Cognitive Function and Medication Usage in Older Adults

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Research is presented from three different cognitive aging laboratories that examines the relationship between cognitive function, age, and the ability to adhere to medication regimens. The first section focuses on the effectiveness of complete, explicit instructions that emphasize the importance of organization of medication information on adherence behaviors for both younger and older adults. The second section examines the role of literal versus inferential medication information in normal elderly and in Alzheimer's patients. This research demonstrates that traditional measures of cognitive functioning are correlated with the comprehension of medication information and medication adherence. Finally, the third section presents an overview of research issues in adherence, including the relative effectiveness of two adherence measurement techniques, as well as a discussion of the effects of illness beliefs on adherence and evidence that adherence is not a global behavior but may vary within the individual as a function of certain medications. Directions for future research are suggested.

Medication adherence is a behavior of great functional importance to older adults. Taking medication correctly can be a complex cognitive behavior for an older adult who uses multiple medications. Each medication may involve a different schedule and may also include special instructions unique to that medication. Thus the apparently simple act of remembering to take medication likely involves many component cognitive behaviors including comprehension, working memory, long-term memory, prospective memory,

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and reasoning (Park, 1992b). It is well documented that age-related declines in cognitive function occur with advanced age (Salthouse, 1991). Some of these declines are particularly pronounced in very late adulthood, that is, in older adults aged 75 and older (Salthouse, 1991). It would appear, based on the basic research data, that among the very old, those who are on complex medication regimens may be at risk of being unable to perform adequately the many cognitive operations required for successful adherence. It would be useful to know both which cognitive operations are involved in successfully following complex medication regimens and how deficits in those operations create problems in adherence. With that knowledge, remediation and environmental supports can be designed to aid medication adherence.

Recently, cognitive aging researchers have become interested in applying knowledge about basic cognitive function in older adults to medication adherence behaviors in the elderly. The present article represents an overview of the ongoing work in this area in three different laboratories—Dan Morrow's of Decision Systems, Sherry Willis's of Penn State University, and Denise Park's of the University of Georgia. Although there is overlap among the three research programs, the emphasis of each research group is different. The Morrow group has focused on the importance of structuring medication information in such a way as to be compatible with the schemes individuals have for taking medication, thus lightening the cognitive burden with respect to comprehension and memory. The Willis group has focused on the role that cognitive function and performance on everyday tasks may play in predicting who will be adherent and nonadherent individuals. Park and her research group initially emphasized measurement of comprehension and memory for medication information in the laboratory but are now more focused on the use of microelectronic techniques to record complex patterns of medication taking in the field and on the development of external cognitive aids to improve adherence.

The present article provides individual summaries of the findings and emphases of each of the three research programs. This is followed by a general discussion of progress that has been made on the topic of aging,

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cognition, and medication adherence, as well as questions that remain to be answered.

The Morrow Research Group: Instructional Design and Medication Adherence

The Morrow Research Group has focused on applying text processing and schema theory to medication adherence. Using this framework, they assume that people must develop a plan to accomplish the adherence task. The plan is composed of a goal (e.g., take medication) and actions that achieve the goal (see Schank & Abelson, 1977, for a discussion of plans). The first step involves gathering information about the tasks such as when and how long to take medication. Nonadherence can result from incomplete information gathering. For example, people may stop taking medication because of effects about which they were uninformed.

After gathering information related to the medication, people interpret the information to understand and remember what to do. This step involves several processes that require working memory capacity, a type of limited cognitive resource. Words are recognized, sentences parsed, and the information integrated with any prior knowledge about the adherence task, the medication, or disease to create a mental model of how to accomplish the specific task (see Wilson & Rutherford, 1989, for discussion of mental models). According to schema theory, comprehension will be easier when prior knowledge guides expectations about how the new information is organized (Hess, 1990). Nonadherence sometimes results from misunderstanding poorly organized medication labels (Morrell, Park, & Poon, 1989). Poor organization compounds other problems, such as vague terminology, that force people to infer how to take the medication (Morrow, Leirer, & Sheikh, 1988).

