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The Relationship Between Prior Functioning on Cognitive and Personality Dimensions and Subject Attrition in Longitudinal Research

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This study compared the intellectual and personality functioning of continuing participants in a longitudinal study with individuals who were lost from the panel after at least 7 years of involvement. Based on their reason for discontinuation, participants who were lost to the panel were categorized into three attrition groups: deceased, ill, and voluntary dropouts. When the performance of these groups prior to leaving the study was compared with that of the continuing participants, no general differences were found. However, specific differences were revealed, particularly on crystallized-type intellectual abilities and the personality factors. Participants who were lost due to illness or death had functioned at the lowest levels of the four groups prior to attrition. These effects varied by age. In late middle age, ill participants functioned at the lowest levels, whereas in old age, participants who subsequently died scored lowest of the four groups prior to attrition. Individuals who had voluntarily discontinued participation in the study most closely resembled the continuing participants, particularly in late middle age. The results indicate that performance effects associated with continued participation vary by age, the intelligence or personality factor being considered, and the reason for loss of the participant. Furthermore, they suggest that loss of participants from a longitudinal panel does not inevitably bias the validity of developmental findings.

DEVELOPMENTAL researchers (Baltes, 1968; Schaie, 1965) have alerted us to the problems inherent in studying change over time in panels that become increasingly selected. As longitudinal studies continue over time, internal and external validity issues take on greater consequences (Campbell & Stanley, 1963). External validity is called into question when participants are lost in a nonrandom manner over the course of a longitudinal study; thus, the final sample entering an analysis might be an unrepresentative subset of the original population and be biased, perhaps favorably, on several factors. When participant loss is related to age, the data also are at risk with regard to internal validity, as observed age gradients might reflect differential attrition rather than developmental change patterns (Schaie et al., 1973).

Differences between continuing participants and nonparticipants have been reported in several major longitudinal studies (Baltes et al., 1971; Jarvick & Falek, 1963; Lieberman, 1965; Obrist et al., 1962; Riegel et al., 1967, 1968; Rusin & Siegler, 1985; Savage et al., 1973; Schaie et al., 1973; Siegler & Botwinick, 1979; Streib, 1966). Such effects indicate that continuing participants exhibit considerably higher levels of functioning on several dimensions (e.g., intelligence, personality adjustment, physiological responses) as compared to individuals who discontinue participation over the course of longitudinal studies. Yet, the extent to which attrition favorably biases longitudinal data depends, in part, on the range of factors considered in the research. With regard to intelligence, for example, attrition seems to have the most pronounced effects on what Horn (1978) referred to as crystallized abilities, such as verbal functioning (Baltes, et al., 1971; Riegel et al., 1967; Schaie et al., 1973). Hence, if the research being examined is oriented primarily toward crystallized abilities, the proportion of significant participation effects is likely to be greater than if a wider range of abilities were considered.

In addition to participation effects varying across abilities, some investigators suggest that they differ by age as well, with particularly pronounced effects of continued participation on performance in older age groups (Riegel et al., 1967; Schaie et al., 1973). Therefore, proper interpretation of longitudinal findings requires examination of participation effects, particularly in samples involving elderly individuals.

Furthermore, some investigators (Baltes et al., 1971; Siegler, 1975) have suggested that *types* of study dropouts might vary in the extent to which they produce participation effects. Two general types of antecedents to experimental mortality and selection problems have been identified: biasing factors related to psychological or sociological reasons for nonparticipation and factors due to biological reasons. In spite of this distinction between reasons for nonparticipation, attrition studies seldom consider differential participation effects based on the reason for dropout.

Riegel and associates (1967) conducted one of the few studies to consider the reason for attrition as a factor in examining participation effects. Although they classified dropouts into three groups, ill, deceased, and refusals, these investigators failed to contrast fully sociological-psychological and biological causes of attrition. Rather, they compared only the prior functioning of each group with that of the continued participants, and then contrasted the ill and deceased groups. Therefore, it is unclear how the refusal group (those who dropped out for sociological-psychological rea-

sons) compared with the ill or deceased groups (those who dropped out for biological reasons) prior to attrition. Furthermore, their study was restricted to a narrow range of cognitive abilities, primarily verbal measures, one general intelligence measure, and a performance component. As a result, it is unclear how various types of dropouts compared at prior stages on a wide range of cognitive dimensions.

