International Journal of Behavioral Development 7 (1984) 463–478
North-Holland

MIDLIFE INFLUENCES UPON INTELLECTUAL FUNCTIONING IN OLD AGE *

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Accepted September 1983

Evidence is presented from the Seattle Longitudinal Study to show that cognitive style and other life style variables in midlife can predict part of the individual differences in pattern and rate of ability decline in old age. Differential importance of certain predictor variables are examined as a function of the extent of actul ability decline at various ages. During early middle age attitudinal flexibility maintains high level of function on the fluid abilities and on motor-cognitive flexibility. High performance on the latter variables at midlife as well as an engaged life style and the absence of family dissolution appear to be critical for the maintenance of high levels of ability performance from middle into old age.

Introduction

The literature on adult intellectual development suggests that there is great intra-individual stability until the sixth decade. Thereafter, one finds decremental changes which proceed first at a slow pace but that accelerate as advanced old age is reached. Nevertheless, there are many deviations from this pattern, both in the timing and rate of decline. One of the pervasive interests of researchers in the field of adult cognitive development, therefore, has been to question whether it might be possible to identify variables in early and middle adulthood which might be strong predictors of intellectual functioning in old age. Answers

* This article was originally presented as a paper at the Biennial Meeting of the International Society for the Study of Behavioral Development, Munich, Federal Republic of Germany, August 1983. Its data base comes from the Seattle Longitudinal Study conducted since 1956 with the coooperation of the Group Health Cooperative of Puget Sound. The study has been supported since 1963 by a number of grants from the National Institute of Health. It is currently supported by Grant No. AG-03544 from the National Institute of Aging.

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to this question would help us understand the basis for the large individual differences in age-related change in abilities, and might even be suggestive of possibilities for intervention (cf. also Schaie 1981).

It has been clearly demonstrated that ability status at earlier ages has highly predictive power, particularly during that phase of life when abilities remain relatively stable (e.g., Hertzog 1979; Schaie and Hertzog 1983; Stone 1980). Similarly, a number of investigations (cf. Eisdorfer and Wilkie 1977; Hertzog et al. 1978; Spieth 1964; Wilkie and Eisdorfer 1971) have demonstrated that cardiovascular disease has an unfavorable effect upon the maintenance of intellectual functioning in old age.

But cardiovascular disease or ability status in early life may very much be related to factors that are either largely heritable or that are the outcome of early childhood experiences resulting from environmental factors largely determined by parental socio-economic status. The middle-aged adult may be able to do relatively little to affect these risk factors as they impinge upon prospective ability changes from midlife into old age. On the other hand, there may be a number of life style and personality factors, that may be amenable to change at midlife, whether through the individual's own conscious decision process, or mediated by environmental interventions designed to facilitate life style changes.

It has long been proposed that cognitive styles or other personality dimensions might be more useful in predicting individual differences in ability levels once decline has occurred in a substantial portion of the population studied. Our own work began by studying the relationship between the Primary Mental Abilities and three dimensions of flexibility–rigidity across adulthood. The early cross-sectional studies revealed modest correlations that seemed stable across age and thus did not contribute to differential prediction. By contrast our longitudinal studies have now revealed certain predictive relationships that are differential in nature.

Our discussion will begin by reviewing some of the data on intra-individual change in intellectual abilities to clarify at what point we should expect third variables to add to our prediction from ability status alone. This introduction is necessary, since one cannot expect to predict changes on abilities if a sufficient range of individual differences in change has not yet occurred. We shall then focus on the relation between flexibility–rigidity and ability measures on a sample of 120 persons followed from middle into old age over a 21-year period (mean age 46 to mean age 67). Additional data will be presented on further samples of individuals with narrower age ranges from middle to old age followed over 14-year periods.

Methods

Subjects

The data base to be discussed here comes from the longitudinal-sequential studies of age changes in cognitive behavior conducted with random samples from the membership of a cooperative health maintenance organization in the northwestern United States. These samples were drawn across the adult age range from 22 years on, in four waves, 1956, 1963, 1970 and 1977. (Data collection for a fifth wave has just begun.) Over 2000 persons have been studied from seven to twenty-one years. All of them are community-dwelling persons who receive regular health care, and at the time of assessment were free of acute illness (for more detailed description of the study see Schaie 1979, 1983). As previously reported (Schaie et al. 1973; Gribbin and Schaie 1979), the longitudinal study participants obviously represent a somewhat favorably attrited selection of the original random samples. Attrition rate has averaged approximately 40 percent over the seven-year intervals between successive data collections.

