Intraindividual Change in Intellectual Abilities: Normative Considerations

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Introduction

The focus of this symposium is upon the consideration as to how effective cognitive intervention efforts have been in remediating cognitive deficit presumed to have previously occurred in the individuals being trained, none of the studies thus far reported in the literature have had available to them pre-experimental data of a longitudinal nature which would confirm the presence and extent of pre-experimental deficit (Willis & Schaie, in press). Nevertheless, it may be possible to address the issue as to how much deficit could have been remediated by examining existing longitudinal data bases. Such an examination may be useful also for other relevant reasons: First, we would like to know the proportion of individuals at different ages who show reliable and well-documented age decrement in specific abilities. Second, we would want to know the extent of the average age decrement at given ages, as a criterion against which we could measure the significance of the magnitude of our remediation efforts. And third, we need to know the range of decrements occuring across individuals, in order to be able to predict, given the results of an intervention study, as to what might be the proportion of the target group showing decrements that could be remediated.

If we wish to answer these questions, it should be clear from the outset, that the focus of our inquiry must be directed to the study of intra-individual differences on the basis of longitudinal data. However, to permit generalization to other populations, such as those in the studies to be discussed in this symposium, intra-individual change must be scaled in terms of individual differences in such intra-individual change.

To accomplish the stated objectives, I will report certain results from the Seattle Longitudinal Study (for greater details see Schaie, 1979), which will speak to each of the above questions. Some of the requisite data have been reported previously, albeit not in a form directly applicable to the issues at hand. Other data have been reexamined for this symposium to obtain the required parameter estimates. I will begin by considering average cumulative decrements on some of the Primary Mental Abilities at several advanced ages. I will next report on the proportion of members of our sample whose individual change could be described as indicating reliable age decrement. And finally, I will report data on the variability and range of decrement observed.

Method

Subjects. The data base in this study comes from the longitudinal-sequential studies of age changes in cognitive behavior conducted with random samples from the membership of the Group Health Cooperative of Puget Sound (Seattle). These samples were drawn across the adult age range from age 22 on, in 1956, 1963, 1979 and 1977. The present analysis considers only those individuals on whom longitudinal data were available for at least seven years prior to attaining the ages of 60, 67, 74 and 81, respectively. These include a total of 345 men and 430 women. They are all community-dwelling persons, receiving regular health care, and at the time of assessment free of acute illness. Data are also reported on 123 participants who were followed over 21 years from 1956 to 1977. As previously reported, the longitudinal subjects obviously represent a somewhat favorably attrited selection of the original random samples. Attrition rate has averaged approximately 40% over the seven-year intervals between data collections.

Variables. Although information on other variables has been collected, we shall here attend only to five measures obtained from Thurstone's (1938)

work on defining the primary mental abilities. The specific version of the test used is the SRA Primary Mental Abilities Test in its 1948 11-17 version. Abilities to be discussed include Verbal Meaning, a measure of recognition vocabulary; Spatial Orientation involving the rotation of gemetric figures in two-dimensional spaces; Inductive Reasoning as measured by letter series problems; Number measured by addition problems; and Word Fluency, a measure of recall vocabulary. To permit comparison across variables and different subject groups, all raw scores were scaled to T-score form with a mean of 50 and a standard deviation of 10, based upon the total aggregation of 2810 subjects at first test.

Results

Average Intra-individual Change. Our first step for this analysis was to calculate the average change within individuals over the seven-year age range monitored. As previously reported, such changes do not attain statistical significance until the sixtieth year is reached. Nevertheless, there are small negative changes which do occur earlier. The conservative approach, therefore, was to consider cumulative age changes from that age level up to which equally small but positive changes have been noted. For our samples, the peak ages are 53 for Verbal Meaning and 46 for the other abilities. In Table 1, I have provided a summary of the cumulative change occurring by ages 60, 67, 74 and 81, separately by sex and for the total sample. Inspection of this table clearly shows that decrement up to age 60 is negligible. However, by age 67 there is decrement in the range from two tenth to one half of the population standard deviation, a small but for some variables statistically significant effect. By age 74, we see decrements ranging from one third to three fourth of a standard deviation, and by age 81 average decrements are between one half to slightly over one full standard deviation. Notice

further, that these decrements are far from uniform across abilities or the sexes. On average, men seem to decline most on Number and Spatial Orientation, but least on Inductive Reasoning and Word Fluency. Women, on the other hand decline most on Word Fluency, but least on Spatial Orientation.

In order to be able to present the above reasonably stable results, it was deemed necessary to average across participants belonging to three different cohorts and cumulate the resultant estimates. It might consequently be interesting to take a look at a single series of cohorts, those whom we have followed for a total of 21 years. Table 2 presents average changes for these small data sets; the youngest group was followed from 25 to 46 years and the oldest from 60 to 81. This, of course, is quite a select group, and the decrements noted are somewhat smaller, albeit consistent in pattern with the larger data base presented earlier.