Previous studies also have failed to consider how cognitive and personality functioning *changes* over the years preceding attrition for different types of dropouts, as most attrition research has been restricted to one point of measurement prior to attrition. Multiple points of measurement prior to the attrition point are required in order to address this issue.

The present study was conducted to clarify earlier research findings by integrating specific aspects of participation effects (i.e., comparing different ages, target abilities, and reasons for nonparticipation) into one study. Each of the four questions posed in the study addressed one of the issues discussed above:

(1) Are there differences in levels of functioning prior to attrition for individuals who drop out of longitudinal studies because of illness, death, or voluntary refusal?

(2) Are participation effects consistent across a range of cognitive and personality dimensions?

(3) Does the relationship between prior functioning and reasons for nonparticipation hold across age groups?

(4) Are there different patterns of performance change prior to attrition for individuals who drop out of longitudinal studies for different reasons?

Answers to these questions would assist developmental researchers in assessing the validity of their findings on several dimensions and in understanding the limitations of their samples. Furthermore, they would provide insight into the onset of conditions that produce different types of participant loss within various age groups.

METHODS

Participants. — All of the individuals included in this study were participants in the Seattle Longitudinal Study (SLS), a 28-year study of intellectual functioning in adulthood. The original SLS sample was drawn in 1956 from the population of more than 18,000 membership records of the Group Health Cooperative of Puget Sound. Participants were retested at 7-year intervals through 1984. At each testing point new participants were sampled from the population and added to the study in order to supplement sample size lost to attrition and to add younger cohorts. Mean birth years of the nine cohorts represented in the SLS up to the 1977 testing point ranged from 1889 to 1952. (See Schaie, 1983, for detailed information on the sampling procedures.)

A subset of 520 individuals was chosen for inclusion in this study because they met three sampling criteria: First, they had base-year data from either 1956, 1963, or 1970. Second, they had participated in the two testing points (1970 and 1977) immediately preceding the 1984 follow-up, which was identified as the attrition point in this research. Third, they were part of the six oldest 7-year cohorts in the SLS, with their ages in 1970 ranging from 43 to 84 years old. These criteria provided the largest subset available from these data for longitudinally examining the change in functioning over a 7-year period prior to the testing interval when middle-aged and older participants were lost to the panel.

In order to study participation effects, this subset of 520 individuals was divided into four groups based on their participation status. Relevant information on their reasons for nonparticipation was obtained from either the response cards returned by the participants during the 1984 recruitment period or their physicians' records. Between 1977 and 1984, 141 of the 520 participants were lost to the SLS panel. The remaining 379 individuals comprise our continuing participants group. Of the 141 persons who were lost to the SLS between 1977 and 1984, 39 individuals (28%) voluntarily eliminated themselves for psychosocial reasons, such as traveling and time constraints. These nonparticipants are referred to as voluntary dropouts. Thirty-five individuals (25%), referred to as ill dropouts, left the study because they were reportedly too ill to continue participating. The remaining 67 individuals (48%) died between the years of 1977 and 1984 and, thus, make up the deceased group.

These four groups were subdivided further based on age. Two age-cohort groups were formed by combining cohorts 1, 2, and 3 (ages 64 to 84 in 1970) for the old group and cohorts 4, 5, and 6 (ages 43 to 63 in 1970) for the late middle-age group. This grouping closely resembles pre- and post-retirement ages that have served as meaningful markers in behavioral and cognitive studies in the past (Riegel et al., 1967). As a result of the two grouping procedures, eight drop status-cohort groups were formed: old voluntary dropouts (n = 15), late middle-age voluntary dropouts (n = 24), old ill dropouts (n = 25), late middle-age ill dropouts (n = 10), old deceased dropouts (n = 43), late middle-age deceased dropouts (n = 24), old continuing participants (n = 68), and late middle-age continuing participants (n = 311).

