patients: They are unmotivated or lazy (Broom & Wittaker, 2004). Rather than blaming the patient, in this study, we looked at the discrepancy between the way patients are prepared and the macrocognitive processes of sensemaking, planning, and decision making needed to actually regulate blood glucose levels. To better understand this discrepancy, we first looked at commonly available patient information and quality training programs.

Patient Training

We reviewed three highly referenced Web-based sources for diabetes patients: the National Diabetes Information Clearinghouse (NDIC), the National Institutes of Health's (NIH's) National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), and the American Diabetes Association (ADA). Virtually all diabetes training available in the United States is based on the NIH information and adopts ADA guidelines. The NIH site provides state-of-the-art information on food choices, exercise, and medication. There are descriptions of the impact of stress, pregnancy, and other anomalies (National Institute of Diabetes and Digestive and Kidney Disease, n.d.). There are also detailed rules and procedures for making decisions. For example, the NIH NIDDK site says, "Eat some starches at each meal. Eating starches is healthy for everyone, including people with diabetes." Examples of one serving are then given as "1 slice of bread, 1 small potato, 1/2 cup cooked cereal, or 1 6-inch tortilla." Similarly, the ADA site has rules and procedures for daily decision making.

We also observed two diabetes education programs. One was affiliated with a respected diabetes clinic, and the other was based in a regional medical center to showcase exemplary diabetes care. Both programs provided accurate and detailed rules about diet and exercise. In one program, the information was presented in the form of a complex set of rules and procedures. In the other, exercise and nutritional information was presented but did not relate to self-management goals. For example, patients were told, "Try to exercise everyday." They were not told that daily exercise could lower blood sugar and make it easier to manage diabetes. Instructors in both programs spent substantial time describing the underlying physiological mechanisms of diabetes. In one center, this accounted for about 25% of the training.

Our reviews of training material and programs suggest that the attention given by current training programs and educational resources to rules and procedures for glucose regulation might help explain why so many people fail. Rules and procedures are useful in well-defined domains where there is a one-to-one correspondence between action, impact, and feedback. The task of glucose self-regulation, however, is ill-structured, if not entirely stochastic. Feedback is delayed and sometimes ambiguous, appropriate choices vary with context, and goals sometimes conflict.

The utility of rules and procedures for maintaining glucose control was addressed by the following research question: How well do rules and procedures help people with type 2 diabetes regulate blood glucose level?

As with tasks in other dynamic domains, rules and procedures can lead to confusion and failure. The Web sites and educational programs paid scant attention to the underlying dynamics and interactions that govern blood glucose levels. The training programs we observed gave limited attention to integrating the detection of blood glucose deviations with considerations of diet, exercise, medication, or stress. If blood glucose regulation is a complex dynamic system, macrocognitive processes such as sensemaking and mental models may better describe its cognitive demands and suggest potential solutions (D. E. Klein, H. A. Klein, & G. Klein, 2000; G. Klein et al., 2003).

The Macrocognition View

The macrocognitive framework grew out of work in naturalistic decision making that describes cognition in settings likely to be ill structured and uncertain, characterized by shifting, ill-defined goals and action/feedback loops. These settings often involve time, stress, high stakes, and multiple players (Orasanu & Connolly, 1993). Unlike well-defined domains, dynamic systems can involve unfamiliar and unanticipated situations (Vicente & Rasmussen, 1992). Decision makers may have to detect and make sense of anomalies. Their sense of the situation must then guide their planning and decision making (G. Klein, Moon, & Hoffman, 2006a, 2006b). Once a decision is implemented, positive results should serve to reinforce ongoing action, whereas negative results should lead to revision or replanning. The more dynamic the task, the more critical are monitoring and replanning (Sterman & Sweeney, 2005). This continual monitoring helps the patient identify deviations and recover from them while developing a mental model of the situation's dynamics. Although people with diabetes are not traditional experts, they must develop sufficient expertise to manage the complexities of their disorder.