Variables

Although information on other variables has been collected the primary dependent variables of interest upon which we shall focus here are five measures obtained from Thurstone's (1938) work on defining the primary mental abilities. These abilities have been measured in our longitudinal studies by means of the SRA Primary Mental Abilities test (Form AM, 11–17) (Thurstone and Thurstone 1949). Abilities measured by this test include *Verbal Meaning*, a measure of recognition vocabulary; *Spatial Orientation*, involving the rotation of geometric figures in two-dimensional space; *Inductive Reasoning*, as measured by letter series problems; *Number*, measured by simple addition problems; and *Word Fluency*, a measure of recall vocabulary.

The principal independent variables studied as predictors of later performance on the ability measures come from the *Test of Behavioral*

Rigidity (Schaie 1958; Schaie and Parham 1975). This test has three parts:

(*1*) The *Capitals* test requires subjects to copy a printed paragraph in writing, first exactly as given, and then again writing capitals for small letters in the original and vice versa. Two scores are yielded: A *Capitals Speed* score, which reflects psychomotor speed, and a *Capitals Flexibility* score, the ratio between the two administrations, which reflects ability to cope with negative transfer.
(*2*) The *Opposites* test requires subjects to write first antonyms and then synonyms to lists of simple words; they must then respond to a third list by writing an antonym if the stimulus word is printed in small letters, but a synonym if the stimulus word is given in capital letters. Three scores are yielded: An *Opposites Speed* score, reflecting ease of responding to simple cognitive demands; and two *Opposites Flexibility* scores, reflecting different modes of measuring interference effects.
(*3*) The *rigidity questionnaire* contains true–false statements involving scale of flexible behavior, flexible attitudes, and social responsibility. Factor analytic studies of this test (Schaie 1955) derived three dimensions of rigidity–flexibility and factor scores are generally computed for the dimensions of *Psychomotor Speed*, *Motor-Cognitive Flexibility*, and *Attitudinal Flexibility*.

Other independent variables come from a detailed life complexity survey instrument (Gribbin et al. 1980). The major topics in that questionnaire include: individual work circumstances (with home-making defined as a job), friends and social interactions, daily activities, travel experiences, physical environment, and educational pursuits. A cluster analysis of this instrument resulted in the development of a scoring procedure for individual subjects on the dimensions of: Social status, subjective dissatisfaction with life status, homemaker characteristics, disengagement, semi-engagement, family dissolution, noisy environment and maintenance of acculturation.

Results

At what age does average individual change in intelligence become noteworthy?

As we indicated earlier, prediction of later intellectual status becomes interesting in the context of a life-span approach particularly at those ages at which we can observe incidence of change in such status from an earlier point in time. There are, however, at least three different types of information that can be obtained from a longitudinal data base that are relevant to this question (also see Schaie 1980). These are findings regarding: (1) Average individual age changes; (2) proportions of individuals who change; and (3) the variability of observed changes.

Average intra-individual change

Small, but statistically significant, age decrement in intellectual abilities have first been noted during the sixth decade (cf. Schaie and Hertzog 1983). Since small negative changes have been observed during the preceding decade, our conservative approach is to consider cumulative age changes from that point up to which equally small positive changes occur. For our samples, peak ability levels are reached at age 53 for *Verbal Meaning* and at age 46 for the other four abilities. Table 1 provides a summary of cumulative age changes (in standard deviation units) occurring by ages 60, 67, 74, and 81, respectively, separately by sex and for the total sample.

Table 1
Decline from peak performance level in standard deviation units.