Measurement variables. — The present study used data for eight dependent variables that served as the principal variables in the larger test battery of the SLS. Five of these variables are tests of the Primary Mental Abilities Battery (PMA) (Thurstone & Thurstone, 1949): verbal meaning, spatial orientation, inductive reasoning, number, and word fluency. The remaining three variables, motor cognitive rigidity (MCR), personality-perceptual rigidity (PPR), and psychomotor speed (PPS) are factor scales from the Test of Behavioral Rigidity (TBR) (Schaie & Parham, 1975). All eight measures were included in the analyses in order to advance previous research by considering the ability-specific nature of participation effects. Although cognitive abilities are, of course, positively related because of a general ability factor, the intercorrelations among these intelligence variables account for less than one third of the common variance (Schaie, 1985). Thus, the relationship between these dependent variables should not create problems for the analyses or interpretation of the findings.

Design and analyses. — In order to address the questions raised above, a 4 × 2 × 2 (Drop Status × Cohort × Occasion) analysis of variance (ANOVA) design was examined. All 520 participants were assigned to a drop status (voluntary dropout, ill dropout, deceased dropout, or continuing participant), and cohort group (old group or late middle-aged group) as described above. The within-group factor, Occasion, refers to the two times of measurement (1970 and 1977) prior to the 1984 attrition point.

RESULTS

The results presented below consist of two parts: (a) comparison of background characteristics for individuals in each of the four drop status groups and (b) comparison of prior performance levels based on drop status and cohort factors using mean group scores in the ANOVA procedure. The first analyses were conducted to uncover any drop status group differences, other than the Attrition factor, that could account for observed group differences in cognitive and personality functioning. The second set of analyses was conducted to address the four central questions posed in this study.

Comparison of demographic characteristics for the drop status groups. — A chi-square test was computed to determine the relationship between age and type of attrition. The test revealed a strong association between the two variables ($\chi^2 = 95$, $df = 3$, $p < .0000$). Ill and deceased individuals were disproportionately represented in the old cohort group, and continuing participants were disproportionately represented in the late middle-age group. Earlier researchers found similar associations between age and reasons for nonparticipation (Riegel et al., 1967).

Within each Cohort group the four drop status groups were compared with regard to occupation, income, and education levels in order to detect any background differences between the drop status groups. In general, within each cohort group, the four drop status types had fairly homogeneous backgrounds. On the average, individuals in our sample had incomes of between $4,000 and $10,000, had education levels in the high school to college range, and had last worked in occupations at the skilled to semiprofessional level.

Only a few significant background differences emerged between drop status groups. With regard to occupation, the last occupation held by the old deceased group was of lower status than that of the old continuing participants group ($p < .02$). Regarding income, the old ill group had a mean income slightly lower than that of the old continuing participants group ($p < .05$). And, in relation to education, the late middle-age ill group was less educated than the late middle-age deceased group ($p < .04$) and the late middle-age continuing participants group ($p < .04$).

These few differences suggest that socioeconomic status (SES) might be positively related to continued participation, as other studies have indicated (Streib, 1966). However, lower SES characteristics do not single out any one of the eight cohort – drop status groups as particularly disadvantaged. Hence, these few SES differences probably had very little influence on the differences in performance between types of dropouts of primary interest in this study.

Levels of performance. — The three-way ANOVA described above provides answers to our four research questions: Are there differences in prior performance for individuals dropping out of the study for different reasons? Are these performance differences the same across abilities? Are these differences the same across age groups? Do patterns of performance change prior to attrition depend on the reason for nonparticipation?

As expected, the analysis revealed significant main effects of cohort and occasion. The cohort effect was in the expected direction, with higher levels of functioning for the late middle-age group than for the old group. Performance scores also were higher at Occasion 1 (1970) than Occasion 2 (1977), representing the expected aging effects. Because such cohort and age effects are well-documented elsewhere (Savage et al., 1973; Schaie, 1983), and are not directly relevant to the questions raised in this research, neither they nor their interaction (Cohort × Occasion) will be discussed here.