Our second research question was the following: Is glucose self-regulation better captured using the framework of a dynamic system?

Although we were interested in the self-management decisions of patients, field observation would not have been practical or productive for several reasons. First, diabetes self-management is a 24-hour-a-day, 7-day-a-week, year-round task that can require alertness to problems, sensemaking, and decision making at every meal and snack; each stressor and physical exertion; every blood glucose reading; and each dose of medication. Second, although some decisions are routine, others occur only rarely. It is impractical to wait for rare events to occur. Indeed, it would be most practical to employ an interview along the lines of the critical decision method. Finally, the presence of an outside observer is intrusive and would likely influence critical health care activities. Together, these factors limit the utility of field observations for our research questions and make an interviewing approach more appropriate.

Other studies of expert decision making that have used retrospective interviews have been fruitful in revealing phenomena and regularities of naturalistic decision making (e.g., Crandall, Klein, & Hoffman, 2006). Critical decision-making (CDM) interviews have been shown to be effective in capturing decision making for rare and tough cases. In addition, we have shown that a variant of the CDM procedure is effective in capturing variation in self-management among patients (Lippa, Klein, & Shalin, 2008).

We conducted CDM interviews with people having type 2 diabetes to explore the two glucose self-management questions described earlier. The interviews addressed routine days but also holidays, stressful times, emergencies, and unique challenges that cannot be observed easily in context. We wanted to understand the interplay between rules and functional knowledge. Without rules, simple tasks become unmanageable, but functional knowledge may be essential for interpreting and applying rules in dynamic and ambiguous situations such as glucose regulation.

We suggest a concept of "everyday expertise" to describe the skill level needed by people with type 2 diabetes (Lippa et al., 2008). Although few patients will become true subject matter experts (SMEs), they still need to move quickly beyond the level of novice. The field of naturalistic decision making has emphasized the study of SMEs, sometimes contrasting novices with experts. Although the performance of SMEs may be the so-called gold standard for evaluating performance in professional domains, this may not be the correct target for the task of blood glucose self-management. This analysis of patient cognition was undertaken to better understand the interplay of rules, functional knowledge, and adherence of patients in the expression of everyday expertise.

Method

Interviewees

Interviewees were recruited using posters and contacts at senior citizen centers and a university pharmacy, as well as by word of mouth. The interviewees were

12 people who had been diagnosed with type 2 diabetes for an average of 7.8 years. They ranged from one newly diagnosed participant to others who had dealt with the disease more than a decade since diagnosis. The interviewees ranged from people with adequate control over their blood glucose levels to those suffering the consequences of poor management.

Procedure

At the interviewee's preference, interviews were conducted in the interviewee's home, a quiet room at a senior citizen center, or a university office. The interviews started with queries about background and disease history: age of onset, initial symptoms, and past diabetes education. We asked about ongoing care and support, adherence to medication schedules, diet, exercise, and daily glucose monitoring. Several interviewees brought along and explained their glucose monitors and diabetes logs, and they described how they monitored their blood glucose and recorded relevant information.

The interviewers elicited challenging incidents that were then used to explore understanding of the disorder and the demands of glucose self-regulation. For the interviewees who brought logs, the blood glucose monitor readings and comments helped reconstruct the incidents. Following the basic CDM procedure, once cases were selected, the interviewers posed questions concerning the cues used to identify glucose imbalances and the strategies used to respond to them. For example, "What made you decide to check your blood?" and "When you decided to get some orange juice, what made you assume your blood glucose was low and not high?"

As with most CDM procedures, the protocol was flexible, allowing the interviewee to provide a self-management narrative. The interviewer then guided further discussion and probed remaining topics. For example, "When you decided to take a walk, why did you think that was a good idea?" and "Can you think of a time when your blood glucose went up when you had been eating properly? Why do you think that happened?" The interviews each took between 1 hr and 20 min and 2 hr.