Age	N	Verbal meaning	Spatial orientation	Inductive reasoning	Number	Word fluency
Males						
60	125	0.06	0.08	0.04	0.18	0.16
67	98	0.29	0.32	0.21	0.48	0.30
74	83	0.55	0.56	0.45	0.76	0.58
81	39	0.88	0.98	0.68	1.20	0.72
Females						
60	150	0.00	0.01	0.05	0.11	0.16
67	133	0.09	0.13	0.24	0.32	0.39
74	98	0.44	0.34	0.54	0.57	0.61
81	49	0.82	0.54	0.73	0.97	1.10
Total						
60	275	0.03	0.04	0.03	0.14	0.16
67	231	0.23	0.21	0.22	0.39	0.35
74	181	0.54	0.44	0.49	0.65	0.60
81	88	0.89	0.69	0.70	1.07	0.94

Inspection of table 1 clearly shows that decrement up to age 60 is quite negligible. By age 67, however there is average decrement in the range from two tenths to one half of the population standard deviation; still a small, but for some variables statistically significant effect. From then on decrements become larger, ranging by age 74 from one third to three fourth of a standard deviation, and by age 81 ranging between one half to slightly over one full standard deviation. Note the lack of uniformity across variables or gender. On average, men seem to decline most on *Number* and *Spatial Orientation*, but least on *Inductive Reasoning* and *Word Fluency*, while women decline most on *Word Fluency* but least on *Spatial Orientation.*

The data in table 1 were obtained by averaging across three different cohorts, and cumulating across successive seven-year intervals, to yield larger sample size and correspondingly greater stability of estimates. It might consequently be interesting to check these results by looking at data from a single series of cohorts, those whom we have followed for a total of 21 years. Table 2 therefore presents average changes for these small data sets; the youngest group being followed from age 25 to 46 and the oldest from age 60 to 81. This, of course, is a favorably attrited group (cf. Gribbin and Schaie 1979; Schaie et al. 1973), and the decrements noted are somewhat smaller, albeit consistent in pattern with the larger data base shown earlier.

Proportions of individuals who change

Averages, of course, can be quite misleading. An alternate approach, therefore, is to examine frequency distributions of persons whose

Table 2
Average age changes for individuals followed over 21 years (in standard deviation units).

Age range	N	Verbal meaning	Spatial orientation	Inductive reasoning	Number	Word fluency
25–46	19	+0.33	+0.31	+0.13	+0.10	−0.13
32–53	19	+0.06	−0.08	−0.06	−0.08	−0.30
39–60	21	−0.12	−0.14	−0.06	−0.22	−0.47 [a]
46–67	31	−0.12	−0.38 [a]	−0.20	−0.50 [a]	−0.61 [a]
53–74	24	−0.44 [a]	−0.31 [a]	−0.44 [a]	−0.44	−0.73 [a]
60–81	9	−0.71 [a]	−0.20	−0.50 [a]	−0.28	−1.00 [a]

[a] Significant at or beyond the 1% level of confidence.

observed change over time (in our case seven-year intervals) fall outside the confidence band of one standard error of measurement (SEM) about their observed score at first test. In other words, we want to know the proportion of persons whose change is a nonrandom shift from the true score at first test, and not as might be the case in an advantage sample, simply regressing towards the mean of the total population. The 1 SEM criterion is quite liberal in the sense that it would allow for approximately a 16% error rate. Erring in the more liberal direction, however, seems in order since we want to be sure not to underestimate the proportion of persons whose performance may have declined.

Figs. 1a and 1b show proportions of subjects at ages 67, 74, and 81, whose performance on the five ability measures has reliably increased, remained stable, or decreased over the preceding seven-year interval. No such data are given for age 60, because of the trivially small number of persons with reliably detectable performance decrement during the preceding seven years.

Although numerous study participants showed stability or increment over the previous seven-year period, there is a substantial minority who experienced reliable performance decrement. Depending upon the specific ability, between a quarter and a third of all subjects declined in the seven years between age 60 and 67, and similar declines prevailed between ages 67 and 74. From age 74 to 80 the proportion of persons declining ranged from a third to almost one half of our subjects.

Variability in observed decrement

Another way of stating the variability of persons in their ability change from middle into old age, is to construct confidence bands which include 95% of all individual changes from the peak performance age to the target age. Table 3 provides these data.

It may be noted that by age 60, intra-individual change from peak age is distributed virtually normally, with only mild decremental skewing appearing for *Word Fluency*. With advancing age, however, distributions become increasingly skewed in the decremental direction, and by age 81 it is obvious that most individuals show some decline.