Drop status effects. — In spite of the high power of this ANOVA test (Cohen, 1977), the Drop Status factor produced significant main effects on only three of the eight dependent variables: verbal meaning, $F(3,512) = 4.25$, $p < .01$, $\beta = .90$; inductive reasoning $F(3,512) = 4.61$, $p < .01$, $\beta = .90$; and PPS, $F(3,512) = 4.54$, $p < .01$, $\beta = .90$. Although participation effects were limited to only three abilities, their magnitude was large ($p < .01$), and they produced consistent group differences across the three tests: The ill group performed at the lowest level prior to attrition on all three tests, whereas the continuing participants group consistently revealed the highest level of functioning. Additional differences based on drop status were found between the voluntary dropouts and the continuing participants on the PPS and inductive reasoning measures, with the voluntary dropouts scoring significantly ($p < .04$) lower than the continuing participants prior to attrition.

As noted earlier, drop status tended to be differentially associated with age, with greater proportions of ill and deceased dropouts belonging to the older cohorts. (The mean cohort level for the ill group was 2.8, and for the continuing participants group it was 4.6 [$p < .001$]. Older cohorts were indicated by lower numbers.) Hence, participation effects might merely reflect age differences. It is important, therefore, to examine the Drop Status × Cohort group interactions in which the effects of drop status are considered while controlling for age.

Age effects on drop status. — Significant Drop Status × Cohort group interactions were found on four of the eight measures: verbal meaning, $F(3,512) = 3.35$, $p < .05$, $\beta = .97$; word fluency, $F(3,512) = 2.66$, $p < .05$, $\beta = .97$; PPR, $F(3,512) = 3.61$, $p < .01$, $\beta = .90$; and PPS, $F(3,512) = 3.49$, $p < .01$, $\beta = .90$, indicating that the effects of drop status varied by cohort group. (Means and standard deviations for the eight Drop Status × Cohort groups on the eight abilities are presented in Table 1.)

Table 1. Means and Standard Deviations for the Drop Status × Cohort Groups: Raw Scores

Groups	Ability variables							
	Verbal meaning	Spatial orientation	Inductive reasoning	Number	Word fluency	MCR	PPR	PPS
Voluntary dropout								
Old (n = 15)	27.40	11.46	7.57	18.27	35.47	44.73	46.00	42.07
	(7.66)	(6.47)	(4.54)	(7.75)	(9.98)	(6.36)	(7.44)	(6.73)
Late middle age (n = 24)	37.21	20.08	14.64	26.83	42.04	49.83	53.38	49.30
	(9.16)	(8.29)	(5.35)	(13.73)	(9.12)	(5.23)	(8.61)	(8.36)
Ill								
Old (n = 25)	25.04	12.94	7.75	19.75	35.40	47.40	47.13	42.54
	(7.50)	(4.49)	(3.87)	(9.35)	(9.06)	(4.74)	(8.84)	(5.45)
Late middle age (n = 10)	33.20	20.11	11.10	27.30	36.80	50.10	46.30	45.10
	(8.03)	(5.71)	(4.43)	(13.89)	(10.98)	(4.95)	(4.99)	(5.97)
Deceased								
Old (n = 43)	24.12	13.14	7.83	20.15	32.31	45.37	43.81	40.67
	(9.27)	(6.88)	(4.78)	(11.38)	(12.50)	(7.04)	(7.03)	(6.71)
Late middle age (n = 24)	41.54	23.46	16.13	29.83	46.17	52.75	52.46	52.29
	(9.26)	(7.48)	(5.29)	(10.45)	(10.88)	(5.09)	(6.99)	(7.06)
Continuing participants								
Old (n = 68)	29.68	13.64	9.96	21.90	37.69	46.87	47.82	45.25
	(9.93)	(6.93)	(5.53)	(10.06)	(12.76)	(6.33)	(7.10)	(7.08)
Late middle age (n = 311)	39.74	21.93	15.94	27.27	43.70	52.23	51.93	51.08
	(8.53)	(8.26)	(5.65)	(9.99)	(10.71)	(4.76)	(7.18)	(7.33)

Note. Standard deviations are in parentheses.
MCR = Motor cognitive rigidity.
PPR = Personality-perceptual rigidity.
PPS = Psychomotor speed.