The interviews were transcribed, and instances that addressed the two research questions were highlighted. The interviews described a wide range of difficulties stemming from using rules and procedures to manage glucose. They also provided instances in which glucose regulation functioned as a dynamic system. Examples selected from the interviews appear as follows.

Results

All interviewees reported that their health care providers had made information available about diabetes and the role of medication, diet, exercise, and glucose monitoring in its management. Nine participants had been prescribed oral medications. Seven took them, but 2 chose not to do so. Three used injected insulin. Although all interviewees reported that diet was a part of their treatment plan, 4 participants said they did not follow diet recommendations. Only 5 participants reported engaging in regular exercise. All participants had blood glucose monitors and had been instructed in their use. Most had booklets or books describing diabetes self-management. Several had searched the Internet for information. Several had attended hospital-based education programs and/or individual counseling sessions with specially trained dieticians or nurses.

In summary, at some point since diagnosis, all participants had access to multiple sources of up-to-date information and tools for monitoring and self-management.

How Well Do Rules and Procedures Help People With Type 2 Diabetes Regulate Blood Glucose Level?

The interviews suggested that diabetes education often failed to provide viable tools for self-management. For more than half the participants, we identified examples of failures in each of five areas: understanding rules and procedures, applying rules and procedures, confusing rules and procedures, understanding functional dynamics, and recovering from errors and anomalies.

Understanding rules and procedures. Interviewees described their training as "learning the rules and what to do." Selected comments illustrate the limited understanding participants had of the rules and procedures taught in diabetes education programs.

> I look at the labels for the carbs, fiber, fats, and calories. I'm not really sure I understand the carbs. . . . On Saturday, when I'm on the run, I'll pick up a McDonald's hamburger or cheeseburger. If I remember, I leave off the mayo.

This interviewee had many rules about carbohydrates but did not know, remember, and/or pay attention to what foods contained them.

> At first, I faxed my doctor a list of everything I'd eaten and what my BG [blood glucose] levels were every week. Then I realized that I wasn't really doing anything with it – just keeping the record.

The interviewees were unsure of how to use the monitoring information to make decisions about diet, exercise, or medication. The majority of interviewees had serious gaps in understanding.

Applying rules and procedures. Each patient is different, and effective self-management must be responsive to the specific conditions of the person and the situation. Most interviewees, however, reported incidents for which the rules provided in training programs were not appropriate for a situation encountered in daily life, and few were able to use the rules to modulate blood glucose. Patients were typically told to monitor and record blood glucose levels so they could report the numbers to their physicians. But this is not sufficient. Patients also need to know how to use the numbers to plan meals and interpret symptoms.

> At first, they say diabetics shouldn't have sugar. Then when they're having a reaction, you're supposed to take sugar. I don't understand it. Not that they haven't told me. My brain doesn't get it.

This interviewee knew that a reaction required action but could not articulate an acceptable response. Similarly, this person had difficulty with many other rules and procedures.

The rule-based approach assumes that there are fixed behaviors that, if followed, can manage blood glucose under all circumstances. Unfortunately, this approach is inadequate in managing a dynamic system in which the appropriate actions depend on the current state of the system.

Confusing rules and procedures. Because of the complexity of blood glucose changes, an enormous set of rules and procedures would be needed to achieve and maintain adequate control. Participants were often overwhelmed with the number and complexity of the rules they were given. A review of the interviews revealed many instances in which rules and procedures were inadequate to facilitate self-care. Carbohydrate counts, food quantities, and food substitutions were particularly difficult.

> I went to a group meeting for diabetics. I mentioned that I was supposed to have 45 grams of carbohydrates. One woman, who had had diabetes for a long time, asked, "Is that 45 a day or 45 a meal?" She said she couldn't remember!

The ADA Web site has dozens of pages of rules and procedures, including for selecting and measuring foods, recording blood glucose readings, and choosing exercises. Although well written, the volume of information alone introduces confusion for those who lack a bigger picture of goals.

