Longitudinal Relationship of Health and Cognitive Functioning to Performance on Tests of Basic Skills and Everyday Problems

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The domain of adult development has greatly benefitted from the use of longitudinal research. This methodology has helped to provide greater understanding of intellectual development across the life span. In particular, it has helped to document that different intellectual abilities have differing developmental trajectories across the life span (Schaie, 1979). With the acceptance of this idea, intellectual development has come to be viewed as susceptible to the influences of both growth and decline.

A variety of environmental, physical, and emotional factors have been investigated in relation to change in intellectual functioning across the life span. One particular factor is general health status. An early study by Klonoff and Kennedy (1966) found that when comparing healthy community-dwelling elderly and hospitalized elderly, differences in health were predictive of differences in cognitive functioning. Willis, Diehl, Gruber-Baldini, Marsiske, and Haessler (1990) found evidence of two primary noncognitive predictors, educational level and self-reported health status, of later performance on tests of psychometric abilities. In contrast, Salthouse, Kausler, and Saults (1990) found that assorted health factors

were relatively unimportant in the relationship between age and cognitive performance. In particular, there were no significant age X health-status interactions. An explanation for these conflicting results may be the healthy subjects typically used in studies of aging. This proposition is supported by research reported by Field, Schaie, and Leino (1988), who found that the health of the subject or the subject's spouse was an important predictor of change in cognitive functioning. Additional support for a relationship between not only health and intellectual functioning, but also for differing developmental trajectories, across the life span was reported by Perlmutter and Nyquist (1990). These authors reported a negative correlation between age and fluid intelligence, and a positive relationship between age and crystallized intelligence. However, particularly for older adults, both self-reported physical and mental health were responsible for a significant amount of the variance in intellectual performance.

Of the research reported by Willis et al., it was noted that the influence of non-cognitive predictors was reduced by the presence of the subject's previous cognitive performance. Other research has indicated that cognitive functioning may serve as an important predictor of future performance on everyday tasks (Willis, Jay, Diehl, & Marsiske, 1992). Consequently, the research reported here posits an association between indicators of an individual's health and cognitive status and later performance on tests assessing abilities in everyday activities. Assessment of this relationship is in a longitudinal sample of elderly subjects. It was hypothesized that similar to previous work, cognitive abilities would serve as antecedents of later performance on activities essential to the elderly's maintenance of independent living. It was also expected that measures of general health status, would also strongly predict future difficulty with performance of everyday tasks.

Method

Subjects

The study sample consisted of 139 individuals from communities in rural central Pennsylvania (19 males and 120 females). All subjects were participants in the first phase of the ADEPT study in 1979, and in the retests of 1986, 1989, and 1991. In 1986, mean educational level of the sample was 12.2 years (s.d. = 3.04), with a mean age of 71.6 years (s.d. = 6.22, range 52-87 years). Subjects rated their general health, hearing and vision on a six-point Likert scale (1=very good, 6=very poor). Mean general health was rated 1.9 (s.d = 0.8), hearing was rated 2.4 (s.d. = 1.0), and vision was self-rated 2.4 (s.d. = 0.8).

Testing Procedure

The testing procedures employed in 1986 and 1989 were similar to those used originally in 1979 (Willis, Jay, Diehl, & Marsiske,1992). While individual assessment was necessary for a few subjects with sensory limitations, testing was typically carried out in small groups of subjects (3-12 persons) by a young adult tester and a proctor. The test battery was administered in two three-hour sessions, with multiple rest breaks provided. Typically, the testing sessions were held within a ten day period. Testing sessions were conducted in facilities (e.g., senior center) in the communities where the subjects resided.

In 1991, subjects were contacted by mail to complete the Everyday Problems Test (EPT). There was no face-to-face encounter between subject and tester.

Measures

Health. Participants (n=139) completed a Personal Data questionnaire in 1986 which

included self-ratings of health, change in health during the previous six years (1980-1986), hearing and vision. These self-ratings were assessed with a Likert scale. For current health, hearing and vision, the scale ranged from 1=very good to 6=very poor. For change in health status, the scale ranged from 1=much better to 7=much worse. Change in hearing and vision was also assessed with a similar Likert scale. Subjects also provided information on the number of hospital and physician visits during the past year. In addition, information was obtained (names, dosage, ordered frequency, and duration of administration) about each prescription drug taken by a participant. In an attempt to summarize the health information into more global health indices, an exploratory factor analyses was conducted (Willis, Diehl, Gruber-Baldini, Marsiske, & Haessler, 1990). The model was modified using maximum likelihood estimation in LISREL VI (Joreskog & Sorbom, 1986), and five health factors (health, vision, hearing, change in health status and number of cardiac drugs being taken) were created. Self-ratings of physical health were considered to be accurate based on a host of research indicating that self-ratings are correlated with number of reported medical problems (Pilpel, Carmel, & Galinsky, 1988) and with physician evaluations of health (LaRue, Bank, Jarvik, & Hetland, 1979).