Finally, people must carry out the plan to accomplish the medication task, which requires remembering to do the task (prospective memory). Adherence improves when elders are provided mail or phone reminders about medication or appointments (Leirer, Morrow, & Pariante, 1991).

In addition to cognitive abilities, such as encoding new information in relation to prior knowledge, adherence involves metacognitive abilities, such as monitoring information in working memory to ensure that the instruction is understood. Adherence also depends on motivation, which is influenced by beliefs about the value of the treatment and about one's ability to perform the task (Janz & Becker, 1984).

Well-Designed Instructions and Support of Cognitive Components of Adherence

Well-designed instructions can improve adherence by reducing cognitive demands imposed by the steps described and by improving motivation. These instructions should be complete and organized to be compatible with any prior task knowledge, and they should emphasize this task organization through explicit formats.

Complete instructions. Complete instructions contain all of the information necessary to take medication accurately. For example, surveys find that patients want to know about warnings, possible side effects, and drug interactions, even though these items are often not discussed by prescribing physicians and are usually not included on medication labels (Gardner Rulien, McGahn, & Mead, 1988). Complete or expanded patient communication is recognized by the Omnibus Budget Reconciliation Act of 1990, which mandates pharmacist consultation with Medicaid patients (Kimberlin, Berardo, Pendergast, & McKenzie, 1993). This expanded communication may, however, present new challenges: How should additional information be presented so that it does not overload older patients' cognitive abilities? One strategy is to make the communication compatible with what elders already know about the task.

Compatible instruction. Procedural instructions that are compatible with preexisting schemes about the task should be easier to understand and remember. These schemes guide comprehension and retrieval of new information, which minimizes the need to reorganize and integrate information in working memory (Wickens, 1992). This compatibility principle is supported by several findings. First, people search computer databases more quickly and accurately when the menu matches organization of their domain knowledge (Wickens, 1992). Second, domain expertise improves recall only when texts are organized in terms of domain principles (Vicente, 1992). Third, both older and younger subjects more accurately recall narratives that are organized in terms of schemes (Hess, 1990).

To apply this compatibility principle to medication instructions, Morrow et al. (1988) first established that adults share a scheme for taking medication. Morrow et al. (1988) had previously identified 10 items that should be included in a complete written medication instruction set. Next, they examined elders' schemes for organizing this information (Morrow, Leirer, Altieri, & Tanke, 1991). Thirty-three older adults (mean age = 71.5) sorted the items into categories and arranged them in a preferred order. Hierarchical cluster analyses of the sort and order data showed that subjects shared a scheme that consisted of three categories: (a) general information (e.g., medication purpose), (b) how to take (e.g., dose and schedule), and (c) possible outcomes (side effects). It was found that instructions were more effective when they were compatible with this medication-taking scheme. To show this, the Morrow research group compared standard instructions that grouped and ordered information according to the scheme, category instructions that presented the three categories in a nonpreferred order, and scrambled instructions for which all items were in nonpreferred positions. A sample of 27 older adults (mean age = 70.5) better remembered the more compatible instructions (standard instructions, 57% items recalled; category instructions, 51% recalled; scrambled instructions, 47% recalled), rated recall of these instructions more highly, and preferred them. These findings suggest that older adults used their scheme to understand and remember the instructions.

Morrow, Leirer, and Andrassy (1993) also examined age differences in scheme organization and instruction recall. Previous research suggests that older and younger adults have similar knowledge structures, even if older adults do not always spontaneously use them in laboratory studies (Hess, 1990). A sample of 42 older adults (mean = 69.5 years old) and 42 adults (mean = 24.6) completed the same sort-and-order tasks that researchers used in the earlier study. In addition to cluster analysis of the order preferences, individual differences in organization were examined. For each subject and medication, each item's position was subtracted from the group (or standard) position. The mean deviation score across the 10 items of the subject's instruction set summarized the differences between the subject's order and the standard order. Then the investigators examined whether or not these individual difference scores related to verbal ability, health care beliefs, and medication taking experience.