The interaction effect of Drop Status × Cohort was more apparent on the two personality dimensions than on the two cognitive factors. Yet, similar patterns of relative performance for the four groups were evident across all four significant measures, for each cohort. In the late middle-age cohort, the ill group was functioning at a much lower level than the other three groups, including the deceased group, prior to attrition. However, for the old cohort, the deceased group was performing at the lowest level of the dropouts prior to attrition.

Comparisons of drop status group means in the two cohorts also revealed significantly greater differences ($p <$ .02) between the ill and the deceased groups in the late middle-age cohort than in the old cohort. Differences between the deceased group and the continuing participants group, however, were greater ($p <$ .02) in the old cohort than in the late middle-aged cohort.

The extent of interindividual differences in all of the drop status – cohort groups is apparent from the standard deviations provided in Table 1. There is almost no consistency, however, in Drop Status × Cohort group variability. The groups with small ns, such as the late middle-age ill group, have the largest variance on some measures, for example on number, but relatively large variance is also seen in the groups with large ns on other measures, such as the late middle-age continuing participants on space or reasoning.

Patterns of group change prior to attrition. — Examination of the Drop Status × Occasion interactions is a way of assessing changes in performance for the different drop status groups prior to attrition. Significant Drop Status × Occasion interactions were found on four of the eight abilities: verbal meaning, $F(3,512) = 6.77$, $p < .01$, $\beta = .90$; word fluency, $F(3,512) = 3.29$, $p < .01$, $\beta = .90$; number, $F(3,512) = 4.69$, $p < .01$, $\beta = .90$; and spatial orientation, $F(3,512) = 2.56$, $p < .05$, $\beta = .97$. With regard to the word fluency and spatial orientation tests, what is important to point out is that although all four drop status groups experienced decline over the 7-year period preceding attrition, the extent of decline varied depending on the reason for attrition. Compared to the continuing participants, the ill group revealed the most pronounced and significant performance deficits between 1970 and 1977. On the verbal meaning test all three groups of dropouts showed significantly greater ($p < .01$) decline between 1970 and 1977 than the continuing participants, and on the number test only the ill and deceased groups declined significantly more ($p < .02$) than the continuing participants.

The three-way interaction of Drop Status × Cohort × Occasion assesses different patterns of change prior to attrition for the different groups of dropouts, with controls for age. On two measures (both personality measures), personality-perceptual rigidity (PPR), $F(3,512) = 3.01$, $p < .05$, $\beta = .93$, and motor cognitive rigidity (MCR), $F(3,512) = 4.12$, $p < .01$, $\beta = .81$, significant three-way interactions were found. On the MCR measure, the most marked change in motor cognitive rigidity between 1970 and 1977 occurred for the voluntary dropout group in late middle age. Not only

did this group show the most significant change from 1970 to 1977, but the change was also in the opposite direction than that experienced by the other groups: between the two testing periods, the late middle-age voluntary dropouts actually became more flexible. On the PPR measure, the three-way interaction was evidenced by the significantly greater change in group level functioning between 1970 and 1977 for the old continuing participants than for the other groups. The participants in this drop status – cohort group became markedly more rigid than individuals in the other groups between 1970 and 1977.

Discussion

The results of this study provide evidence that subject attrition produces an increasingly positive bias in data obtained over the course of longitudinal studies. However, these findings were not widespread (only 13 of the 32 [41%] ANOVAs involving the Drop Status factor were significant), and must be qualified by considering the reason for nonparticipation, the age of the nonparticipant, and the specific ability or personality dimension being considered.

In general, individuals who left the SLS for biological reasons (the ill and deceased groups) produced the greatest participation effects. These two groups of dropouts were functioning at lower levels prior to attrition than were individuals who left the study for sociological reasons (voluntary dropouts) and the continuing participants. Biological antecedents to attrition also were linked with greater deterioration over the 7-year period prior to attrition than were sociological antecedents. The former type of dropouts tended to be significantly older than the latter type. Yet, when age was controlled for, performance differences remained.