The prediction of ability performance at later ages

The data on individual changes in ability discussed above suggest, that the measure on a particular ability itself ought to be the best predictor

of performance level at a later point in time, when assessing individual change from young adulthood into middle age. Because of the differential timing of the onset of ability change, it is likely further that performance on certain abilities at Time 1 might improve the predictability of such abilities at Time 2, when considering change from

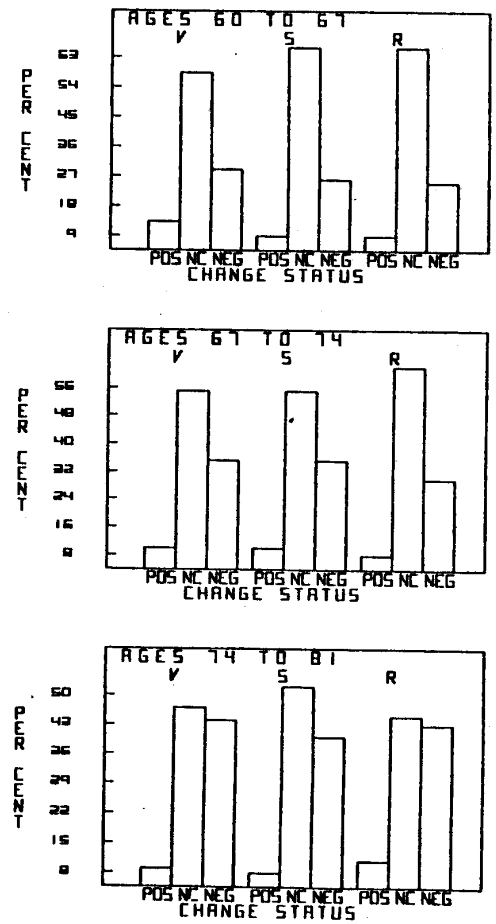

Fig. 1a. Proportions of subjects who showed increment (INC), No Change (NC), or Decrement (DEC) for the abilities of Verbal meaning (V), Spatial orientation (S), and Reasoning (R).

middle age into early old age. It is in the prediction of change from middle age into the late sixties and seventies where we would expect cognitive and life style variables to be most important.

We will test these propositions by examining the multiple regression of our flexibility measures at Time 1 upon ability performance at Time

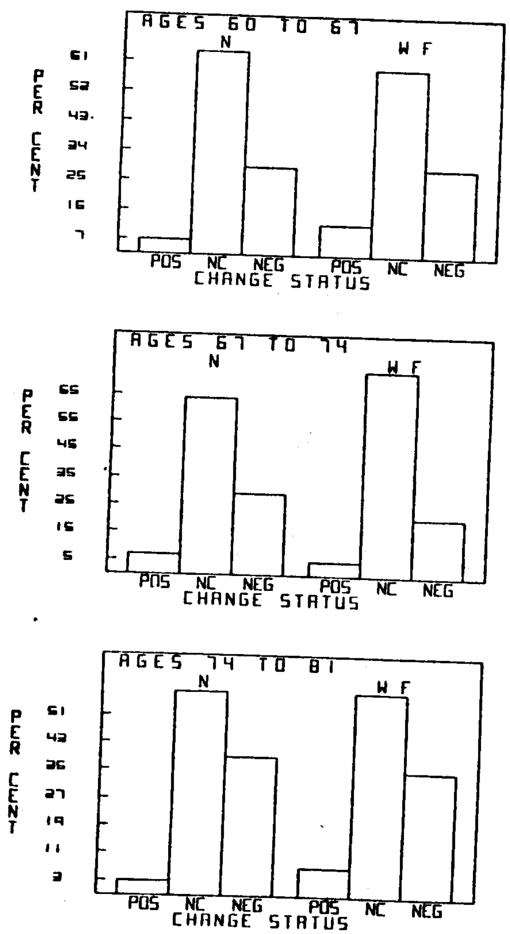

Fig. 1b. Proportions of subjects who showed Increment (INC), No Change (NC), or Decrement (DEC) for the abilities of number (N), and Word Fluency (WF).

2, and we will further explore possible causal directionalities by examining cross-lagged correlations (corrected for differences in reliabilities and stationarity by Kenny's (1975) method) between both ability and flexibility–rigidity measures at Time 1 and Time 2. Sub-samples from our study to be considered for this purpose are, first of all, the 120 persons who were followed for 21 years from mean age 46 to mean age 67. An additional three sets of subjects followed over fourteen years, represent the age-lags from 35 to 49 ($N = 128$), 49 to 63 ($N = 150$), and 63 to 77 ($N = 52$).