Understanding dynamics. Rules may be inherently incomplete and unable to cover all possible life circumstances that affect blood glucose. People may be clueless in situations for which they had no specified rule. Lacking a functional understanding of glucose control responses, they will have trouble with surprises and unusual situations.

> This morning my BS [blood sugar] was 121. I had a leftover salad for breakfast and checked my BS again before I left the house and it was 136. I worked all day and sweated like crazy, but drank Crystal Light. When I came home today and checked my BS, it has rocketed up to 191! What gives? I didn't even have time to eat anything else because I was so busy.

This man's understanding was incomplete. He had eaten very little and engaged in physical activity all day, yet his blood glucose kept rising. Each of these alone would be expected to reduce glucose. He did not understand that physical activity could also trigger the body to pump glucose into the blood when glucose is too low.

When participants did not know the reasons for rules and procedures, their decision making was compromised. For example, most knew that exercise was good, but not precisely why with respect to diabetes. For this reason, they reclassified their ordinary physical activities as exercise after being diagnosed. One participant reported,

> I'm supposed to walk every other day but I don't. So I figured I gotta clean the house, take care of the cars, take care of the yard, and that's how I get my exercise.

Not realizing the need to increase aerobic activity, this participant relabeled usual activities, focusing on their aerobic properties. When people did not know that exercise could reduce their glucose levels, they were not usually motivated to exercise regularly or to use exercise to reduce moderately high glucose levels.

When interviewees talked about the why or how of diabetes, it was with vague references to pancreatic functions and insulin receptors. We do not believe it is necessary to understand the physiological and metabolic mechanisms of diabetes, but an understanding of the relationships among factors that influence blood glucose appears to be critical for making effective decisions in unusual situations. Only 2 of the 12 interviewees were able to describe some of the functional dynamics of glucose control.

Recovering from errors and anomalies. Managing errors and anomalous situations without functional understanding was particularly problematic. Because patients do not understand the dynamics relating to treatment elements and blood glucose levels, they are ill prepared to recover from mistakes. One participant reported,

> I went over to [fast-food chain] for lunch [reports a high carbohydrate lunch] and when was through, I felt like I needed sugar. I don't know why that is but that'll happen quite often.

The lunch raised her blood glucose, but the symptoms of high and low glucose are easy to confuse. People try to "listen" to their bodies, but they do not understand what they "hear." She misinterpreted her symptoms of high blood glucose and applied the rule for low glucose. Rather than reviewing her recent food consumption to make sense of her subjective reactions, she ate candy, exacerbating the problem and missing the opportunity to learn about lunch choices for the future.

Even when participants reported knowing the rules and procedures, they could not always use them to manage unexpected stress, normal age-related changes, and the constraints of other medical conditions.

Rules and procedures, which are linear models, are a starting point for adherence. However, they are poor substitutes for a functional understanding of glucose self-regulation, which is a dynamic and nonlinear system. The poor performance reflected in the interviews is consistent with the unhealthy blood glucose levels documented in large national samples (Manos, 2004).

Is Glucose Self-Regulation Better Captured Using the Framework of a Dynamic System?

We also reviewed the interview transcripts to see how the demands of glucose regulation matched the characteristics of dynamic systems (Orasanu & Connolly, 1993). At least a quarter of our interviewees made reference to factors that can be interpreted as pointers to each of the characteristics associated with complex dynamic systems: time pressure, high stakes, ill-structured problems, ill-defined or competing goals, uncertain/dynamic environments, action/feedback loops, and multiple players. Examples that follow illustrate how glucose control fits with the features of dynamic systems.

The decisions for controlling dynamic systems are often made under *time pressure*. Because of the immediate danger associated with low blood glucose, extreme readings require immediate intervention. People with diabetes need to ingest carbohydrates when their blood glucose is low. When their blood glucose is extremely high, they need to seek medical help and initiate long-term changes. Interviewees were often sensitive to the time pressure associated with diabetes regulation.

