INTRODUCTION

Studying expertise has supported the design of interventions to improve cognitive performance and decision making in professional domains (Salas & Klein, 2001). Chronic illnesses can require nonprofessionals to make complex, daily decisions about health care. With the increasing prevalence of chronic illnesses, the development of the everyday expertise needed to make health management decisions must be understood.

This study uses cognitive characteristics that differentiate experts from novices in professional domains to analyze decision making in the management of type II diabetes. Diabetes self-management is often approached using simple rules and procedures (Ellis, et al., 2004; Reeves & Steil, 2004; Zoffman & Kirkevold, 2005), but effective self-management requires many of the same cognitive processes used in other complex domains (H. A. Klein & Lippa, in press). The complexity and importance of diabetes self-care make this a good domain for studying everyday expertise.

Objective: To assess the relationship between decision making and successful diabetes self-management. Background: Patients with type II diabetes make routine but critical self-management decisions. Method: We conducted cognitive task analysis interviews with 18 patients to examine problem detection, functional relationships, problem-solving strategies, and types of knowledge used to make self-management decisions. We expected that these decision processes would be related to behavioral adherence and glycemic control. Results: Verbal reports displaying problem detection skills, knowledge of functional relationships, and effective problem-solving strategies were all related to better adherence. Problem detection skill was linked to greater glycemic control. Participants differed in declarative and applied knowledge. Conclusion: Diabetes self-management draws on the same cognitive skills found in experts from diverse professional domains. Considering diabetes self-management as a form of expertise may support adherence. Application: Human factors approaches that support professional expertise may be useful for the decision making of patients with diabetes and other chronic diseases.
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2004). This allows experts to understand the dynamics behind a problem and formulate better approaches to solving it.


Knowledge and Health Behavior

There is a debate about the utility of knowledge for improving health behavior. Some researchers have found that knowledge after an educational intervention improves health behavior (Devine & Reischneider, 1995; Spirito et al., 1993), whereas others have found little or no relationship (Glanz, Lewis, & Rimer, 1997). One explanation for such conflicting results is that some studies look at declarative knowledge about health, whereas others target applied knowledge (Anderson, 1982; Nokes & Ohlsson, 2005). In the present study, we distinguish declarative and applied patient self-management knowledge.

Diabetes as Domain

In 2006, diabetes contributed to 224,092 deaths and many severe health complications (Anderson & Smith, 2002). These consequences often can be avoided if patients maintain healthy glucose levels (serum glucose = 80–120 mg/dl, hemoglobin A\(_1c\) \(\leq 6.5\); Diabetes Control and Complications Trial Research Group, 1993). Unfortunately, 66% of patients fail to meet recommended guidelines (Manos, 2004).

Controlling glucose requires complex daily decision making. Patients must use somatic information and feedback from home glucose blood monitoring to evaluate diet, medication, and exercise choices; to take remedial action; and to plan future self-management. This task is complicated because stress, illness, and aging all impact glycemic control and disease dynamics (National Institute of Diabetes and Digestive and Kidney Diseases, n.d.a). Because experts are highly attuned to situational cues, participants who use more cues for problem detection are expected to show better self-management. Effective self-management also requires using an understanding of the functional relationships underlying glucose control to guide self-care. Because experts are more aware of functional relationships, participants who make sense of the factors involved in blood glucose control are expected to demonstrate better self-management. Finally, when patients detect a blood glucose irregularity, they need to restore control. Because experts have access to many problem-solving strategies, participants who describe more problem-solving strategies are expected to demonstrate better self-management.

METHODS

Participants

Twenty participants previously diagnosed with type II diabetes were recruited. Most participants were brought in by friends or relatives enrolled in introductory psychology courses. These participants’ friends or relatives received course credit.
Three participants volunteered after seeing a flyer posted in a grocery store or pharmacy and received no compensation for participating. Two participants were dropped because they were unable to respond to interview questions, leaving a sample of 18 participants.

**Procedure and Materials**

Individual sessions lasted 1 to 1.5 hr. One interviewer was present at each session; a second researcher participated in one quarter of the interviews. With the participants’ consent, all sessions were audiotaped. Each session consisted of an interview followed by a self-report measure.

**Measures of expertise and knowledge: Interviews.** Interviewers began with questions about demographics and personal and family history of the disorder. They then addressed daily self-management practices and recurrent problems. Next, critical incidents were sought (Crandall & Getchell-Reiter, 1993). Participants were asked open-ended questions, which were adapted depending on conversational flow (Gordon & Gill, 1997).