For the most part, older subjects organized the items in the same manner as in the earlier study. The only age difference related to doctor's name—older subjects grouped it with possible outcomes, whereas younger subjects grouped it with the general information category. Consistent with previous research, older subjects were more likely than younger subjects to hold externally directed beliefs about their health care. They also reported taking more medication. However, regressing demographic and health belief scores on the instruction organization deviation scores showed that verbal ability primarily accounted for variability in the scores—subjects with higher vocabulary scores had smaller deviation scores, suggesting that they created more standard medication instructions.

A second group of older and younger adults read and recalled standard, category, and scrambled instructions. Although younger subjects recalled more information than did older subjects (64% vs. 47% items recalled, $p < .001$), the more compatible instructions were once again preferred and recalled more accurately (standard = 59%; scrambled = 52%; standard vs. scrambled, $p < .001$). Notably, Age did not interact with Instruction, suggesting that older as well as younger subjects benefited from well-organized instruction. Age and Instruction had similar effects on self-assessment of recall performance. Younger subjects rated their recall more highly than did older subjects, and recall ratings were higher for more compatible instructions. Once again, Age did not interact with Instruction, showing that both older and younger adults were attuned to the benefit of their scheme on message recall.

In summary, Morrow and colleagues found few age differences in schemes for taking medication, which is consistent with evidence that knowledge structures such as scripts are largely age invariant (Hess, 1990). Notably, both older and younger subjects more accurately recalled instructions that were compatible with this scheme. Of course, instructions should be made compatible only with prior knowledge that may improve adherence. For example, instructions should contradict rather than support incorrect beliefs about the disease or medication (Rice & Okun, 1992).

Explicit instructions. Instructions should also be easier to understand and remember when their format explicitly describes and emphasizes the task organization because readers can readily integrate information in the instructions with their scheme (Morrow, Leirer, & Altieri, in press). In this study, categorized list, simple list, and paragraph instructions were compared. These three formats emphasize both order and grouping organization (items are grouped and labeled according to the three categories of the scheme), only order organization, or neither, respectively. Older adults preferred the more explicit list instructions over the paragraph and answered questions about the two list instructions more quickly than they did questions about the paragraph, with no difference between the list formats. In this same study, the investigators also examined the impact of format on recall with restricted study time. Simple list recall was more accurate than either paragraph or categorized list, apparently because subjects read more of the list than the paragraph instruction during the study period. As in other studies, older adults were generally aware of the benefits of organization for understanding the instructions, because the effects of organization on self-rated comprehension and memory performance were similar to the effects on actual performance.

Conclusion

These studies suggest that instructions improve adherence when they are complete, compatible with what older adults already know about the task, and emphasize this task organization by means of explicit formats. Older and younger adults in these studies shared preferences for how to organize instructions and for organizing medication information. They better remembered instructions that were compatible with these preferences and that emphasized this organization by means of list formats. Moreover, they were aware that these instructions improved comprehension and memory, and they preferred to use them. Therefore, well-designed instructions may also motivate elders to take their medication correctly.

Well-designed instructions can facilitate several stages of communication between health professionals and patients. They can be used to structure consultation between pharmacists or physicians and the patient and later be used as a guide by patients at home. These principles may also improve the design of other forms of health communication. For example, older and younger adults also share preferences for organizing reminder messages about health care appointments (Morrow, Leirer, Andrassy, & Tanke, 1993).

Willis and Diehl: Comprehension of Medication Information in Normal and Demented Elderly

Most studies of medication comprehension have focused on normal, cognitively intact elderly. However, in early phases of cognitive impairment, those suffering from dementia or other forms of impairment are often living in the community, sometimes alone, and attempting to carry out essential activities of daily living that involve complex cognitive abilities. Little is known about their ability to perform these critical everyday tasks, and so this has been a recent focus of the research group. Prior research on the elderly's understanding of prescription drug labels has focused largely on comprehension of *literal* information, most frequently intake instructions (i.e., number of pills per time interval). This emphasis in previous studies on understanding literal information and the finding that nondemented elderly made relatively few comprehension errors may lead to the erroneous conclusion that the elderly have little difficulty with comprehension of complex medication information. Comprehension of medication information often requires making *inferences*, that is, drawing conclusions or making an interpretation when the information needed is not explicitly stated in the directions. For example, if the label states that the medication is to be taken three times a day, at what time should each dose be taken? How is the caution label "Do not take while operating machinery" to be interpreted by an elderly housewife?