> I worry when I feel really "icky." I'll take my BG and see how badly I'm doing. I need to know if I should go to the emergency room to get an insulin shot. If it's over 600, I'd go to see if they wanted me to get a shot. That's real dangerous.

Interviewees who had been diagnosed for some time often acknowledged the *high stakes* associated with high blood glucose.

> I think my next significant event would be my renal disease. I'm now at 20% kidney function. They dialyze you at 10–12%. But I still have my feet. I'm not blind. Things can be a lot worse.

Renal disease and also neuropathy, retinopathy, and other diseases associated with type 2 diabetes carry high financial and personal stakes. Successful self-management depends on recognizing the high stakes associated with glycemic control before actually experiencing complications.

Blood glucose regulation presents an uncertain, dynamic environment. Even people skilled at identifying problems may find that key clues and symptoms change with stress, illness, and age. The first sign of a cold may be an elevated blood glucose reading, not a runny nose.

Interviewees had difficulty making decisions when faced with ill-structured problems. The symptoms of high and low blood glucose can be difficult to distinguish.

> Sometimes I know when I'm hypoglycemic and sometimes I don't. It may be a thick tongue feeling. I may talk more slowly. Sometimes it's just irritability. People who know me well know before I do.

> I know that something is happening. I feel disoriented like things were out of control. I get very tired. Sometimes, I can see my hand shaking.

I usually get something to eat. I think it can also happen when I have too much sugar. It can happen 24 hours later. I can feel shaky even after I've eaten.

Diabetes self-management can present shifting, competing, and ill-defined goals. These goals can be related to self-management demands.

I do whatever it takes to keep my sugar down – even things I shouldn't do. I'm going to get it down at all costs even if I go on a week of fasting. I'm trying to aggressively force myself to get it down.

For a patient with diabetes, high blood glucose is bad, but fasting is also bad. This interviewee had difficulty finding the right balance.

Patients with type 2 diabetes are more likely to suffer from other chronic medical conditions that can alter blood glucose level and can introduce competing goals, and they have increased incidences of coronary problems. What is a patient to eat when his cardiologist cautions against meat and dairy, whereas his endocrinologist cautions against carbohydrates? Diabetes can also compete with life goals.

I live back with my folks now. My mother always cooks good country food for dinner. My sister makes my favorite cake for me – chocolate. How can I say no? I try but I just can't follow my diet at home.

People with diabetes must balance the demands of family, friends, and work with self-care demands. Holidays may involve quantities of rich food. Career goals may demand long hours, making a regular exercise program difficult.

The dynamic nature of diabetes is seen in action/feedback loops. Each meal, instance of physical exertion, illness, and dose of medication influences blood glucose over a distinctive time course. Stressful experiences can arise, suddenly altering blood glucose levels when the patient is least able to adapt. Effective control requires attention to subjective and objective feedback from unexpected events. The patient must learn to anticipate the outcome of actions and to use past feedback to accommodate expected discrepancies.

When my mother has to take insulin and she's very active, she splits up her doses. If she's sick, she has to monitor more often.

The first time I had Moo Goo Gai Pan at a Chinese restaurant, my blood glucose went really high. Now, I only eat about a half a serving.

Because these people were able to detect adverse changes, they were able to make sense of the changes in context and plan effective strategies to improve future management.

The term *self-management* suggests that decisions are made alone, but they often involve multiple players. Physicians, nurses, dieticians, fitness specialists, and/or diabetes educators provide guidance for treatment plans and managing problems. Patients also receive well-intended but sometimes erroneous advice from family and friends. When advice differs, the patient must balance the credibility of sources along with social implications of rejecting well-intended advice.

In sum, the interviews provided numerous examples of the ill-structured, uncertain, dynamic environments; shifting, ill-defined goals; action/feedback loops; time stress; high stakes; and multiple-player nature of blood glucose management. If glucose regulation is a complex dynamic system, it is not surprising that people fail when they depend on rules and procedures.

