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Herausgeber

Psychologie der Lebensalter

STEINKOPFF DARMSTADT (1995)

Cohort-sequential longitudinal studies of personality and intelligence

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In designing what was to become the Bonn Longitudinal Study on Aging (BOLSA), Hans Thomae and his associates early on recognized the fact that human development was not a static phenomenon fixed immutably across time, but was highly sensitive to the need to imbed such studies into shifting societal context (31). He thus astutely chose the life experiences of two successive population cohorts exhibiting very different life experiences.

My own thinking on this issue was influenced by one of the early geropsychologists, Raymond Kuhlen (4, 5), who pointed out that, in addition to ontology generating change within individuals, there were also changes occurring in society within which context life course development needed to be understood. The issue of cohort or generational differences could no longer be ignored once I tried to compare results from my own cross-sectional and longitudinal studies of adult intellectual development. My original view of cohort (or generational) effects in behavioral studies of development was that they represented a methodological artefact that needed to be controlled in order to obtain "pure" estimates of ontologic change (8, 11, 17). As it turned out, cohort effects where particularly critical for the internal validity of cross-sectional studies, or for single-cohort longitudinal studies, and I published data that showed this to be the case in adulthood as well as in the reanalysis of some child development data (9, 10). Soon, however, I began to understand what my sociological colleagues had always known (1), that cohort effects had substantive meaning as well and that they deserved study in their own right (13). Hence, I began to study and report findings on cohort differences in my inquiries of intellectual aging, and in the collateral studies that involved cognitive styles and certain personality traits (12, 20, 23, 25, 29).

While cohort differences have generally been studied in the context of groups of people entering the environment at the same point (or range) of calendar time, it should be stressed that other non-calendar definitions of cohort can also be used. For example, the initial group of workers hired for a new factory would represent a cohort (regardless of the individuals' calendar age), as would the initial membership of a newly formed club, or the initial inhabitants of a new residential subdivision (13).

Characteristics of cohort-sequential designs

Because conventional cross-sectional studies confound age and cohort effects, and because findings from single cohort longitudinal studies are often only

applicable to the particular cohort on which they are collected (9), I introduced several alternative sequential strategies (8). The term "sequential" implies that the required sampling strategy includes acquisition of a sequence of samples taken across several measurement occasions. Perhaps the most widely used sequential strategy is the cross-sequential design, in which two or more cohorts are followed over the same time period. This approach permits the comparison of longitudinal and cross-sectional data (provided that the calendar time ranges are similar for age and cohort (2)). The advantage of this approach is that only two points in time are needed; hence the early appearance in the literature of studies using this design (6, 28, 30). For purposes of cohort comparisons, however, this approach represents a "model misspecification" (17) because it does not allow comparing each cohort over the same age range.

Developmental psychologists often find the cohort-sequential design of greatest interest because it explicitly differentiates intraindividual age changes within cohorts from interindividual differences between cohorts. This design also permits a check of the consistency of age functions over successive cohorts, thereby offering greater external validity than would be provided by a single-cohort longitudinal design. A cohort-sequential study consists of two or more cohorts being followed over two or more points in time. The minimum design involves three measurement points, allowing each of two cohorts to be followed over the same age range.

In a typical longitudinal study repeated measures are taken of the same subjects at successive times. Another possibility is to use the same research design but with independent samples at each point on the time scale. In the latter alternative one would draw a new (independent) sample from the same cohort initially tested. The independent sampling approach works well when a large sample is drawn from a large population, and when one is primarily interested in the estimation of population parameters. This approach controls for the internal validity threats of experimental mortality, regression, and reactivity (3, 11, 14). If small samples are used it is, of course, necessary to make sure that successive samples are matched on factors such as gender, income, and education to avoid possible differences due to selection biases (7).