Medication information comes in many forms. Prescription drug labels that provide information on a single drug are the most common form of information. However, many elderly take multiple prescription drugs and are often advised to develop or are given a patient medication chart involving information on multiple drugs. Relatively little research has been conducted examining the elderly's ability to comprehend drug information when presented in the form of a patient medication chart.

Work by Willis and colleagues has focused on medication comprehension in both normal and demented elderly. Reported here are findings regarding aspects of drug information that normal and elderly have difficulty comprehending. Based on prior text analysis research (Meyer, Marsiske, & Willis, in press; Meyer, Young, & Bartlett, 1989), the Willis research group hypothesized that level of comprehension would vary across different forms of medication information (prescription drug label for a single medication versus patient medication chart for multiple drugs). It is also hypothesized that comprehension would be higher for factual (literal) information than for information requiring inferential reasoning. In addition, because memory and abstract reasoning are cognitive processes showing the earliest impairment in dementia, it was hypothesized that tasks involving inferential reasoning and requiring working memory would be particularly difficult for demented elderly.

Comprehension of Prescription Drug Label Information

In the research presented here, the ability of normal and demented elderly persons to deal with literal and inferential questions related to information on a standard drug label produced in a hospital pharmacy is examined. An example of a literal (factual) question is, "What are the possible side effects of taking this medication?" An example of an inferential question is, "For how many days will this supply of medicine last, if taken according to directions?" Responding to the literal question involved simply stating the information presented in the auxiliary label, such as "May cause drowsiness." The information required to answer the literal question could be found in a single place on the label. The warning was stated explicitly and required no inference or interpretation to answer the question. The elderly could restate the information on the label.

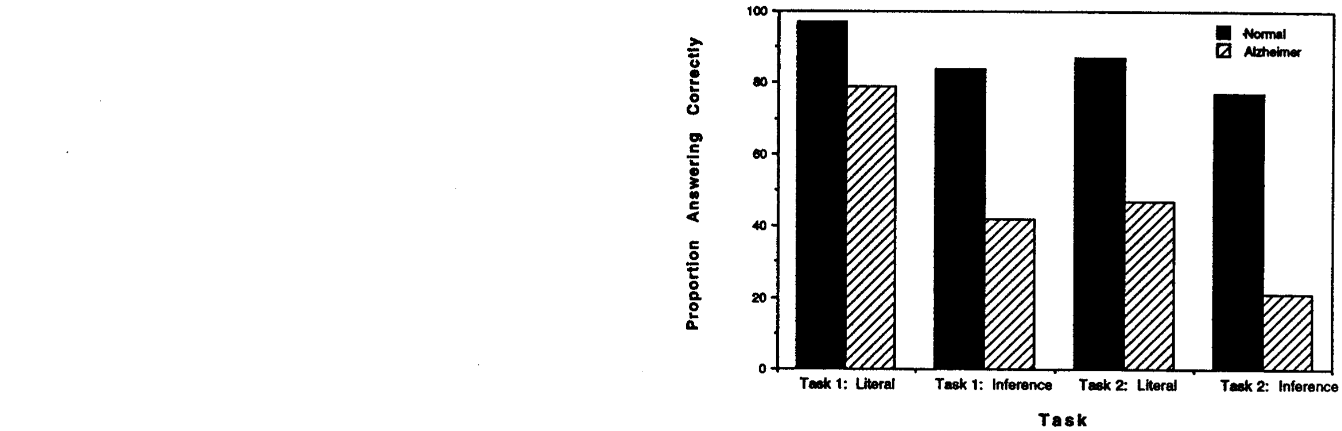

Figure 1. Ability to comprehend and solve problems related to drug label information as a function of inferential versus literal questions and cognitive impairment.