Discussion

Our review of model educational programs and commonly used training material found an emphasis on rules and procedures as guides for decision making. The interviewees, consistent with available training practices, believed that if they followed the rules and procedures, they would succeed in maintaining a safe blood glucose level. Although rules and procedures help with simple, routine decisions, they can fail for dynamic contexts and with complex decisions. Our interviews document that patients with type 2 diabetes fail to control their blood glucose level in part because their functional understanding is too shallow to detect problems, make sense of anomalies, and handle the decision-making challenges of the disease. When patients find high blood glucose readings after following the prescribed rules, future adherence can, understandably, be compromised.

Rules can help people coordinate and plan for the demands of self-management. For process control activities such as blood glucose management, no set of rules will be sufficient. How do effective self-managers develop and apply tacit knowledge to help them make better use of rules? A macrocognitive perspective, in contrast to a rules and procedures perspective, would be useful for guiding the development of better training as well as informing our understanding of the ways in which everyday expertise develops.

The macrocognitive framework has been applied primarily to professional and technical specialists (G. Klein et al., 2003). The framework emphasizes the importance of problem detection, sensemaking, decision making, and planning/replanning. Problem detection identifies anomalies and difficulties in available information. The person with diabetes, for example, might detect a subtle change in energy level. Sensemaking is needed to identify causes and potential remedies. The patient must consider the context of a fluctuation in blood glucose level: "What have I eaten recently?" "How long ago did I exert myself physically?" "Has something stressful just happened?" The emerging picture directs the search for additional causes and remedies.

Interviewees commonly struggled with the task of interpreting subjective and objective readings systemically. Glucose control requires decision making, ranging from ordering from a menu to planning for a potentially stressful family obligation or managing multiple illnesses. The interviewees faced critical decisions under time pressure with uncertain information, ill-defined goals, and shifting demands. In this way, diabetes self-regulation parallels the decision-making demands of other dynamic systems, such as intensive care nursing, firefighting, and anesthesiology.

When blood glucose regulation is seen as a dynamic system, it is clear why rule- and procedure-based training does not prepare patients for difficult decisions. Effective control in complex domains requires going beyond rules to a deeper level of understanding and skill. Similar to professional domains that require expertise, these patients need to engage in ongoing problem detection, understand functional relationships, and use problem-solving strategies (Lippa et al., 2006).

Applications in professional and technical domains suggest the importance of mental models for handling challenging conditions. We suggest that mental models are also central for everyday cognition and for journeymen. Research on expertise (e.g., Ericsson, Charness, Feltovich, & Hoffman, 2006) can inform the way we help nonexperts increase their macrocognitive abilities even though they do not need to become domain experts. One direction for future research, therefore, is to look at the ways people increase the complexity and sophistication of their mental models to a sufficient level of expertise for everyday problems.

There are, of course, important differences between patients with type 2 diabetes and the professional communities usually studied by naturalistic decision-making researchers. First, professionals are selected for ability and motivation. Diabetes is more egalitarian, and so training must serve people varying in cognitive ability, background, and motivation. Second, professional training can take years, whereas patients must manage blood glucose and respond to critical changes almost immediately. Finally, professionals typically belong to communities of practitioners, sharing background, attending the same meetings, and reading the same journals. Diabetes patients often lack a supportive community. Online chat rooms for patients with diabetes present information that varies in accuracy; advice from family and neighbors can be dangerously incorrect.

Even with these differences, research with professionals suggests ways to increase the expertise of patients with diabetes. One approach would be to use simulation-based training, which has been shown to provide risk-free practice for skills and decision processes in pilot training and medical education (Kaiser & Schroeder, 2003; Lane, Slavin, & Ziv, 2001). Simulations provide immediate feedback and the chance to integrate feedback into an action strategy for later use. A simulator can present a "patient" who shares the trainee's target blood glucose range, food preferences, medication, and exercise patterns. The trainee can make decisions about the "patient" and review the outcomes. Presented with anomalies and unusual events, trainees can practice sensemaking, planning, and decision making and then review the outcomes.