Examples of cohort-sequential studies

Cohort-sequential designs were first introduced in analyses conducted for the third cycle of the Seattle Longitudinal Study (SLS; 21, 22). This study began in 1956 as a cross-sectional inquiry of the primary mental abilities over the age range from the 20s to the 70s. Longitudinal follow-ups have been conducted at five successive time points (seven years apart) in 1963, 1970, 1977, 1984, and 1991 (15–20). Table 1 shows the basic design of the study and indicates the number of subjects entering the longitudinal analyses. All subjects were community-dwelling members of a health maintenance organization and represent the upper 75% of the socioeconomic spectrum. Because of our interest in assessing the possible impact of cognitive styles such as rigidity-flexibility we also included measures of the latter construct. These measures, in turn, provided us with a limited amount of data on other personality traits.

In this chapter, I will illustrate the importance of sequential data sets by summarizing data on two mental abilities from our core battery measuring intellectual functioning and on two of the dimensions of rigidity-flexibility derived from the Test of Behavior Rigidity (24). In order to avoid dealing with the confounds implicit in repeated measures in longitudinal studies (e. g., experimental mortality, practice, regression effects), I have elected in this brief presentation to report only data using the independent random sampling approach (i. e., new samples drawn at successive measurement times from the same cohorts). Given our six data points it is possible to chart cohort-sequential data for three successive cohorts over a 21 year age range. With two sets of three cohorts each, this allows us to cover the age range from 25 to 74 years. More extensive analyses of the repeated measurement data can be found in Schaie (18), and more complete data on cohort differences have been reported by Willis (32) for unrelated individuals and by Schaie, Plomin, Willis, Gruber-Baldini, and Dutta (27) for generational differences within families.

Table 1. Basic design of the Seattle Longitudinal Study (SLS)

Study Waves					
1956	1963	1970	1977	1984	1991
S_1T_1 (N=500)	S_1T_2 (N=303)	S_1T_3 (N=162)	S_1T_4 (N=130)	S_1T_5 (N=92)	S_1T_6 (N=71)
	S_2T_2 (N=997)	S_2T_3 (N=420)	S_2T_4 (N=337)	S_2T_5 (N=204)	S_2T_6 (N=161)
		S_3T_3 (N=705)	S_3T_4 (N=340)	S_3T_5 (N=225)	S_3T_6 (N=175)
			S_4T_4 (N=612)	S_4T_5 (N=294)	S_4T_6 (N=201)
				S_5T_5 (N=628)	S_5T_6 (N=428)
					S_6T_6 (N=693)

S = Sample; T = Time of Measurement

Studies of Intellectual Functioning

Because of the differential developmental patterns I will examine a measure of a fluid ability (PMA Reasoning) and one crystallized ability (PMA Number). Brief descriptions of these measures are as follows:

PMA Reasoning: The study participant is shown a series of letters (e.g., a b x c d x e f x g h x). The letters in the row form a series based on one or more rules. The study participant is asked to discover the rule(s) and mark the letter that should come next in the series. In this case, the rule is that the normal alphabetical progression is interrupted with an x after every second letter. The solution would therefore be the letter i. There are 30 test items, with a time limit of 6 min.

PMA Number: The study participant checks whether additions of simple sums shown are correct or incorrect. The test contains 60 items, with a time limit of 6 min.