An example of an inference question is, "For how many days will this supply of medicine last, if taken according to directions?" To answer this question, the elderly patient must search for relevant information in several places on the label. That is, the patient must read the intake instructions and determine, for example, that four pills are to be taken each day. Next, the patient must determine, in another place on the label, the number of pills contained in the bottle (e.g., 20 pills). Finally, a mathematical operation must be performed on the collected information to determine that the bottle contains five days of medication, if taken as directed. Determining the correct answer to the inference question is made difficult by the necessity to search multiple places on the label for information and the necessity of performing a mathematical operation.

These questions were presented to normal older adults and to older adults with early stages of Alzheimer's disease who had a median Minimental State Exam score (Folstein, Folstein, & McHugh, 1975) of 17. The results are presented as Task 1 in Figure 1. The data indicate that ability to comprehend and solve problems related to a prescription drug label varied (a) as a function of whether literal or inferential questions were asked and (b) as a function of cognitive impairment. The literal question was answered correctly by 97% of normal elderly and 79% Alzheimer's subjects, respectively. The inferential question was answered correctly by 84% of normal and 42% of Alzheimer's subjects.

It is notable that Alzheimer's patients in a relatively early disease phase were still able to answer literal questions with regard to information on a prescription drug label. The inference question, however, was more difficult for both normal elderly and for the demented. Of particular interest is that there was a dramatic decline in the Alzheimer's patient's ability to deal with tasks that involve the making of inferences and the search for relevant information in multiple locations.

Comprehension of Patient Medication Charts

In the second task, the same subjects were shown a patient medication chart similar to those used by many elderly. The chart contained four headings or columns, representing four types of medication information (name of drug, intake instructions, dosage, and symptoms for consulting a doctor). The chart involved four rows in which the above information was presented for four medications commonly taken by the elderly. The chart represented a 4 × 4 matrix of information with four types of information for each of four different medications.

The literal question was very similar to that asked for the single-prescription drug label, focusing on comprehension of caution or warnings: "Which medication could cause problems with swelling?" The question involving inferential reasoning was also similar to that asked for the single drug label: "How many days will the supply of penicillin last?" However, the task of answering the literal question on the patient medication chart was made more difficult, because the elderly adult was required to search for the relevant information with regard to each of the four medications. That is, the elderly needed to read the caution statement for each of the four drugs and determine for which drug the caution of potential swelling applied. Likewise, a more complex search process was required for identifying information relevant to the inference question.

Figure 1 also presents findings (Task 2) with regard to a normal and demented elderly person's ability to answer literal and inference questions based on the patient medication chart. The literal question was answered by 87% of the normal elderly but by only 47% of the Alzheimer's patients. The inference question was answered correctly by 77% of the normal and by only 21% of the Alzheimer patients.

Although the types of questions asked in the first and second task were very similar, subjects had more difficulty with the second task, the medication chart. Because the medication chart involved information on four drugs, there was a significant increase in information that had to be searched and comprehended to answer the questions. Although the medication chart might be perceived as a memory aid to assist Alzheimer's patients with medication adherence, the increased amount of information presented in the chart significantly increased the difficulty of the task for the demented elderly.

Conclusion

One major finding from this study was that older adults' level of comprehension varied considerably for different forms of medication information. The hypothesis that level of comprehension would vary depending on the assessment of literal or inferential information was supported. Elders' performance was best for literal comprehension, requiring a simple restatement of explicit information on the label. However, older person's comprehension is reduced when presented with information that requires making inferences. For example, participants in the study had considerable difficulty inferring from the available information on the label (i.e., number of tablets taken per day, the number of tablets in a prescription, the number of refills) the duration of their prescriptions or the number of days a refill would last. This limitation in inferential reasoning may affect patients' medication-taking behavior in two respects. First, it suggests that older adults may have difficulty self-monitoring their medication-taking behavior and their adherence to their medication regimen. Second, patients may have difficulty determining, in advance, when to refill a prescription or to make an appointment with their physician to obtain a new prescription.