Questions covered the time course of each incident, cues used to diagnose the problem (problem detection), explanations of the incident (functional relationships), and actions taken in response to the incident (problem solving). For example, for episodes of high blood glucose, questions included “When did you notice it was high?” and “Did you do anything to help bring your blood sugar down?” Each participant was asked to describe at least one incident of high glucose and one of low glucose. If no solution was reported, participants were asked how they could have ameliorated the problem. Participants’ descriptions of effective remedies provided assessments of applied knowledge. Participants were also asked direct questions tapping declarative knowledge, such as “What things make blood sugar go up?”

**Measure of adherence and self-management.** Adherence was measured using a six-item self-report measure derived from the Summary of Self-Care Activities (validity between .40 and .87 and alpha reliability between .86 and .97; Glasgow, McCaul, & Schafer, 1987; Hampson, Glasgow, & Toobert, 1990). The first four items, taken directly from Glasgow et al.’s (1990) scale, asked about adherence to treatment in the last week (see Table 1). The last two items asked about highest and lowest glucose measures. Adherence was taken as an additive measure of the first four items in Table 1; for exercise, each day of exercise reported counted as 5/7 of a point in order to yield a maximum score of 5, comparable to the other items.

Glycemic control for each participant was assessed by rank ordering the highest reported blood glucose level in the last week. Two participants could not report their highest glucose reading in the last week; these participants’ ranks were interpolated from reported HbA1C results.

**Transcription and Coding**

Interviews were transcribed using a method designed to capture meaningful content (Kowal & O’Connell, 2004) in semantic units, each encompassing a single complete idea (Chi, 1997). Based on initial coding of six pilot interviews and input from expert researchers, a code list was iteratively refined to produce 78 nonredundant codes capturing maximal content (Bohm, 2004; Flick, 1998). Each code was operationally defined based on key words and concepts. Codes assessed expertise as defined by references to problem detection cues, functional relationships, and problem-solving strategies; see Table 2. Coding reliability, based on one third of the transcripts coded independently by two raters, indicated substantial agreement (rk = .76, SE = .05).

**TABLE 1: Questions About Treatment Adherence**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
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<tbody>
<tr>
<td>How many of your injections or pills did you take when you were supposed to?</td>
<td></td>
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<tr>
<td>How often did you test your glucose levels at the time of day you were supposed to (no more than 30 min early or late)?</td>
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<tr>
<td>How often did you follow your recommended diet over the last 7 days?</td>
<td></td>
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<tr>
<td>How many days during the last week have you exercised for at least 30 continuous min?</td>
<td>_____ days</td>
</tr>
<tr>
<td>During the past week, what was your highest blood glucose reading?</td>
<td>_____ mg/dl</td>
</tr>
<tr>
<td>During the past week, what was your lowest blood glucose reading?</td>
<td>_____ mg/dl</td>
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*aResponses to these items were on a 5-point graphic rating scale.*
For each process associated with expertise, participants were divided into three groups according to the total number of relevant statements. Separate analyses counting only unique statements versus total number of statements did not differ significantly. To reduce the influence of measurement error from the categorization scheme, we created groups for problem detection cues and functional relationships where natural breaks occurred in the data. For example, groups for problem detection were those who articulated 0 to 2 cues, 4 to 8 cues, and 10 to 17 cues. For the problem-solving strategies, there were no natural breaks, so groups were created that were as equally sized as possible without placing participants who used the same number of strategies in different groups.

Five participants always fell in the same group (i.e., always had a low number of statements); 11 participants always fell in two adjacent groups (i.e., usually a low number of statements but, on one occasion, a medium number); and 2 participants fell in disparate groupings (i.e., at least once had a low number of statements and once had a high number). To avoid assumptions about the scales, we used Kruskal-Wallis nonparametric ANOVAs to compare groups with respect to self-reports of adherence and degree of glycemic control.

We used a binomial distribution to test if the probability that he or she had described an effective solution when discussing a critical incident (applied knowledge) could predict the probability that he or she had described an effective solution when discussing a critical incident (applied knowledge). This allowed us to determine whether declarative and applied knowledge are distinct for self-management.