The main sample: middle age to old age (46 to 67 years)

Multiple regression analyses, as shown in table 4, yielded significant relationships between the flexibility–rigidity factor scores at mean age 46 and the ability measures at age 67. When cross-lagged correlations were examined, direction of predictability was found to be statistically significant (Pearson-Filon test, $p > 0.05$) from *Psychomotor Speed* in middle age to the ability of *Number* in old age, and from *Attitudinal* and *Motor-Cognitive Flexibility* at the earlier time to *Word Fluency* at the final measurement point. In addition, the *Capitals Flexibility* score predicted *Verbal Meaning* and *Number*. Another interesting path led between the two inventory scales of *flexibility*. Here positive response on the scale of *Flexible Behavior* in middle age was predictive of such response on the scale of *Flexible Attitudes* in old age.

Confirming the hypothesis that differential ability change might lead to significant cross-lags among abilities, it was further found that earlier performance on *Verbal Meaning* and *Inductive Reasoning* predicted later performance on *Number*; and middle-aged performance on *Spatial*

Table 3
Range of individual differences of age changes expressed as the 95% confidence interval for changes from peak performance age (in standard deviation units).

Age	N	Verbal meaning	Spatial orientation	Inductive reasoning	Number	Word fluency
60	275	+1.08 to −1.14	+1.14 to −1.22	+1.08 to −1.14	+1.16 to −1.11	+1.11 to −1.43
67	231	+1.02 to −1.48	+0.99 to −1.41	+0.90 to −1.34	+0.98 to −1.76	+1.01 to −1.71
74	181	+0.78 to −1.86	+0.79 to −1.63	+0.65 to −1.63	+0.83 to −2.13	+0.98 to −2.12
81	88	+0.66 to −2.44	+0.68 to −2.06	+0.62 to −2.02	+0.49 to −2.63	+0.81 to −2.67

Orientation predicted old-age performance on *Inductive Reasoning* and *Word Fluency*.

The auxiliary samples: 35 to 49; 49 to 63; and 63 to 77

The data for the 21-year lags had to be based on rather age-heterogenous samples to obtain large enough sample size for our analyses. A more fine-grained analysis based on more age-homogenous samples is possible for the fourteen-year lags. For these samples significant multiple correlations were obtained for all abilities, except *Spatial Orientation*, when regressing the flexibility–rigidity dimensions at base age upon later ability performance. Interestingly, as the target prediction age increased from middle to old age, the importance of the *Psychomotor Speed* variable lessened, and that of the *Motor-Cognitive Flexibility* variable increased.

Examination of cross-lags as shown in fig. 2 indicated that from late young adulthood to middle age, *Attitudinal Flexibility* was a significant predictor of later performance on *Spatial Orientation, Inductive Reasoning*, and *Motor-Cognitive Flexibility*. From middle into early old age *Psychomotor Speed* was predictive of later performance of *Word Fluency*. More importantly, as shown in fig. 3, *Motor-Cognitive Flexibility* in early old age predicted *Number, Word Fluency* and *Psychomotor Speed* in later old age.

Predictive value of life style variables

Turning now to the impact of life styles, we have earlier reported that we have found differential decline for four different expressions of such

Table 4
Multiple correlations and beta weights for the regression of flexibility–rigidity upon the ability measures after 21 years.

Ability	Multiple regression coefficients	Beta weights		
		Motor-cognitive flexibility	Attitudinal flexibility	Psychomotor speed
Verbal meaning	0.614	0.180	0.135	0.478
Spatial orientation	0.394	0.294	0.119	0.114
Inductive reasoning	0.562	0.240	0.192	0.342
Number	0.529	0.133	0.000	0.477
Word fluency	0.516	0.163	0.188	0.348

life style. We have found least decline (over seven year periods) for those persons who had high socio-economic status and were fully engaged in interaction with their environment, next were those fully engaged persons of average socio-economic status, next those who were relatively passive in their interaction (the semi-engaged), and those persons showing greatest decline were non-career widows who showed a rather disengaged life-style (Gribbin et al. 1980; Schaie 1983). The type differences were statistically significant for all abilities except *Number*, and similar type by age change effects were also found for rigidity–flexibility dimensions.