A second major finding from this study was that elderly suffering from cognitive impairment are particularly at risk with respect to comprehension of drug label information. Demented subjects had particular difficulty when faced with comprehension questions involving inferential reasoning or when presented with increasing amounts of information, such as in the patient medication chart. The structural features of the chart, such as organization of information and headers, which have been shown to facilitate comprehension in normal subjects, appear to have provided less assistance for the demented. The information search process required in the chart was particularly difficult for the cognitively impaired.

The Park Research Group: Monitoring Techniques, Belief Systems, and Patterns of Adherence

Although early work by this research group was focused on laboratory studies of medication cognition (Morrell et al., 1989; Morrell, Park, & Poon, 1990), more recent work has been focused on the measurement of adherence behaviors in the field with actual patients. The focus of this discussion is on in-process research and techniques used by Park, Morrell, and colleagues to study medication adherence. Major findings from laboratory work indicated that older adults evidence both poorer memory and comprehension for medication information, even when unlimited study time is allowed (Morrell et al., 1989). The data also suggested that both young and old profited from well-organized labels (Morrell et al., 1989) but that only young adults improved medication memory when pictorial information was substituted for verbal information on the prescription label (Morrell et al., 1990). In an initial field study, Park, Morrell, Frieske, and Kincaid (1992) also reported that oldest-old adults were more nonadherent than young-old adults, a finding later replicated in a study of hypertensive adults (Park, 1992b). As this research group's work in adherence has progressed, they have moved to more ecologically valid measures of adherence behavior. In attempting to measure actual adherence behaviors of patients while they are at home, Park and colleagues have had to confront a range of research issues that intersect with, but do not focus on, cognitive function, to assess accurately the contribution of cognition to adherence. Three issues that have become particularly relevant to the work and that will be discussed here include (a) measurement techniques for adherence behaviors, (b) the important contribution of belief systems to adherence behavior, and (c) the complexity and selectivity of adherence behaviors.

Measurement of Adherence

The Park research group has used two techniques in the laboratory to measure adherence behaviors: the Videx Time Wand System and the Medication Event Monitoring System (MEMS). Both systems permit the monitoring of discrete medication-taking events over time and both provide data regarding the exact time the medication was taken as well as the identity of the medi- cation. The systems differ primarily in terms of cost and obtrusiveness. The Videx Time Wand system is markedly less expensive to use than the MEMS system. It is based on bar code technology and consists of a small, credit-card-sized device that has an electric eye for scanning bar codes like those used on many grocery items. The only cost for this system is the initial purchase price of the individual time wand and the software for downloading. Subjects are given individual bar codes for each medication that are labeled and placed in a wallet. Each time they take their medication, they scan the bar code with the time wand and the date and time of the scan for each medication is recorded. The data stored in the time wand is downloaded, and a record of it can be printed. Disadvantages of the time wand system are that subjects are always aware that they are being monitored, which may increase adherence behavior as a function of the measurement technique, and that the wands are active for only a week before they must be recharged. Finally, scoring of the data is time-consuming. Park et al. (1992) did, nevertheless, find the Videx time wand system to be sensitive to interventions. They reported significant improvement in old-old subjects' adherence rates as a result of cognitive interventions, using the Videx system to measure adherence behaviors.

The MEMS system has none of these disadvantages. With MEMS, subjects' individual medications are outfitted with bottle caps that have a microchip inside the cap. Each time the cap is removed, the date and time is recorded. The cap is then downloaded and detailed information about adherence is presented. The MEMS is much less noticeable to subjects, and batteries stay active for months. Data is also presented in a format more conducive to analysis. Park and colleagues have used the system very successfully in recent work and believe that it represents a considerable improvement over the Videx system. The primary disadvantages are that the bottle caps are rented on a monthly basis and the cost of using the system can be prohibitive. Researchers have just completed a comparison of 40 osteoarthritis patients tested for 2 months: 20 on the time wands and 20 on MEMS. There do not appear to be major differences in the rates of adherence or adherence patterns as a function of the two systems, and so the choice of system may largely be a matter of budget and preference.