**RESULTS**

**Demographics**

Participants varied in years since diagnosis (mean = 10.8, range = 0.66–35), age (mean = 53.9 years, range = 19–76), gender (6 women, 12 men), and education (8 high school or less, 8 college, 2 postgraduate). Four participants had worked in health care fields. None of these variables (time since diagnosis, age, gender, education, or occupation) was significantly correlated with adherence or glycemic control. Participants reported highest blood glucose readings for the last week between 86 and 450 mg/dl (mean = 180.2 mg/dl, SD = 109.4). Reported lowest blood glucose readings ranged from 65 to 130 mg/dl (mean = 90 mg/dl, SD = 23.1). Participant adherence for the last week averaged 3.02 (SD = 0.63). There was no correlation between glucose readings and adherence.

**Expertise**

For each process associated with expertise – problem detection, functional relationships, and problem solving – we assessed the relationship between the process and self-management behavior in terms of adherence and glycemic control. Qualitative descriptions were used to illustrate how

<table>
<thead>
<tr>
<th>Process</th>
<th>Sample Statements and Self-Report Items</th>
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<tbody>
<tr>
<td>Problem detection cues</td>
<td>“I could always tell when my blood sugar was getting too low, but it had to be confirmed with the Accucheck.”</td>
</tr>
<tr>
<td></td>
<td>“I get spots in my eyes when it gets really low, and um – I always know when it’s getting low ’cause...I see these spots.”</td>
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<tr>
<td>Functional relationships</td>
<td>“Some of that [high glucose levels] might have been because I wasn’t exercising as much.”</td>
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<tr>
<td></td>
<td>“Sometimes you get under stress [and] your blood sugar is going to go up.”</td>
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<tr>
<td>Problem-solving strategies</td>
<td>“I can’t have it that high. So I went and took a walk and everything.”</td>
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<tr>
<td></td>
<td>“I took that, and boy it was low because I’d used a lot of blood sugar teaching. So I started taking a little snack.”</td>
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**TABLE 2: Codes for Expertise**
participants’ skill in using the cognitive process affected self-management.

Problem detection. To test whether articulation of problem detection cues was related to better self-management, participants were divided into three groups (those who mentioned 0–2 cues, 4–8 cues, and 10 or more cues). A Kruskal-Wallis test indicated significant group differences in adherence to treatment ($H = 7.13, p < .05$). Although the small sample size precluded paired comparisons, group means increased monotonically, indicating that those who articulated more problem detection cues generally reported greater adherence. A second Kruskal-Wallis test indicated that the groups differed significantly in glycemic control ($H = 9.93, p < .05$). Those who reported more problem detection cues tended to have lower glucose levels.

The problems facing patients are often ambiguous and embedded in the particular context. Participants made 106 statements including problem detection cues; 17 of 18 participants mentioned at least one strategy.

The simplest approach to problem detection was to use a home glucose monitor to check blood glucose levels on a regular schedule. For example, a participant in the bottom third in terms of adherence and the middle third in terms of glycemic control said, “I check my blood sugar every morning when I get up.” Although this strategy is simple, its efficacy is limited, as the participant would be aware of only those problems that coincide with scheduled monitoring.

Other participants used somatic cues to detect problems. For example, a participant in the middle third of the sample in terms of adherence and glycemic control said, “I... woke up at 4:00 in the morning with a really bad headache. And diabetes was the first thing that came into my head.” This strategy is limited because only problems that cause noticeable symptoms will be detected. Further, unlike objective measurements, symptoms are easily misinterpreted, leading to inappropriate action.

More expert participants combined somatic cues and monitoring to detect problems. For example, a participant (top third in adherence and glycemic control) said, “As soon as I started to feel sleepy, I knew that my blood sugar was above 180. When I started to feel sick to my stomach I knew that my blood sugar was above 180. When I did test it, it was 258.” This strategy was effective because it allowed the participant to detect ongoing glucose fluctuations while retaining the accuracy associated with objective testing. Overall, results indicated that participants who used more problem detection cues had better self-management. The expert participants combined multiple cues to increase their problem detection efficacy.

Functional relationships. To test whether the use of functional relationships was related to better self-management, participants were divided into three groups: those who articulated 1 to 2 relationships, 4 to 9 relationships, and 11 to 16 relationships. Kruskal-Wallis tests found significant differences between groups in adherence ($H = 6.085, p < .05$); group means increased monotonically. Those who articulated more functional relationships tended to better adhere to treatment. No significant differences were found for glycemic control. The fact that results were significant for adherence but not for glycemic control is not surprising, as participants’ self-reports of adherence and glycemic control were not significantly correlated.