Another strategy would be to apply decision skills training (DST). Carefully scripted scenarios could provide the basis for group problem-solving exercises. A facilitator would guide a group of patients as they explore glucose regulation in a series of progressively more difficult situations. The group might look at the self-management demands of a high glucose reading and consider possible actions. Later, they might explore the self-management demands of Thanksgiving Day with family, a business trip, or an episode of flu. The facilitator would foster the habit of deliberate practice, support emerging problem detection and sensemaking skills, and provide experiences in planning/replanning. DST has less fidelity but is more social, less costly, and independent of computer literacy (Pliske, McCloskey, & Klein, 2001). These characteristics may make DSTs particularly well suited for older adults.

The Web-based support sites offered by the ADA and NIH (*www.diabetes.org* and *diabetes.niddk.nih.gov*) provide rules and procedures as well menus and exercise plans, but they could provide much more. Available technology could allow guided practice and interactive trials with immediate feedback. Web-based support could include intelligent tutoring systems with modules tailored to different needs. Online coaches could supply expert advice to individual patients. Cigna is already experimenting with this technology to provide behavioral counseling to its members (O'Donnell, 2005).

Conclusions

This exploration of the self-management demand of type 2 diabetes presents an important opportunity for naturalistic decision-making researchers. We have typically studied highly trained professionals. Such people start with a high potential for success, receive years of training, and have strong peer support. Applications such as patient medical adherence will have to accommodate a broader range of initial abilities. Nonprofessional applications require that we find ways to convey the dynamics of problem detection, sensemaking, planning, and other macrocognitive processes to nonprofessionals.

Although it is easy to retreat to rules and procedures, our findings suggest that the complex demands of medical adherences require that the patient have an understanding of dynamic systems. Training for life applications will have to accommodate individual cognitive differences, preparation, and needs. In so doing, we may be able to expand our understanding of macrocognition, the constraints of naturalistic decision making, and the demands of complex dynamic systems.

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References

American Diabetes Association. (2005). *National diabetes fact sheet, 2005.* Retrieved November 27, 2005, from *http://diabetes.org/uedocuments/NationalDiabetesFactSheetRev.pdf*

Broom, D., & Wittaker, A. (2004). Controlling diabetes, controlling diabetics: Moral language in the management of diabetes type 2. *Social Science & Medicine, 58,* 2371–2382.

Clement, S. (1995). Diabetes self-management education. *Diabetes Care, 18,* 1204–1214.