Belief Systems and Adherence

It seems clear that individuals have beliefs about medications that likely affect whether or not they are taken, in what quantities, and at what intervals. In ongoing research, the Park research group has adopted the Leventhal and Cameron (1987) self-regulatory model to better understand adherence behaviors. This model views the individual as a problem solver who has a cognitive representation of illness and attempts to regulate the illness based on this representation. Adherence or nonadherence to medication is an important self-regulatory strategy available to the individual. Based on individuals' beliefs as well as feedback received from usage of medication, adherence behaviors will be adjusted as dictated by dynamic changes in the illness representation and beliefs about medications. Park (1992b) has presented a model of adherence where beliefs and illness representation play a more important role in adherence behaviors for young adults, whereas cognitive function plays an increasingly important role in adherence behaviors as age becomes more advanced. Based on these hypotheses, in current research, Park, Morrell, and colleagues have developed complex measures of coping strategies and beliefs about illness, as well as measures of cognitive function, in an effort to develop a more complete model of adher- ence behavior. They hypothesize that cognitive function will be a more important predictor of adherence in older adults, whereas coping strategies and belief systems will be better predictors for young adults. It also needs to be recognized that the use of medications can in itself be a coping strategy. Park (in press) makes this point and notes that in future work, adherence behaviors should be used as a predictor rather than as an outcome. In other words, do individuals who evidence high rates of adherence have a better functional health status, less depression, more mobility, and a generally higher quality of life? As researchers learn more about adherence behaviors, a more sophisticated understanding of them in general models of health behavior should evolve.

Selective Nonadherence

Selective nonadherence occurs when subjects are taking multiple medications and they correctly adhere to one medication but not another. Park (1992b) recently monitored 48 hypertensive adults who were taking multiple medications. The Videx system was used, and the monitoring period was 2 months. Selective nonadherence can be detected only if individual subject records are examined over prolonged periods. Selective nonadherence was defined as occurring when subjects, for 5 or more days, evidenced a 25% adherence difference between two medications. Using this criterion, Park (1992b) isolated 24 of 48 subjects who met this criterion. An example of a subject's data appears in Figure 2. It can be seen that the subject initially failed to adhere to a vitamin supplement early in the monitoring period. Later in the month, the subject accurately took the vitamin but then became nonadherent with hypertension medications. These data are presented to illustrate the importance of different levels of analyses in understanding adherence behaviors, a point discussed more completely in Park, Morrell, Frieske, Gaines, and Lautenschlager (1993). Depending on the issue, it may be useful to examine overall weekly or biweekly adherence rates collapsed across medications and subjects, or it may be informative to look at the individual subjects' data day by day as the unit of analysis, as Figure 2 demonstrates.

