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Relation Between Aging and Research Productivity of Academic Psychologists

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Using a cross-sequential design involving four birth cohorts and five measurement periods, a curvilinear relation between aging and research productivity was found for more than 1,000 academic psychologists. Productivity typically began at a low rate in the 20s, increased to a peak around age 40, then decreased in the later years. Substantial individual differences were also observed. Those who began as high publishers remained more productive than the low or medium groups at each age level examined, and even at ages 55–64 they were more productive than the medium or low publishers were at their highest rate. Altogether, across cohorts and publishing levels, age accounted for 6.5% of the variance in publication rate from ages 25–34 to 55–64.

The relation between age and research productivity has generated lively discussion over the years. Some investigators have argued that research productivity begins to decrease very early (Lehman, 1953). Others believe that a curvilinear relation exists, with productivity rising slowly in the early decades, reaching a peak in the middle decades, and slowly decreasing in the later decades (Cole, 1979; Dennis, 1956b, 1966). Finally, still others have argued that age plays only a minor role in productivity (Over, 1982a, 1982b). According to this latter point of view, an individual's previous publishing rate is the more important determinant of his or her later rate. In the present research we investigated more thoroughly the relation between age and research productivity and examined individual differences with a larger sample, a wider time frame, and a more powerful design than has been used to date.

Lehman's (1953) monograph is an often-cited starting point for discussion. He studied retrospectively the achievements of deceased scholars from several disciplines, all of whom had become famous for their contributions. The age at which death occurred for these individuals ranged widely from the early 20s to the late 80s. Consulting historical lists and biographies, Lehman calculated the age at which the most significant contribution was produced by each scholar, summed across all individuals in each discipline, and reported the mean per year for each 5-year period as a proportion of all individuals in the discipline. Because the age intervals contained different numbers of subjects, he adjusted his figures by assigning a value of 100% to the age interval with the highest modal value and proportionate percentage values to the remaining averages.

The average age for the most significant achievement was found to be between 30 and 39 years. Individual differences in the relation between age and achievement were also noted, with some authors making their greatest achievement as late as age 60 and beyond. Total achievements per person per decade revealed that on this measure too, the peak age ranged from 30 to 39 years. Subsequently, studies of living scientists confirmed this finding (Lehman, 1960, 1962, 1963, 1965, 1966a, 1966b).

Several methodological criticisms of Lehman's studies have been offered. Dennis (1956a), for example, argued that because age at death was not controlled, a skewed distribution toward the younger age group may have resulted in an overrepresentation of significant achievements in the earlier years. To compound the problem, Dennis (1956a) argued, Lehman may have selected age intervals that inadvertently maximized the peak. Age intervals actually varied somewhat from discipline to discipline, depending on the age at which the highest value occurred (e.g., 30–35, 31–36, 32–37, 34–39).

Because of these potential confounds, Dennis (1956b, 1966) conducted his own retrospective investigations of the total scientific contributions of highly eminent scientists, philosophers, historians, and artists who had lived to be at least 70 years of age. With slight variations, Dennis (1956b, 1966) found that average productivity grew rapidly from the 20s to the 30s, peaking in the decade of the 40s, then decreasing in the 50s and 60s. Dennis's findings are thus strikingly similar to those of Lehman, the main difference being that the peak age in Dennis's samples occurred in the 40s rather than in the 30s, as did Lehman's.

More recently, Cole (1979) elaborated on Dennis's (1956a) criticisms of Lehman's methodology. Cole stated that because Lehman calculated the significant achievements for each age interval by taking the number occurring per interval as a proportion of the total number of individuals in a specific discipline, the younger age intervals would have a higher proportion of significant achievements simply because there were more individuals alive in these intervals. Cole suggested that a more realistic measure of the relation between age and productivity would be the number of significant achievements occurring in

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each age interval as a proportion of the total number of achievements produced in that age interval. This would produce the ratio of highly impactful accomplishments to overall accomplishments occurring in each age interval.

However, after correcting in this manner and carrying out a retrospective cross-sectional analysis of individuals from six academic scientific fields, Cole (1979) again found the curvilinear relation between age and productivity. He found the rate increased in the 20s and 30s, peaked in the early 40s, and declined thereafter. His findings, therefore, are similar to both Lehman's (1953) and Dennis's (1956b, 1966) in demonstrating the curvilinear relation, but more similar to Dennis's than to Lehman's in that the peak occurred in the 40s, rather than in the 30s.