Codario, R. A. (2005). *Type 2 diabetes, pre-diabetes, and the metabolic syndrome: The primary care guide to diagnosis and management.* Totowa, NJ: Humana.
Crandall, B., Klein, G., & Hoffman, R. R. (2006). *Working minds: A practitioner's guide to cognitive task analysis.* Cambridge, MA: MIT Press.
Ericsson, K. A., Charness, N., Hoffman, R. R., & Feltovich, P. J. (Eds.). (2006). *Cambridge handbook of expertise and expert performance.* New York: Cambridge University Press.
Farmer, A., Gibson, O. J., Tarassenko, L., & Neil, A. (2005). A systematic review of telemedicine interventions to support blood glucose self-monitoring in diabetes. *Diabetic Medicine, 22,* 1372–1378.
Ferrannini, E. (2000). Insulin resistance: The prime mover in type 2 diabetes. In D. J. Betteridge (Ed.), *Diabetes: Current perspectives* (pp. 93–110). London: Martin Dunitz.
Higgins, T. (2000). *Brittle diabetes mellitus* [Report]. Boulder, CO: Boulder Medical Center.
Kaiser, M. K., & Schroeder, J. A. (2003). Flights of fancy: The art and science of flight simulation. In P. S. Tsang & M. A. Vidulich (Eds.), *Principals and practice of aviation psychology* (pp. 435–471). Mahwah, NJ: Erlbaum.
Klein, D. E., Klein, H. A., & Klein, G. (2000, May). Macrocognition: Linking cognitive psychology and cognitive ergonomics. In *Proceedings of the 5th International Conference on Human Interactions With Complex Systems* (pp. 173–177). Urbana-Champaign: University of Illinois at Urbana-Champaign.
Klein, G., Moon, B., & Hoffman, R. R. (2006a, July/August). Making sense of sensemaking 1: Alternative perspectives. *IEEE Intelligent Systems,* pp. 70–73.
Klein, G., Moon, B., & Hoffman, R. R. (2006b, September/October). Making sense of sensemaking 2: A macrocognitive model. *IEEE Intelligent Systems,* pp. 88–92.
Klein, G., Ross, K. G., Moon, B. M., Klein, D. E., Hoffman, R. R., & Hollnagel, E. (2003, May/June). Macrocognition. *IEEE Intelligent Systems,* pp. 81–85.
Lane, J. L., Slavin, S., & Ziv, A. (2001). Simulation in medical education: A review. *Simulation & Gaming, 32,* 297–314.
Lippa, K. D., Klein, H. A., & Shalin, V. L. (2008). *Everyday expertise: Cognition and decision making in diabetes self-management*. *Human Factors, 50,* 112–120.
Magee, E. (2004). *Tell me what to eat if I have diabetes: Nutrition you can live with.* Franklin Lakes, NJ: New Page Books.
Manos, D. (2004). Majority of diabetics do not follow guidelines for maintaining health, despite a decade of warning, study shows. *Report on Medical Guidelines & Outcomes Research, 15*(4), 1, 5–6.
National Institute of Diabetes and Digestive and Kidney Diseases. (n.d.). *National Diabetes Information Clearinghouse.* Retrieved November 27, 2005, from *http://diabetes.niddk.nih.gov/*
O'Donnell, A. (2005). An ounce of prevention. *Insurance and Technology, 30*(3), 14.
Orasanu, J., & Connolly, T. (1993). The reinvention of decision making. In G. A. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 3–20). Norwood, CT: Ablex.
Pliske, R. M., McCloskey, M. J., & Klein, G. (2001). Decision skills training: Facilitating learning from experience. In E. Salas & G. Klein (Eds.), *Linking expertise and naturalistic decision making* (pp. 37–53). Mahwah, NJ: Erlbaum.
Rogers, W. A., Mykityshyn, A. L., Campbell, R. H., & Fisk, A. D. (2001). Analysis of a "simple" medical device. *Ergonomics in Design, 9*(1), 6–14.
State of Diabetes Health. (n.d.). *Blood sugar levels are too high in America.* Retrieved February 1, 2008, from *http://www.stateofdiabetes.com/blood_sugar_levels.html*
Sterman, J. D., & Sweeney, L. B. (2005). Managing complex dynamic systems: Challenges and opportunities for naturalistic decision-making theory. In H. Montgomery, R. Lipshitz, & B. Brehmer (Eds.), *How professionals make decisions* (pp. 57–90). Mahwah, NJ: Erlbaum.

Vicente, K. J., & Rasmussen, J. (1992). Ecological interface design: Theoretical foundations. *IEEE Transactions on Systems, Man, and Cybernetics, 22,* 589–606.

Helen Altman Klein is professor of psychology and director of the Applied Psychology Laboratory at Wright State University. Her research interests include the application of human factors and macrocognition – problem identification, sensemaking, decision making, and planning – to improve performance on complex tasks. Applications in the medical domain have addressed patient adherence and medication instructions. In the military domain, she has studied multinational peacekeeping, psychological operations, air operations planning, and training.

Katherine D. Lippa is a Ph.D. candidate in the Human Factors Psychology program at Wright State University, where she obtained her M.S. in human factors psychology in 2006. Her research interests include complex cognition, decision making, medical cognition, and patient self-care. She anticipates completing her dissertation on physician and patient reasoning about multiple sclerosis in December 2008.