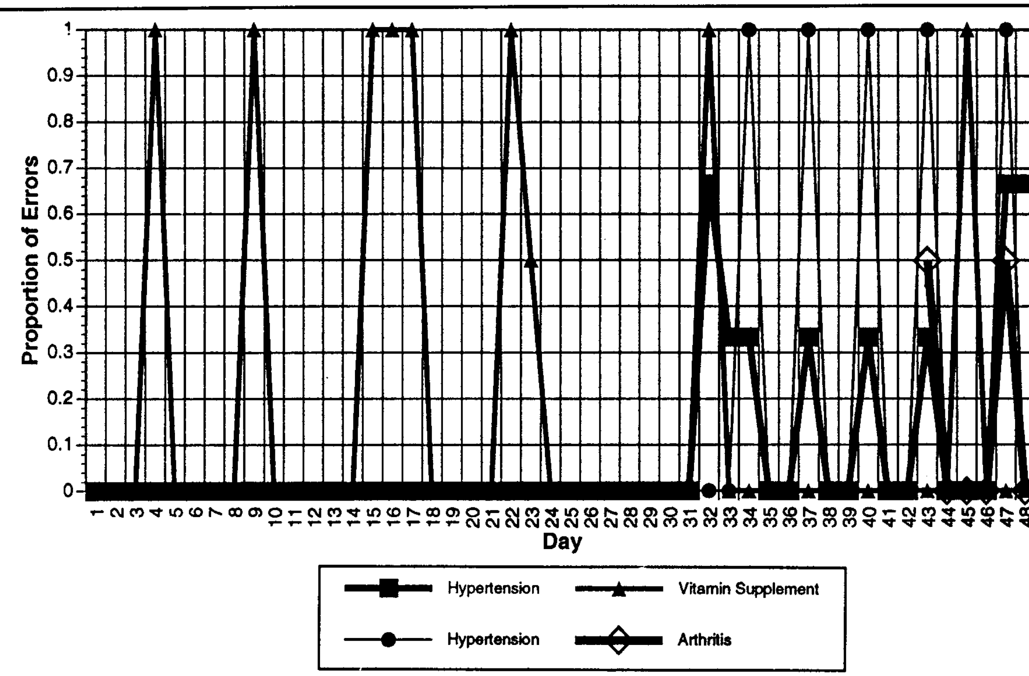

Figure 2. A demonstration of selective nonadherence to different medications across a period of days.

General Discussion

The research programs presented in this article all deal with a complex real-world behavior, medication adherence, that has a substantial cognitive component and is also a behavior with important implications for health and well-being of elderly citizens. Perhaps the most notable aspect of all three research programs is that all are firmly grounded in basic laboratory research. The Morrow program adopts ideas from schema theory and text processing; the Willis program is based on component cognitive behaviors isolated in longitudinal studies of cognitive development; and Park has drawn her ideas from basic memory research in the laboratory as well as from social psychological theories of health behaviors. This integration represents two important emerging trends in behavioral research in general. First, the application of laboratory work to a complex real-world behavior represents the fact that researchers have made steady and substantial progress toward understanding the componential cognitive processes underlying cognitive function in older adults. The investment in basic research in cognitive aging is beginning to pay off, and work has progressed to the point where theoretical constructs readily map onto real-world behaviors. Second, there is an increasing interest on the part of Congress and the Clinton administration in social outcomes for research dollars spent. Thus there is concern at the federal level that applications of basic research occur. It is not clear whether this is a desirable trend or not, but there seems to be general agreement that this pressure is not likely to be lessened in the immediate future. The result is that more and more basic scientists are conducting research applications of basic constructs to real-world situations.

Another common theme to the present work is the emphasis on intervention. The work of Morrow points clearly to ways of structuring text to facilitate comprehension of information and enhanced adherence behaviors. Willis' work focuses on this issue also, providing some insight into problems older adults have with medication instructions that require inference, as well as the unique problems faced by early Alzheimer's patients. Park's work has focused on the development of sensitive monitoring techniques to measure the effect of cognitive interventions on adherence behaviors (Park et al., 1992). As the work in this area progresses, an increasing emphasis on intervention techniques seems likely.

The role of individual differences and the complexity of adherence behaviors is an area that needs further development. The use of regression, discriminant analysis, and even structural equation modeling will help us understand individual difference variables that may put an individual at particular risk of nonadherence. The other important point is the complexity of adherence behaviors and the fact that they are not global behaviors. Park reports that about half of her subjects showed evidence for what she calls "selective nonadherence." That is, they took one drug correctly but not another, a finding that suggests the underpinnings of some nonadherence may relate to beliefs about drugs rather than cognitive abilities to correctly adhere.

The selective nonadherence data suggest that it may be important to look at adherence behaviors as they relate to specific illnesses. It may be that adherence behaviors for a life-threatening heart condition or a very painful arthritic condition might be very different from adherence behaviors for a silent hypertensive condition. Thus an important question for future research will be to understand the interaction of cognitive variables with illness variables, as well as medication variables (i.e., side effects, number of doses per day, etc.).

Work on aging, cognition, and medication adherence is progressing rapidly. An integration of this work with general models of health behaviors is an important direction for future efforts. Additional areas of importance include understanding the interaction of cognitive function with belief systems, disease-specific models of adherence, and the relationship of adherence to quality of life and other health behaviors.

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