A novel feature of Cole's (1979) study was his examination of individual differences in productivity. He carried out a retrospective longitudinal analysis on a cohort of mathematicians, generating three categories of publishers—*nonproductive, weak,* and *strong.* Over a period of 25 years following the receipt of a PhD, Cole found that 43.5% of his sample did not change categories and that the proportion of productive individuals in the cohort remained constant over time. Unfortunately, he provided no overall correlations or summary statistics.

Most recently, Over (1982a, 1982b) criticized all of the earlier studies on the grounds that their designs (either cross sectional or longitudinal) confounded possible cohort differences and time-of-measurement effects with age. He argued for the use of a cross-sequential design that includes—besides cross-sectional and longitudinal components—a time-lag component in which comparisons can be made of measurements for the same age across different years for different cohorts (see Kausler, 1982, for a description of this design).

Using this design, Over (1982a, 1982b) studied publication rates of a sample of Australian and British academic psychologists, respectively, across a 10-year period and found that those who were over age 45 published significantly less often than did their younger colleagues. In addition, although the rate of publication in the younger group remained constant over the 10-year period, the publication rate of those over age 40 decreased. Like Cole (1979), Over analyzed the stability of individual differences in research output by generating three publication levels (low, medium, and high) and found that 56% did not change categories over the 10-year period. The rate of early publication was found to be a better predictor of later performance than was age, which, Over concluded, appeared to play only a minor role.

To summarize, although many criticisms have been leveled at Lehman's (1953) methodology and several additional studies have been carried out, the basic finding of a curvilinear relation between age and achievement remains. In addition, individual differences were noted in all studies; although some individuals decreased and some increased their rate of publication, most remained stable over time.

Several unresolved issues remain. For example, although from Over's (1982a, 1982b) studies we know that past publishing rate predicts future publishing rate, this prediction is limited to a 10-year span. It would be of interest to know how predictive initial publishing rate is over a longer time period. Another issue is the relation between age and productivity after the age of 65. Cole (1979) grouped together all of the scientists over 60 years of age, thus providing little information about this later age group, whereas Over excluded from his studies anyone over the age of 65. Clearly, additional research would be of value. The present study was conducted to investigate more decisively the relation between research productivity and age. It goes beyond previous research by extending the age range to include those over 65 years. Moreover, it uses a cross-sequential design to assess the effects of age on productivity independent of cohort effects. Finally, it investigates the stability of individual differences in publishing over a period of 50 years—considerably longer than any previous study.

Method

Subjects

The sample consisted of 1,084 living North American male academic psychologists. They were selected from among the subjects studied by Endler, Rushton, and Roediger (1978), supplemented from the list in the 1980 edition of the *International Directory of Psychologists* (Vol. 5–7, Jacobson & Reinert, 1980). The age and sex of each individual were obtained from the *Directory of the American Psychological Association* (American Psychological Association, 1981) and from the 1980 edition of the *International Directory of Psychologists.* The names of psychologists who had subsequently died were eliminated from the sample. This information was determined from issues of the *American Psychologist* prior to June 1984. The names of those psychologists in private practice or those who were employed chiefly by a medical establishment were eliminated after consulting the *Directory of the American Psychological Association* (1981). The 1,084 subjects were divided into four cohort groups: Cohort 1 (n = 69), subjects born between 1909–1914; Cohort 2 (n = 232), subjects born between 1919–1924; Cohort 3 (n = 352), subjects born between 1929–1934; and Cohort 4 (n = 431), subjects born between 1939–1944.

Measures of Productivity

The publications of each individual were counted from each edition of the *Cumulative Author Index to Psychological Abstracts* (American Psychological Association, 1939–1983) for five 5-year periods: 1939–1943, 1949–1953, 1959–1963, 1969–1973, and 1979–1983. No distinction was made between position of authorship (senior or junior), type of publication (research paper, literature review, book, or book review), or the relative quality of the journal. In other words, all publications were treated as equal.

A cross-sequential design similar to Over's (1982a, 1982b) was used, with a total of 14 cells representing the five age groups for each of the four cohorts, as determined by the periods of measurement. This design is composed of three distinct components: cross sectional, longitudinal, and time lag (Kausler, 1982). Measures for each component were obtained by computing the mean rate of publications per individual per year across each of the 5-year measurement periods for each of the four cohorts.