Ability battery. The ability battery administered in 1979 was readministered in 1986. This battery was developed within the fluid (Gf) and crystallized (Gc) model of intelligence (Cattell, 1971). Included in this battery were multiple marker tests of four broad, second-order dimensions of intelligence: Fluid Reasoning (Gf), Crystallized Knowledge (Gc), Memory Span (Ms) and Perceptual Speed (Ps) (Baltes et al, 1980). Longitudinal invariance of this factor structure from 1979 to 1986 has been established (Willis & Jay, 1989).

Fluid Reasoning was represented by the primary abilities of Figural Relations (CFR) and Induction (I). Tests of these abilities require the subject to detect patterns of relationships within an array of figures. Crystallized Knowledge was represented by the primary abilities of Social Knowledge (EMS) and Verbal Comprehension (V). The EMS test requires the generation of solutions to social problems, while the verbal measures involve the recognition of vocabulary tests. Semantic Relations (CMR) represent both fluid and crystallized intelligence. Tests of this ability require the subject to complete verbal analogies. The primary ability of Memory Span (Ms) was assessed by how many digits a subject could hold in memory and represented Memory. Finally, Speed was assessed with the primary ability of Perceptual Speed (Ps), and marker tests evaluated the speed with which a subject could make visual discriminations. Table 1 presents a summary of these intellectual ability measures and their hypothesized primary and second order factor structure.

Insert Table 1 about here

For the testing sessions, some adaptation of the testing measures was required. Test stimuli were enlarged to simplify administration to an elderly population, and the number of test items was reduced so that administration could be carried out in two sessions.

Basic Skills. In 1989, returning subjects completed the Educational Testing Service Test of Basic Skills (ETS, 1977). The Basic Skills test is a 65-item paper and pencil measure for the assessment of adults' ability to comprehend printed materials pertaining to everyday tasks (medicine labels, bus schedules, etc.). A content analysis of the ETS Basic Skills test

determined that over 58% of the items represented tasks associated with IADLS.

Everyday problems measure. The Everyday Problems Tests (EPT) was completed by subjects who returned in 1991. The EPT is also a paper and pencil measure specifically designed to assess the older adults' ability to understand everyday printed materials. Printed materials representing the seven IADL domains (food preparation, medication use, telephone use, shopping, financial management, housekeeping, laundry, and transportation) and relevant to older adults are presented. Each stimuli is presented with two questions.

Statistical Analyses

The relationship between health and ability and later performance on measures of everyday living was examined via path analysis. The final path model, presented in Figure 1, was derived through a two-step procedure. First, based on the pattern of correlations among the conceptually relevant variables, a fully recursive model was specified. Based on the results from the fully recursive model, a reduced model was then estimated using only the statistically significant paths. Ordinary least squares estimation was used to estimate the models. For both the fully recursive and reduced models, exogenous variables were allowed to be correlated with each other.

Results

Results of the analyses are presented in two parts. First we present the results of the analyses pertaining to the longitudinal non-cognitive or health predictors of performance on 1989 and 1991 test performance. Second, we present the results of the analyses of the longitudinal cognitive ability predictors of 1989 and 1991 test performance.

Longitudinal non-cognitive predictors of performance

Figure 1 presents the full path model with the significant paths shown. The relationship between health status variables (health change, current health, hearing, vision, and cardiovascular functioning) in predicting longitudinal performance on tests of everyday activities was examined. Inspection of the estimated beta values demonstrated the significant paths (Figure 1).

Put Figure 1 about here

As seen in Figure 1, the significant non-cognitive longitudinal predictors were self-rated assessment of change in health from 1980-1986, current self-reported health status, and age. The variable health change 80-86, though not predictive of 1989 ETS basic skills performance, was a positive predictor of 1991 EPT performance (b=.20). Current health status, again not predictive of 1989 performance, was a negative predictor of 1991 EPT performance (b=-.15). Contrary to the other non cognitive predictors, age was a negative predictor of 1989 ETS performance, though not 1991 EPT performance (b=-.24).

Longitudinal cognitive predictors of performance

Of the seven primary mental abilities, only verbal ability (a measure of crystallized intelligence) and figural relations (a measure of fluid intelligence) were predictive of longitudinal performance. Both were significant predictors of 1989 ETS performance. Verbal ability was positively associated, with b=.34, while figural relations was even more strongly predictive (b=.48).

The strength of the cognitive predictors appears to be moderated by ETS performance, as neither verbal ability or figural relations ability is directly predictive of 1991 performance. However, 1989 ETS performance is an extremely strong positive predictor of 1991 EPT performance (b=.60).