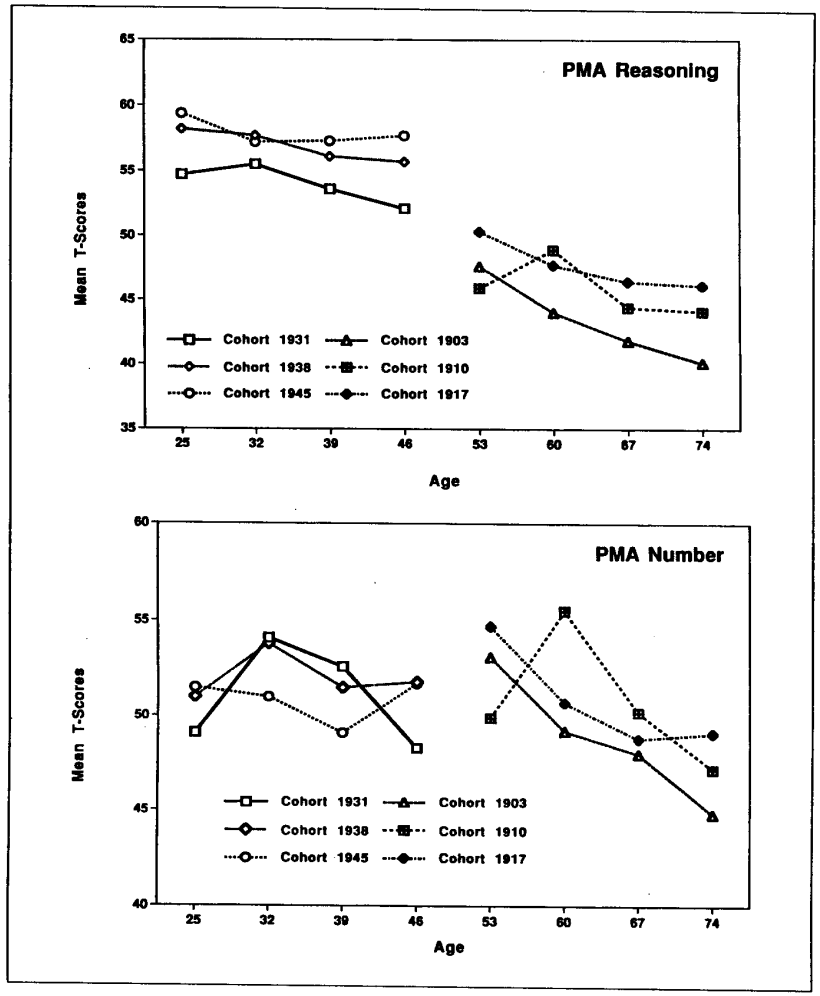

Fig. 1. Cohort-sequential data for the PMA Reasoning and Number tests.

Figure 1 shows the cohort sequential data for the two abilities. Continuous lines represent data drawn from the same birth cohort. Examining the top part of the figure for the PMA Reasoning test, one immediately notes that there is an overall increase in level for successive cohorts. While there is some decline in middle adult for the oldest cohort (*Cohort* 1931), there is virtually no change over this period for the most recently born cohort (*Cohort* 1945). Similarly, while