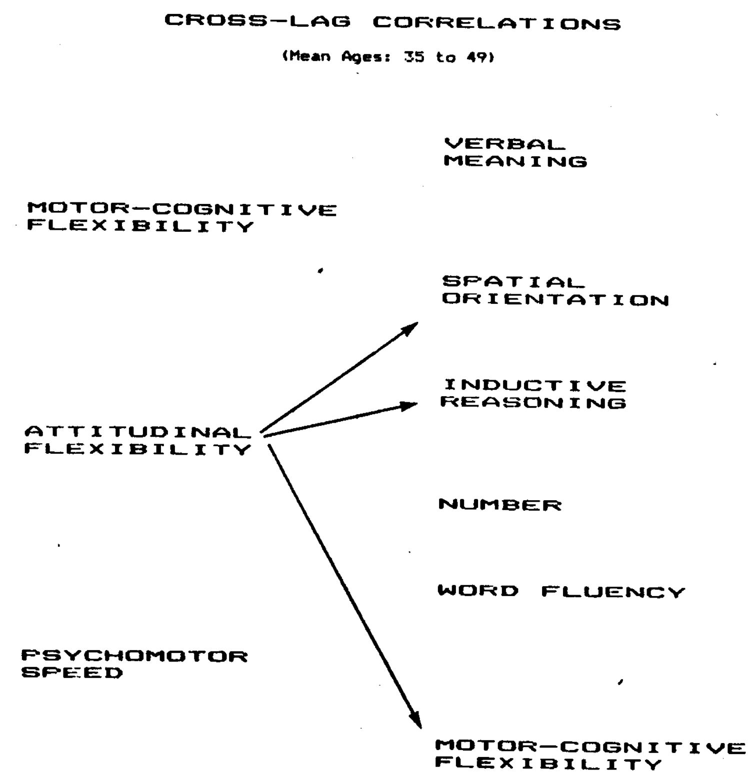

Fig. 2. Cross-lag correlations between flexibility–rigidity and mental abilities from mean ages 35 to 49.

Of further interest are the findings of systematic significant correlations between the occurrence of certain earlier life style variables and later ability status. For example, as shown in fig. 4, the *social status* cluster predicts high performance at a later time for all abilities, while the *disengagement* cluster has a systematic negative relationship. In addition *Maintenance of acculturation* is a positive predictor of *Word Fluency, Attitudinal Flexibility* and of *Psychomotor Speed*; and *family dissolution* predicts negatively to future performance on most variables. Finally, centrality of the *homemaker* role, predicts positively to *Psychomotor Speed,* but negatively to *Spatial Orientation.*

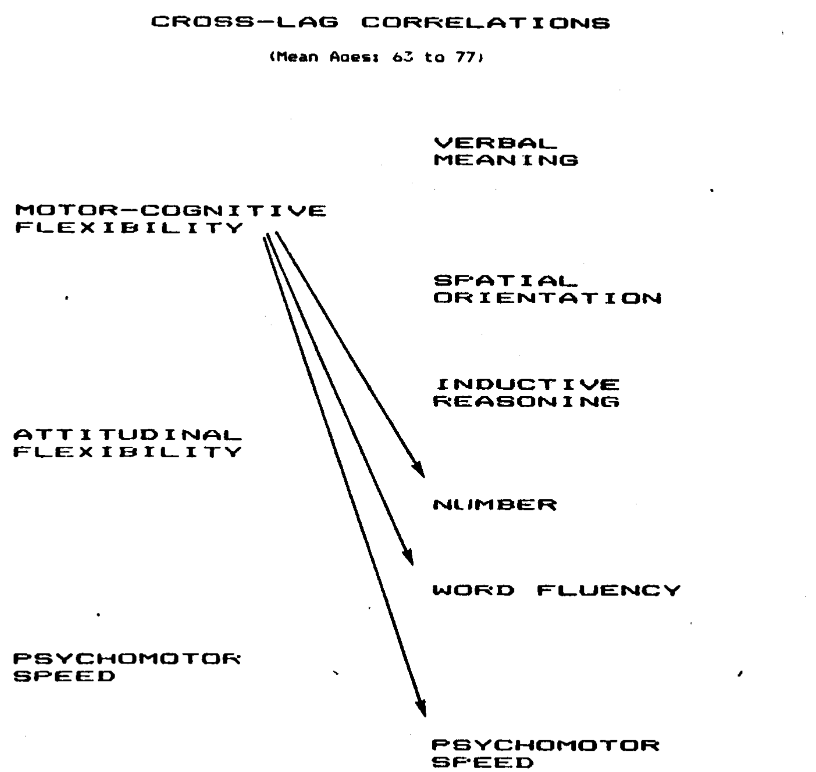

Fig. 3. Cross-lag correlations between flexibility–rigidity and mental abilities from mean ages 63 to 77.