Proportion of Individuals who Change. In addition to knowing what may be the average amount of decrement to be remediated by training, it would also be of interest to consider the proportion of individuals in community-based samples who had shown reliably measured decrement in specific abilities. I have examined this issue by determining the frequency distribution of individuals whose observed scores across a seven-year interval fall outside the confidence band at 1 Standard Error of Measurement about the observed score at first test. That is we want to be sure that we denote as decrement or increment only those scores, where we could not reasonably argue, that the score observed at the second test, does not simply represent a random deviation (in an advantaged sample, probably regressing towards the mean of the total population) from the true score at first test. The 1 SEM criterion is quite liberal in that it would allow for approximately a .16 error rate. In this instance, however, it seems appropriate to err in the more liberal direction, since we wish to

be sure that we do not underestimate the proportion of persons who might require remediative services.

Table 3, provides 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. Similar data are not provided for age 60, because of the trivially small number of individuals with reliably detectable performance decrement.

Although substantial numbers of study participants showed stability or increment over the seven-year periods studied, there is a substantial minority which experienced reliable performance decrement. For the three age intervals shown in Table 3, proportions of individuals showing decrement range from 29 to 44% for Verbal meaning, from 26 to 40% for Spatial Orientation, from 25 to 43% for Inductive Reasoning from 29 to 39% for numerical skills, and from 21 to 35% for Word Fluency. Sex differences in proportion of individuals showing reliable decrement should also be noted with more women declining on Reasoning and Word Fluency.

Variability of Observed Decrement. Since the focus of this symposium is upon the modification of individual behavior and the assessment of intra-individual change, it seems appropriate to consider variability of such change across individuals. We shall report relevant data using two different approaches. First, we will provide information about the 95% confidence interval which includes changes to the target ages used in Table 1. We do this in standard deviation units to permit generalization to other studies, and also as a guide to what the range of unremediated decrement might be in a sample used for an intervention or training paradigm. Table 4 provides the relevant data. Note that by age 60, intra-individual change from peak age is virtually normally distributed, with some mild decremental skewing appearing only for Word Fluency.

With advancing age, distributions become increasingly skewed in the decremental direction, and by age 81 it is obvious that most individuals have declined.

Confidence intervals such as those presented here of necessity make normality assumptions, which may not always be warranted. As an alternative we are therefore also providing Table 4 which gives proportions of persons showing a given magnitude of change in intervals of .20 standard deviation units. This table may be quite useful in intervention research, as it permits determination of the extent of gain that is needed in order to remedy age decrement for specified proportions of the population at specific ages.

Discussion

Substantial evidence has accumulated to show that various cognitive intervention strategies are quite successful in obtaining improvement in the elderly in their performance on specific ability measures as well as to maintain the level of improvement at least over short intervals (cf. Baltes & Willis, in press; Denney, 1980, Willis & Schaie, in press). It has often been explicitly argued or implicitly assumed that the techniques used in these studies are capable of remediating at least ability-specific age deficit. This assumption, of course, must rely upon indirect evidence, for none of the studies now in the literature have longitudinal pre-experimental information, that would permit an assessment whether the intervention strategies have resulted in actual remediation of existing deficit, or have simply improved the performance of individuals functioning at a pre-experimentally stable level.

In the absence of longitudinally-based training studies, however, it may be possible to utilize existing longitudinal data bases to provide normative data on the extent to which intra-individual decrement is likely to be observed in community-dwelling populations. Given such information, it is then possible for an investigator to specify the amount of gain (in population standard

deviation units) which would be required, in order to sustain the conclusion that an intervention paradigm had or had not remediated the average decrement likely to obtain in a sample of elderly target subjects at a given age. More importantly, it would be possible to appraise the effectiveness of specific remediation strategies against the kind of normative data presented here. Indeed, as this symposium progresses, I will be most interested to see whether the data to be presented can be assessed in the suggested framework.

The data I have presented permit some additional conclusions. First of all, it appears that there are too few individuals with substantial cognitive decrement to warrant remediative activities prior to the mid-sixties; this is not to say, however, that obsolescence reducing educational activities may not be needed for persons in midlife. Beyond the sixties, however, there appears to be a large number of persons with demonstrable performance deficit. Fortunately, the magnitude of the deficit seems to lie well within the range of training success previously reported. These data then provide support for concluding that cognitive intervention efforts with older adults seems certainly warranted. And finally, attention is called to the wide range of individual differences in older adults, so that differential success in intervention studies must be expected, for while remediation may be required for some persons, others, even in advanced age, probably function as well as they should, with or without our help!