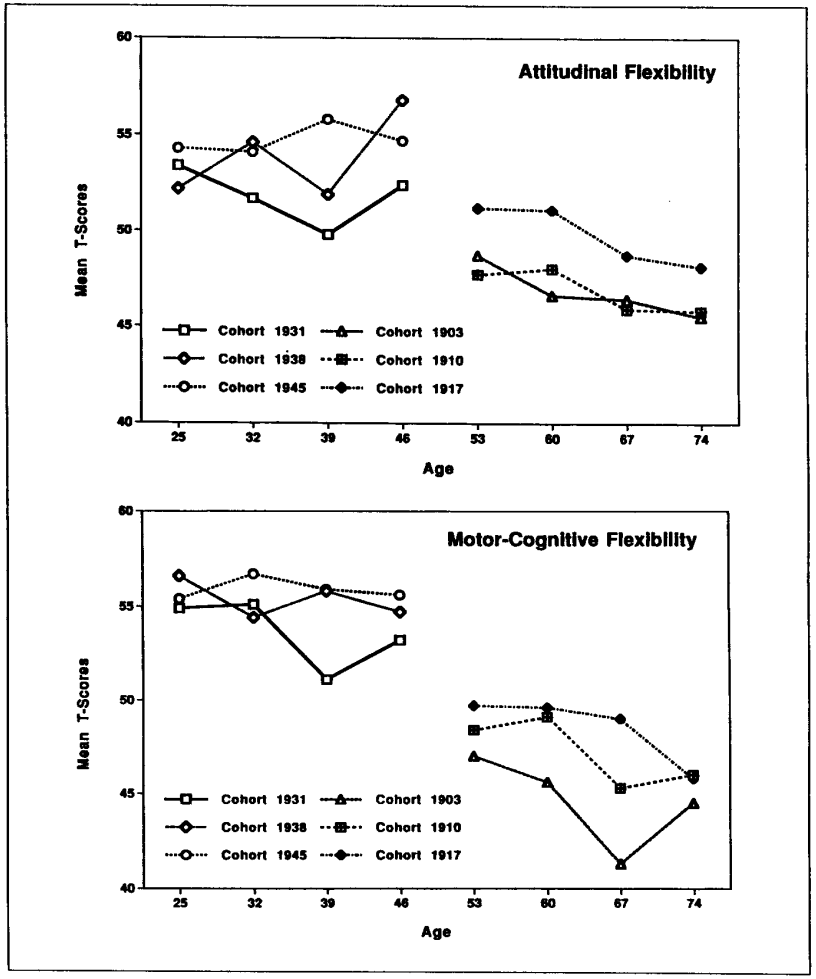

Fig. 2. Cohort-Sequential data for the Attitudinal Flexibility and Motor-Cognitive Flexibility measures from the Test of Behavioral Rigidity.

fairly steep decline from ages 53 to 74 is shown for the oldest cohort (*Cohort* 1903), this trend has moderated. In other words, the rate of average decremental age change has slowed significantly over three cohorts born 14 years apart.

Rather different findings are seen for the PMA Number test (bottom part of Fig. 1). Here the cohort differences in level are concave in nature. That is, there is an increase in performance level from the oldest cohort on, but this pattern is

reversed and the most recently born cohort actually performs at the lowest level! Rate of age changes also varies by cohort. For the most recent cohorts there is virtually no decline in midlife, even though such decline is evident for the older cohorts. By contrast to the Reasoning test, there is only very weak evidence of a reduction in the rate of change at advanced ages.

Studies of Personality Characteristics.

As examples from our sequential investigations of personality characteristics, I am using the factor scores for the dimensions of Attitudinal and Motor-Cognitive Flexibility. The former is derived from true and false inventories of rigidity and perseveration scales. The latter represents two perseveration measures. In the first, subjects copy a paragraph in writing which is then recopied reversing small and capital letters. In the second, subjects respond to two lists of simple words by giving first antonyms and then synonyms. In a third list, subjects must provide synonyms if the stimulus is printed in capital letters, but antonyms if the stimulus is printed in small letters. Ratio scores representing the amount of interference are then computed.

Figure 2 shows the cohort sequential data for independent samples for these two personality characteristics. Attitudinal Flexibility (see upper part of figure 2) also shows a systematic increase in level of flexibility across all cohorts. In midlife, the most recent cohort has a virtually flat agegradient, which contrasts with some decrement from young adulthood to middle age in the earlier born cohorts. In advanced age there is a slight decline in flexibility beginning at age 67 which appears constant across cohorts. A similar pattern can be observed as well for Motor-Cognitive Flexibility. However, rate of aging has slowed for the most recent cohort followed from middle to old age, with a significant decline on this dimension postponed until age 74.

Summary

In this chapter I have summarized the principles underlying the design of sequential studies and have illustrated data employing a cohort-sequential data analysis strategy to selected ability and personality variables from the Seattle Longitudinal Study. Because of space limitations, I could not deal with the confounds in longitudinal repeated measurement data on the same individuals and, therefore, confined my examples to the comparison of independent samples from several cohorts over the same age period. Nevertheless, these data point out that cohort-sequential analyses can inform us on generational differences in performance level as well as differences in rate of aging phenomena.

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