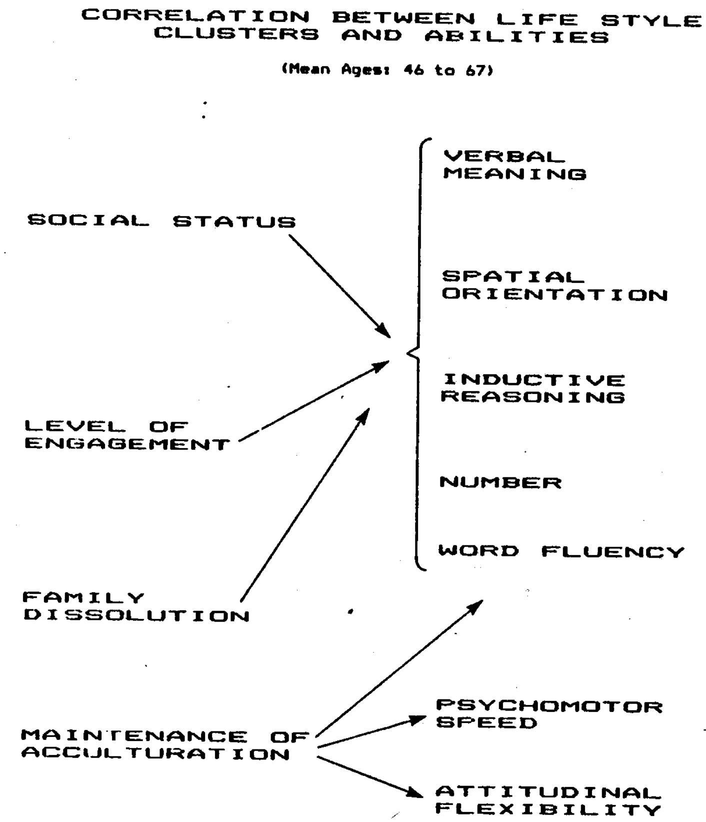

Fig. 4. Significant correlations between life style clusters and abilities.

Conclusions

We have presented some evidence that a number of factors can be identified which may account for at least some of the individual differences in pattern and rate of ability decline in old age. While acknowledging the obvious role of genetic and physiological factors, we have here emphasized those variables more directly amenable to psychological intervention, namely cognitive styles and other life style variables. The inter-relationship of these factors is quite complex, however, and seems to express itself somewhat differently at different stages of adult development.

As best as we can tell, it appears that during early middle age, *Attitudinal Flexibility* may have salient importance in maintaining high activity on the fluid abilities, as well as in assuring a high level of *Motor-Cognitive Flexibility*. The latter variables, as well as the maintenance of an *engaged* life style, and the absence of *family dissolution* seem to be critical in turn in maintaining high levels of ability performance from middle into old age.

What seems to be happening is that the rigid person will establish life styles which through disuse lead to the early decline of fluid abilities such as Spatial Orientation and Inductive Reasoning. Physiological and societally mandated envrionmental changes, however, require high levels of novel problem solving for most persons in late midlife and early old age, and the effective utilization of all abilities may therefore be impacted by early rigidification and loss of fluid problem-solving abilities. Indeed, it has been shown that the effective use of even overlearned skills may require a high level of fluid ability in old age (Willis and Schaie 1983).

It is apparent then, that those who would wish to maintain a high level of intellectual functioning in old age must mind not only the efficiency of their physiological apparatus, but need take care to maintain flexible behaviors and attitudes, to remain involved in a broad spectrum of intellectually stimulating activities, and in particular to "practice" their problem-solving abilities. Fortunately recent work has shown that some of the observed cognitive losses can be reversed through behavioral intervention (e.g. Blieszner et al. 1981; Willis et al. 1981). Hopefully, such interventions, when invoked over a spectrum of abilities, might effect as well cognitive styles such as the *Motor-Cognitive Flexibility* variable, shown here to be so important in the prediction of performance levels forward into advanced old age.

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