Participants made 129 statements containing functional relationships. All participants mentioned at least one relationship. Rather than seeing glucose control as a unified system, participants associated some factors with low glucose and others with high glucose. Participants attributed high glucose to eating carbohydrates ($n = 13$), disobeying doctors’ orders ($n = 3$), and stress ($n = 6$). Low glucose was usually associated with medicine ($n = 13$) and exercise ($n = 12$).

Less sophisticated participants often explained abnormal glucose levels using a single factor. For example, when asked why his glucose might be high, one participant (bottom third in adherence) responded, “Sweets...and stuff, breads, pastas, all that kind of stuff that turns into sugar.” He linked high glucose to one factor: eating too many carbohydrates. More expert patients used multiple factors to explain glucose imbalances. For example, a participant (top third in adherence) explained high glucose levels as resulting from “stress, overeating, [or] if I don’t take my medicine.” However, even expert participants used different factors for explaining low and high glucose. In summary, participants decomposed the blood glucose system into subsystems for high and low glucose. Despite this simplification, participants who articulated more functional relationships had better adherence but did not differ in glycemic control.

Problem solving. To assess the relationship between articulation of problem solving strategies
and self-management, we divided participants into three groups: those who articulated 0 strategies, 1 to 2 strategies, and 3 to 7 strategies. Kruskal-Wallis tests found significant differences for adherence \( (H = 6.70, p < .05) \) but not for glycemic control.

Participants gave only 37 statements about this process, compared with more than 100 for both problem detection and functional relationships. Ten people mentioned strategies for coping with low glucose, whereas only 3 reported strategies for high glucose. The most common strategy was eating to elevate low glucose levels.

For example, a participant in the middle of the sample in terms of adherence said, “I took my sugar this morning; it was 66… I was scrambling for that orange juice.” This action was probably the most common because low glucose can almost always be ameliorated by eating, whereas correcting high glucose relies on understanding the dynamics of glucose control. The correct action for low glucose is routine, so it is well described by the rules and procedures approach taken by diabetes education. By contrast, each of the 3 participants who attempted to ameliorate high glucose used a different strategy. Overall, although few participants could articulate problem-solving strategies, especially for high glucose levels, those who did articulate strategies tended to have higher levels of adherence but not glycemic control.

**Knowledge and Health Behavior**

When asked for the appropriate response to low and to high blood glucose, 12 and 11 participants, respectively, reported the correct action, indicating declarative knowledge. In contrast, when describing their actions during an actual incident of low or high blood glucose, only 5 and 4 of these participants, respectively, took the correct action. Binomial analyses indicated the probability of participants having accurate declarative knowledge was significantly greater than the probability of their applying this knowledge during a critical incident for both high glucose \( (H = .00077, p < .05) \) and low glucose \( (H = .00071, p < .05) \). This supports the distinction between self-care knowledge and self-care actions.

**DISCUSSION**

In this research, we asked whether cognitive aspects of expertise are related to self-management behavior. This question was explored by comparing evidence of expertise revealed in interviews with self-reports of self-management behavior. This explanatory approach necessitated a small sample with limited statistical power. In future studies, a larger sample would allow the use of structural equation modeling as a tool for testing causal patterns. The interviews and self-reports depended on participants’ accurately reporting their experience with diabetes and self-management behaviors. To increase accuracy, future research might supplement interviews with real-time measure of adherence and laboratory test results.

Despite limitations, the results showed that participants with greater expertise in problem detection adhered better to treatment and had lower glucose levels. Those with greater expertise in functional relationships and problem solving showed greater adherence but did not differ in glycemic control. Adherence may have been more closely related to expertise than to glycemic control for two reasons. First, the glucose system is a dynamic, stochastic system, so medically recommended
actions do not ensure glycemic control. Second, experts monitored their glucose levels more frequently and were therefore more likely to detect elevated glucose levels, as compared with less sophisticated participants.

Overall, these results suggest that the cognitive processes that differentiate experts from novices in professional domains also distinguish performance quality in health management. This implies that techniques and interventions that foster superior performance in professions may also support developing the everyday expertise needed for chronic illness self-management.

The factors that foster the development of expert performance include practicing routine and unusual tasks, honing perceptual skills, and using feedback to learn from past performance (Hoffman, 1996; O’Bryne, Clark, & Malakuti, 1997). These elements could be incorporated into diabetes education. Simulations could provide supervised practice in making decisions about glucose regulation. Patients could be supported as they learn to associate somatic-sensory cues with different glucose levels. Finally, patients could be guided in the use of glucose monitoring as a feedback mechanism.