Discussion

Previous research has shown that the relationship between performance on measures of cognitive functioning and later performance on tests of everyday activities is not truly bi-directional (Willis, et al., 1990). Because we apply our cognitive abilities whenever we take a test, performance on measures of cognitive ability more strongly predicts later everyday activities test performance than does everyday test performance of earlier cognitive functioning. Therefore, this analysis began with two potential lines of reasoning. First, we hypothesized that cognitive abilities would precede functioning or performance on tests assessing the elderly's capacity to perform activities essential to maintenance of independent living. Second, non-cognitive factors (i.e. self-rated change in health, subjective and objective indicators of current health status, current cardiac health, hearing, vision, age, and education) would also play a role. In the area of intervention, this proposition is critical. A demonstration that both cognitive functioning and non-cognitive factors are predictive of later functioning on everyday problems opens many avenues. Not the least of which is that it may be a practical way to assess and identify those elderly individuals in need of (and appropriate for) cognitive training intervention to maintain their independence and delay institutionalization. Based on these analyses, this does seem to be a reasonable conclusion, since earlier cognitive functioning was highly predictive of later performance on tests of everyday activities.

The relationship between verbal ability (a measure of crystallized ability) and later test performance is not surprising. Verbal skills and recognition vocabulary are both aspects of crystallized ability and are critical to performance on any verbal or written test, such as the ETS Test of Basic Skills or Everyday Problems Test. Likewise, the relationship between figural relations (a measure of fluid intelligence) would also be predicted, as many test items reflect domains of everyday living where skills related to fluid reasoning would be crucial.

The participant's health status was also predictive of later performance. However, reducing the model did modify the importance of these non-cognitive variables. The participant's perception of changing health between 1980-1986 and 1991 performance, in particular, remained significant. One reason change in health status remained a strong predictor may involve a relationship between the subject's perception of a changing physiological state and the environment. For example, individuals may weight more heavily health changes that influence perceptions of their own health and that restrict their behavior concomitantly. For example, increasing arthritis may not influence the perception of health in an individual whose main hobby is reading, whereas for the elderly individual whose passion is gardening this could be a significant concern, and may intensify the subjective distress felt by the individual. It may be that when rating their change in health what they focus on is the fact that they have a much harder time getting on their knees in the garden to work, and consequently rate their health as much worse. It could also be that self-assessed change in health status is a self-efficacy measure, where health-related concerns cause individuals to feel they can't quite do what they used to be able to do.

The shrinking importance of non-cognitive longitudinal predictors may be a function of the survival rate of the sample population. The sicker, less healthy subjects may dropout between 1986 and 1991, thus leaving a sample of healthy subjects. In other words, the sample attrition may attenuate the range of possible responses (high ceiling,low floor), and as a result, the health predictors predictive power is reduced. Salthouse, Kausler, and Saults (1990) also suggested this as a possible consequence of this type of longitudinal design, which allowed for the inclusion of those subjects with data at all four times of measurement (1980, 1986, 1989, and 1991). Participants who died, or became too ill to continue, were excluded. One method of re-examining these data is through the use of an attrition and mortality analysis. The possibility then exists to examine whether health and cognitive ability performance may predict dropouts and subsequent mortality.

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Table 1
The ADEPT Ability Battery: Second-Order Dimensions, First-Order Primary Mental Abilities and Marker Tests

General Dimension	Primary Ability	Test	Source
Gf	CFR	Culture Fair Test (Scale 2, Form A) and Power Matrices (Scale 3, Form A, 1963 ed., and Form B, 1961 ed.)	Cattell & Cattell (1957,1961,1963)
	CFR	ADEPT Figural Relations Diagnostic Test (Form	Plemons, Willis, & Baltes (1978)
	CFR	Raven's Advanced Progressive Matrices (Set II)	Raven (1962)
Gf	I	ADEPT Induction Diagnostic Test (Form A)	Blieszner, Willis, & Baltes (1981)
	I	Induction Standard Test	Ekstrom, French, Harman & Derma, (1976); Thurstone, (1962)
Gf/Gc	CMR	Verbal Analogies I	Guilford (1969a)
	CMR	Word Matrix	Guilford (1969b)
Gc	EMS	Social Translations (Form A)	O'Sullivan & Guilford (1965); O'Sullivan, Guilford, & de Mille (1965)
	EMS	Social Situations	Horn (1967)
Gc	V	Verbal Meaning (9-12)	Thurstone (1962)
	V	Vocabulary (V-2, V-3, V-4)	Ekstrom, et al. (1976)
Ms	Ms	Visual Number Span	Ekstrom, et al. (1976)
	Ms	Auditory Number Span	After Ekstrom, et al. (1976)
	Ms	Auditory Number Span--Delayed Recall	After Ekstrom, et al. (1976)
Ps	Ps	Finding A's	Ekstrom, et al. (1976)
	Ps	Number Comparisons	Ekstrom, et al. (1976)
	Ps	Identical Pictures	Ekstrom, et al. (1976)

FIGURE 1: LONGITUDINAL PREDICTORS OF PERFORMANCE