Footnote

[1]Data reported in this paper were collected with the cooperation of the Group Health Cooperative of Puget Sound and supported by grant No. AG 00480 from the National Institute on Aging.

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Table 1. Decline from Peak Performance Level in Standard Deviation Units

MALES

Age	N	Verbal Meaning	Spatial Orientation	Inductive Reasoning	Number	Word Fluency
60	125	.06	.08	.04	.18	.16
67	98	.29	.32	.21	.48	.30
74	83	.55	.56	.45	.76	.58
81	39	.88	.98	.68	1.20	.72

FEMALES

Age	N	Verbal Meaning	Spatial Orientation	Inductive Reasoning	Number	Word Fluency
60	150	.00	.01	.05	.11	.16
67	133	.09	.13	.24	.32	.39
74	98	.44	.34	.54	.57	.61
81	49	.82	.54	.73	.97	1.10

TOTAL

Age	N	Verbal Meaning	Spatial Orientation	Inductive Reasoning	Number	Word Fluency
60	275	.03	.04	.03	.14	.16
67	231	.23	.21	.22	.39	.35
74	181	.54	.44	.49	.65	.60
81	88	.89	.69	.70	1.07	.94

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	+ .33	+ .31	+ .13	+ .10	- .13
32–53	19	+ .06	- .08	- .06	- .08	- .30
39–60	21	- .12	- .14	- .06	- .22	- .47*
46–67	31	- .12	- .38*	- .20	- .50*	- .61*
53–74	24	- .44*	- .31*	- .44*	- .44	- .73*
60–81	9	- .71*	- .20	- .50*	- .28	-1.00*

*Significant at or beyond the 1% level of confidence

Table 3. Proportion of Individuals whose Performance has Increased, Remained Stable or Declined over Seven Year Period (Decimals Omitted)

	Verbal Meaning			Spatial Orientation			Inductive Reasoning			Number			Word Fluency		
	Incr.	Stable	Decr.	Incr.	Stable	Decr.	Incr.	Stable	Decr.	Incr.	Stable	Decr.	Incr.	Stable	Decr.
Ages 60 to 67															
Males	12	53	35	5	65	30	7	69	24	8	56	36	13	62	25
Females	14	61	24	11	66	23	10	64	26	6	70	24	11	57	32
Totals	13	58	29	9	66	26	9	66	25	7	64	29	12	59	29
Ages 67 to 74															
Males	12	58	30	11	52	37	4	75	22	6	64	30	4	76	20
Females	8	52	40	9	57	34	11	52	37	7	64	29	6	71	22
Totals	10	55	35	10	55	35	8	62	30	7	64	29	5	74	21
Ages 74 to 81															
Males	5	54	41	8	41	51	13	41	46	5	53	43	11	68	21
Females	12	42	46	8	61	31	10	49	41	2	63	35	4	49	47
Totals	9	47	44	8	52	40	11	45	43	3	58	39	7	58	35

Table 4. 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	+ .99 to - 1.41	+ .90 to - 1.34	+ .98 to - 1.76	+ 1.01 to - 1.71
74	181	+ .78 to - 1.86	+ .79 to - 1.63	+ .65 to - 1.63	+ .83 to - 2.13	+ .98 to - 2.12
81	88	+ .66 to - 2.44	+ .68 to - 2.06	+ .62 to - 2.02	+ .49 to - 2.63	+ .81 to - 2.67

Table 5. Proportion of Individuals with Age Decrement of Specified Magnitude (Decimals Omitted)

Magnitude of Change	Verbal Meaning	Spatial Orientation	Inductive Reasonging	Number	Word Fluency
Ages 60 to 67 (N = 235)					
Zero or Increment	47	39	41	35	38
.01 to .33	20	21	27	26	23
.34 to .66	12	23	26	18	19
.67 to 1.00	7	8	6	10	10
Greater than 1.00 S.D.	13	9	5	10	11
Ages 67 to 74 (N = 181)					
Zero or Increment	34	40	31	36	31
.01 to .33	23	21	28	27	29
.34 to .66	20	18	25	17	21
.67 to 1.00	10	10	9	10	9
Greater than 1.00 S.D.	13	10	6	10	9
Ages 74 to 91 (N = 88)					
Zero or Increment	35	34	38	18	26
.01 to .33	19	17	19	33	24
.34 to .66	15	25	34	22	26
.67 to 1.00	16	16	7	14	11
Greater than 1.00 S.D.	16	8	2	14	14

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74	181	+ .78 to - 1.86	+ .79 to - 1.63	+ .65 to - 1.63	+ .83 to - 2.13	+ .98 to - 2.12
81	88	+ .66 to - 2.44	+ .68 to - 2.06	+ .62 to - 2.02	+ .49 to - 2.63	+ .81 to - 2.67