As expected based on previous research, drop status effects were stronger in old age than late middle age for voluntary dropouts and dropouts who died. This seems reasonable, as the SLS uses a highly active, community-dwelling sample; much of the voluntary nonparticipation experienced prior to old age is likely to result from participants being too busy to participate because of time commitments to intellectual pursuits and social activities that help to maintain, and enhance, their cognitive functioning (Gribbin et al., 1980). In fact, the late middle-age voluntary dropouts in the sample actually increased in flexibility on the MCR measure in the 7-year period preceding attrition, which might reflect some involvement in cognitively enhancing experiences. Participant loss in middle adulthood, therefore, should not favorably bias the remaining sample. In contrast, in old age, it is possible that individuals who claim time constraints and disinterest are merely refusing to participate because they have recognized performance decrements and feel anxious about having them exposed. Their attrition should produce greater participation effects.

We can only speculate as to why death creates greater participation effects in old age than in late middle age. It is possible that death in old age is likely the result of long-term conditions that create a great deal of deterioration prior to death, thereby significantly affecting functioning over time. In contrast, death in late middle age is usually more often the result of accidents and acute conditions that strike rather suddenly and, thus, produce limited decline prior to occurrence. Unfortunately, our data did not permit us to test these explanations for our findings; however, such hypotheses should be pursued in future research.

Unlike death and voluntary nonparticipation, the impact of illness on participation effects was greater in late middle age than in old age. This finding is inconsistent with an earlier report by Riegel et al. (1967). (Others, such as Baltes et al., 1971, and Schaie et al., 1973, also reported stronger participation effects with age, but they did not consider the reasons for attrition.) However, because this age pattern with regard to the ill group was consistent across all four of the significant tests, it is unlikely that it can be attributed to random error. Again, although we can only speculate because of the absence of health measures in these data, it is possible that several of the late middle-age ill dropouts were suffering from chronic conditions, such as heart disease or hypertension, the effects of which could have originated early and already begun to impair functioning in late middle age. Indeed, strong negative effects of chronic illness on cognitive performance have been documented (Hertzog et al., 1978; Wang & Busse, 1974; Wilkie & Eisdorfer, 1974a, 1974b).

Fairly consistent with previous research (Riegel et al., 1967, 1968; Siegler & Botwinick, 1979) was the finding that participation effects were more evident on crystallized (e.g., verbal meaning and word fluency) rather than fluid cognitive abilities, and on the personality dimensions. It is not clear why crystallized abilities are prone to survivorship effects when normative patterns of age change indicate that such abilities typically are maintained longer than fluid abilities (Horn, 1978). Perhaps because fluid abilities deteriorate for almost everyone across old age, additional effects related to attrition factors, such as illness or impending death, are obscured. On the other hand, because crystallized abilities are least affected by *normal* aging, it might be possible to see stronger deteriorative effects due to biological antecedents of attrition, which were in fact the strongest producers of participation effects in this study.

Regarding the personality dimensions, the fact that the ill and the deceased groups tended to be more rigid than the other groups prior to attrition seems reasonable and consistent with previous research (Riegel et al., 1967). It seems likely that attitudinal rigidity (PPR) contributes to the illness and deterioration that often result in nonparticipation; individuals who are inflexible might be relatively unwilling to alter their life styles and behavior in order to avoid certain biological conditions. Although such individuals did not show an increase in rigidity over the period preceding attrition, the ill group was initially more rigid than the other groups in 1970. On the dimension of PPS, the rigidity of the ill and deceased groups also seems understandable, as it is possible that their physical conditions affected the physiological component of speeded tests.

This study reveals that attrition effects are not pervasive and general. Rather, participation effects are highly complex, and require consideration of not only the specific variables being examined but also the age of the dropouts and the reasons for their attrition. When participant loss involves younger individuals who leave a study voluntarily,

primarily because of psychosocial reasons such as travel and time constraints, the resulting data should not be severely affected. Therefore, in studies of active community-dwelling adults, such as the SLS, where this type of dropout is fairly common, subject attrition does not inevitably bias the longitudinal sample, thereby creating validity problems in the developmental findings.

With regard to future research on attrition, this study points to the great need to include more extensive biological/health data in future analyses. The results presented here show clear age or Cohort × Drop Status effects, primarily involving ill and deceased dropouts, which cannot be explained adequately by the available data. A more complete understanding of the conditions that lead to experimental mortality and biasing problems might depend on more in-depth consideration of such biological/health data.

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