Results

Table 1 shows the means and standard deviations for the 14 cells of the design. The weighted means were calculated across cohorts to determine the overall relation between age and publication rate. This distribution is depicted in Figure 1, inspection of which reveals a curvilinear relation between age and research

Table 1
Means and Standard Deviations of Number of Publications for Subjects by Age and Cohort

	Age group					
Cohort	25–34	35–44	45–54	55–64	65–74	Overall *M*
1 (1909–1914)						
M	0.86	1.11	0.96	0.64	0.37	0.79
SD	1.11	1.14	0.87	0.82	0.73	
n	69					
2 (1919–1924)						
M	0.59	1.32	0.96	0.72		0.90
SD	0.92	1.21	1.03	1.04		
n	232					
3 (1929–1934)						
M	0.76	1.28	0.89			0.98
SD	0.92	1.26	1.05			
n	352					
4 (1939–1944)						
M	1.17	1.08				1.12
SD	1.06	1.07				
n	431					
Overall weighted mean	0.89	1.20	0.92	0.70	0.37	1.01

Note. N = 1,084 North American psychologists.

productivity. The average rate of publication per year at ages 25–34 was 0.89, rising to a peak of 1.20 at ages 35–44, then decreasing to a rate of 0.70 at ages 55–64, and to 0.37 at ages 65–74. A priori planned comparisons revealed that the 35–44 year olds published at a significantly higher rate per year than those aged 25–34 ($p < .005$), 45–54 ($p < .005$), 55–64 ($p < .005$), or 65–74 ($p < .005$). In turn, the 45–54-year-olds published significantly more than did the 55–64-year-olds ($p < .005$), and the 55–64-year-olds were more productive than were the 65–74-year-olds ($p < .005$).

Cross-Sectional Analyses

Analyses on the cross-sectional part of the design contrasted the publication rates, separately, for each of the four cohorts within the four measurement periods, 1949–1953, 1959–1963, 1969–1973, and 1979–1983. Significant one-way analyses of variance (ANOVAs) were found for each period of measurement ($p < .001$). Multiple comparisons of means by independent t tests revealed that for each cohort the publication rate at ages 35–44 was significantly higher than at ages 25–34 ($p < .001$) or at ages 55–64 ($p < .001$). In the main, no significant differences were found in the rate per year for ages 35–44 to 45–54. Thus, the cross-sectional analyses provide additional support for a curvilinear relation between age and rate of publication.

Repeated Measures Analyses

Comparisons were made of publication rates per year at various ages in each of the four cohorts (see Table 1). Comparisons between ages by repeated measures ANOVAS and multiple matched-pair t tests revealed significant differences in publication rates between the ages. On average, the rate per year at ages 35–44 was significantly higher than that at ages 25–34 ($p < .001$), 45–54 ($p < .001$), and 55–64 ($p < .001$), with only slight variations within the cohorts. Thus, further confirmation of a curvilinear relation between age and research productivity emerged from these longitudinal analyses.

Time-Lag Analyses

In order to examine cohort differences at specific ages, comparisons were conducted between cohorts within specific ages, collapsing across periods of measurement, by one-way ANOVAS and multiple independent t tests. The only age interval in which significant cohort differences were found was 25–34. The mean rate per year in this age interval for Cohort 4 (1939–1944) was found to be significantly higher ($p < .001$) than for either of the other cohorts (see Table 1). Thus, with this one exception, there were no significant differences in publishing rate found between cohorts at any age interval.

Individual Differences

To investigate individual differences in research productivity initially and across time, publication levels were determined by calculating the frequencies of mean publication rates per year at ages 25–34. A tertial split was made to generate three categories of initial publishers: low (.20 publications or less per year), medium (between .20 and 1.00 publications per year), and high (more than 1 per year). The means, collapsed across cohorts for the three publishing levels, are shown in Figure 2.

It can be seen that for both the low- and medium-level publishers, a curvilinear relation emerged in their mean rate per year across time. The rate at ages 35–44 significantly exceeded ($p < .05$) the rate at ages 25–34, 55–64, and 65–74 for both of these groups. The differences in rate of publication between the 35–44-year-olds and the 45–54-year-olds was not significant. Trend analyses confirmed that for both groups the quadratic component was significant ($p < .001$). In addition, for the me-

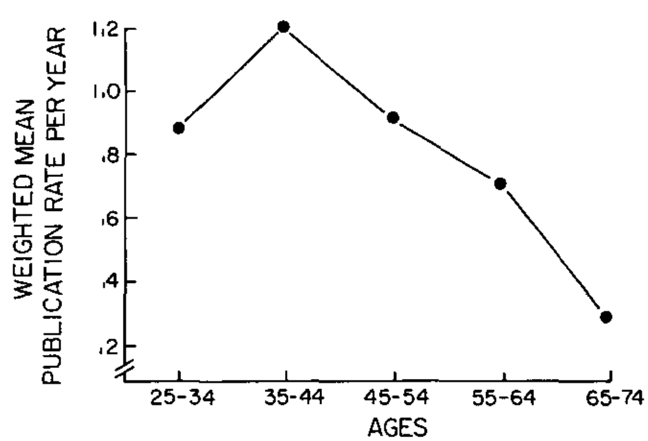

Figure 1. Weighted mean publication rate per year for 1,084 North American academic psychologists at five age intervals.