Knowledge and Health Behavior

Our results found differences between declarative and applied knowledge. More participants were able to describe appropriate responses to abnormal glucose levels when asked directly than when describing critical incidents. These participants did not translate their declarative knowledge into action. This finding is consistent with the distinction between declarative and applied knowledge noted earlier (Anderson, 1982; Nokes & Ohlsson, 2005). It suggests that training must go beyond facts and rules to include experiences designed to change action patterns, focusing less on didactic and more on experiential forms of learning (Kolb, Boyatzis, & Mainemelis, 2000). Future research on patient education and patient cognition would do well to distinguish between different types of knowledge.

Implications for Understanding Expertise

On the definition of expertise. A number of distinct definitions have been used to define expertise, including training, tenure in the field, and gold standards (Dreyfus, 1972; Ericsson & Charness, 1994). Consistent with Hoffman (1996), this study used the cognitive differences between experts and novices found in other domains to define expertise. These criteria were related to both behavior (adherence to treatment) and laboratory results (blood glucose levels). These results suggest that instead of considering expertise as an external outcome (i.e., professional achievement; Ericsson, Krampe, & Tesch-Romer, 1993), one may define expertise in terms of specific cognitive processes. Future research should consider when expertise is best described in terms of cognitive characteristics (Chi, 2000) and/or less abstract, daily experience (Shalin & Vrdile, 2003).

Relationship between processes associated with expertise. Data suggest that the three processes associated with expertise are related (see Figure 1). Participants provided rich and varied descriptions of problem detection and functional relationships. However, when they had to select actions to solve glucose imbalances, less than two thirds took any action, and many who responded did so by following rules and procedures or by turning to medical professionals.

Greater sensitivity to contextual variables may allow expert participants to effectively detect problems even under ambiguous circumstances. The increased contextual awareness associated with concomitant problem detection may help practitioners develop knowledge of functional relationships. Similarly, use of functional relationships may help in detecting problems. These interrelated processes allow expert patients to detect ambiguous problems and to understand why these
problems have occurred. Finally, it is possible that the development of problem-solving strategies depends upon previous sensitivity to problem detection cues and the use of functional relationships. The quotation near the end of the Results section illustrates that these processes are also related during particular problem-solving episodes.

Research frequently treats the cognitive processes that distinguish experts from novices as independent processes (Chi et al., 1988). Although not a longitudinal study addressing the developmental course of expertise in self-care, this study suggests that these processes are interrelated and that the development of some cognitive skills may be prerequisites for others (Dreyfus & Dreyfus, 1986). Future research should consider how cognitive processes indicative of expertise are related and how these relationships affect training and performance.

Implications for Diabetes Education

Because diabetes is dynamic, requiring ongoing problem solving and decision making, rule-based education may not be sufficient for effective self-management (Becker, 2001; Rubin, 2004). This study demonstrates that diabetes knowledge does not necessarily translate into effective self-care. This is compounded when patients encounter problems not directly covered by education. Typically, education neither provides a functional, dynamic model nor describes the relationships among the factors that influence glycemic control (H. A. Klein & Lippa, in press). When physiological or environment disturbances prevent the system from responding as posited by the rules provided, patients have nothing to guide decision making.

Environmental cues and feedback help patients monitor the dynamic glucose system and make decisions. This research suggests that patients could benefit from training techniques used in other complex domains. Computerized simulations, a staple of aviation and medicine (Swezey & Andrews, 2001), could provide patients with practice in controlling glucose levels. Patients could also benefit from experiential knowledge of the functional dynamics of the disease and decision-support training (Lehmann, 1997). Finally, tracking systems on home glucose monitors could be redesigned to foster attention to critical variables and identify patterns in glucose levels.

CONCLUSIONS

Few studies have examined how nonprofessionals develop expertise. Health management provides an important domain for understanding lay decision making. Through an analysis of cognition and behavioral reports by patients with type II diabetes, this study suggests that factors that differentiate experts from novices are important for making decisions about health management. Participants with a more expert understanding, as indicated by problem detection cues, use of functional relationships, and problem solving strategies, reported higher levels of adherence and glycemic control. Techniques that help develop expertise in other domains (e.g., simulations) may be useful interventions for improving patient education and treatment adherence.

REFERENCES

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