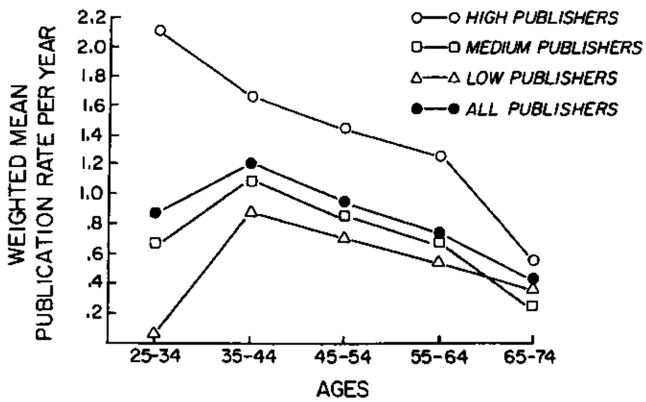

Figure 2. Weighted mean publication rate per year for high, medium, and low publishers among 1,084 North American academic psychologists at five age intervals. (The heavy line represents weighted means across all publishing levels [from Figure 1].)

dium publishers but not for the low publishers, a linear trend was also significant ($p < .005$).

For the high publishers, on the other hand, a significant linear decline ($p < .001$) was found after an early peak at ages 25–34. The 25–34-year-olds produced significantly more than did the 35–44-year-olds ($p < .001$), the 45–54-year-olds ($p < .01$), the 55–64-year-olds ($p < .01$), or the 65–74-year-olds ($p < .01$). There was no significant difference between the rate at ages 35–44, 45–54, or 55–64.

Amount of Variance Accounted for by Age

The present results demonstrate a significant relation between age and research productivity. It is of interest, however, to estimate how much of the variance in research productivity over time can be accounted for by age. To estimate this effect, eta^2 was calculated for the 301 individuals in the sample who had reached age 65 (i.e., Cohorts 1 and 2). Age accounted for 6.9% of the variance across time for Cohort 1 and 6.5% for Cohort 2. However, there was variation between the publication levels: Collapsing across the two cohorts, age accounted for 17.9% of the variance for the low publishers, 7.3% for the medium group, and 8.5% for the high publishers.

Stability of Individual Differences

To examine the degree of stability of individual differences in publishing rate over time, Pearson correlation coefficients were calculated for the sample as a whole. The rate at ages 25–34 significantly predicted the rate at ages 35–44 ($r = .40, p < .001$), ages 45–54 ($r = .37, p < .001$), and ages 55–64 ($r = .31, p < .01$), but was not a significant predictor of the rate at ages 65–74. Calculations were made of the proportion of subjects maintaining, raising, or lowering their level from ages 25–34 over the complete period to ages 55–64. The subsample for these calculations consisted of the 301 subjects from Cohorts 1 and 2 for whom a rate was available at ages 55–64. Of this group, 15% (45 out of 301) maintained a stable publishing level throughout their career; 27% (81 out of 301) changed publication levels once, up or down; and 58% (175 out of 159) made two or more changes.

To equate our analyses with those of Over (1982a, 1982b), we also calculated the proportion of our subsample remaining stable throughout 10-year periods—that is, from 25–34 to 35–44, from 35–44 to 45–54, and from 45–54 to 55–64. Overall, the proportion remaining stable in each 10-year period was 51% (ages 25–34 to 35–44, 48%; ages 35–44 to 45–54, 54%; ages 45–54 to 55–64, 50%).

Discussion

From the cross-sequential design of this study, a curvilinear relation emerged between age and research productivity, such that on average, academic psychologists began to publish at a relatively low rate in their late 20s and early 30s, increased their productivity to a peak around age 40, then tapered off in their later years. This finding occurred not only in the cross-sectional analyses but, more convincingly, it occurred longitudinally as well. These data thus support those of previous researchers (Cole, 1979; Dennis, 1956b, 1966; Lehman, 1953; Over, 1982a, 1982b). Except for the initial publishing rate, we found no differences between cohorts in their rate across time. The higher initial mean rate for Cohort 4 can be explained by the fact that there was a greater proportion of high publishers in our sampling of this group.

The finding of a curvilinear relation between age and research productivity was qualified by evidence from the high-level publishers (those producing more than one article per year and composing one third of the sample). These authors began to publish at their peak earlier than the rest of the sample (at 25–34 years of age), but thereafter showed a steady decline. Even after decline, however, this group at 55–64 was more productive than the remaining two thirds of the sample had been at their peak. This confirms a previously noted observation that highly creative people often demonstrate great productivity very early in life and continue to do so to the end of a long career (Albert, 1975; Simonton, 1984). Clearly, individual differences are important. Yet whether productivity peaks early or builds slowly, all of the analyses show some decline in productivity between the ages of 25 and 65. Overall, 6.5% of the total variance in productivity was accounted for by age, an estimate in accord with the 5% obtained by Over (1982a).

With respect to individual stability over time, Cole (1979) noted that 43% of the sample showed stability of category (low, medium, high) over a 25-year period, and Over (1982a, 1982b) found that 56% did so for a 10-year period. We, however, found that only 15% maintained a stable rate when a 30-year period was examined, beginning at ages 25–34. The proportion who remained stable increased to 20% when stability was examined over a shorter, 20-year period. The proportion remaining stable over 10-year periods rose to 51%, an observation in accord with those previously reported. Given the longer time period and the finding of an overall decline with age, this suggests that a greater proportion of researchers might have slipped down a category or two as their careers progressed.

It would appear, therefore, that research productivity does decline with age, and also that individual differences play an important role in determining the initial publication rate, the rate at the peak, when the peak will occur, and the rate in the later years. What remain to be established, of course, are the factors that influence the productivity rate over time and the concomitant individual differences.

Two broad classes of explanatory variables can be offered for the observed relations: social structural hypotheses and those hypotheses based on the individual. In terms of social variables, one of the most widely acknowledged is the scientific reward system, in which work is recognized (e.g., by colleagues and through citations) and rewarded (e.g., through increased access to resources such as financial support, graduate students, and collaborators; Cole, 1979). These reinforcers allow for the continuation of high quantity and quality research. The lack of such rewards leads correspondingly to the decrease and eventual cessation of their research productivity.

A second structural variable proposed is that researchers may decrease their publication rate after middle age because of competing commitments. Zuckerman and Merton (1972) found that as scientists aged, less time was spent in research and that a larger proportion of their time was spent in administrative positions. Contrary to this viewpoint, however, Fox (1983) noted that unless a scientist moves out of research completely when attaining an administrative position, the increased resources available should facilitate, rather than impede, research productivity. A third variable is that of university affiliation. This accounted for more than 6½% of the explained variance in the publication rates of Over's (1982b) sample. Long and McGinnis (1981) suggested that a high level of research productivity results from appointment to a prestigious institution, partly because of the expectations of that university.

A different set of hypotheses to explain the observed findings is derived from the perspective of the individual. For example, there are indications that genetically influenced intellectual and personality dispositions have a role to play in the production of both the quantity and quality of research (Findlay & Lumsden, in press; Rushton, in press; Simonton, 1984). For example, Rushton, Murray, and Paunonen (1983) found effective researchers to be ambitious, enduring, seeking definiteness, dominant, intelligent, showing leadership, aggressive, independent, nonmeek, and nonsupportive. In this case, the decline in productivity would be accounted for in chronogenetically based life history changes in cognition and personality (Rushton, Littlefield, & Lumsden, 1986). Consistent with this hypothesis, Raynor and Entin (1982) observed that young scientists are motivated to achieve future goals, whereas beginning in the middle years and increasing thereafter, the older scientist becomes more past-oriented, especially if major goals have already been achieved.

A second set of individual variables concerns age decrements in cognitive and metabolic efficiency. Generally, aging produces declines in biological systems, with some functions (e.g., brain size, cardiac and respiratory physiology) beginning their decrease before age 40 (Ho, Roessmann, Straumfjord, & Monroe, 1980; Weg, 1983). Consequent decrements in intellectual and physical energy are likely to lower productivity.

These two potential categories of influence are by no means exhaustive or proven (Jackson & Rushton, in press; Simonton, 1984). There is, of course, no need to see the alternatives as incompatible. Social and individual sources of variance are most appropriately viewed as providing complementary analyses (Findlay & Lumsden, in press; Rushton et al., 1986). Challenging issues for future research clearly confront us in understanding this decades old, but increasingly timely, topic.

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