Journal of Personality and Social Psychology
1977, Vol. 35, No 11, 791-804

Creative Productivity, Age, and Stress: A Biographical Time-Series Analysis of 10 Classical Composers

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The determinants of creative productivity were specified in the form of six hypotheses. Using a multivariate cross-sectional time-series design with several controls, the lives and works of 10 classical composers were analyzed into consecutive 5-year age periods Two independent measures of productivity were operationalized (works and themes), with each measure subdivided into major and minor compositions according to a citation criterion. It was consistently found across both productivity measures that (a) quality of productivity is a probabilistic consequence of productive quantity and (b) total productivity, while affected by age and physical illness, is otherwise free of external influences (viz., social reinforcement, biographical stress, war intensity, and internal disturbances). Due to the more selective nature of the thematic productivity measure, the criterion of total themes alone was affected by competition and a time-wise bias. The article closes with a brief discussion of the broad substantive utility of the methodological design.

It is often observed that one of the most prominent characteristics of the great creative genius is his or her immense productivity (Albert, 1975; Dennis, 1955; Price, 1963, chap. 2). Not only do the major geniuses begin their productive careers at unusually early ages (Dennis, 1954a, 1954b) but, additionally, their creative productivity may extend well into the later years of life (Dennis, 1966). This conspicuous productivity notwithstanding, there also can be little doubt that such creative activity may vary considerably within the life span of the individual genius. Every creator has years of "inspiration" and so-called "dry years." Yet what are the primary determinants of such fluctuations in creative productivity within each individual's career? The answer to this question has practical, methodological, and theoretical interest. From the perspective of applied psychology, it is evident that any knowledge of the longitudinal etiology of productivity may offer guidance regarding the optimal settings for nourishing and sustaining creative output. And from the methodological perspective, a number of designs in behavioral sciences, particularly *generational analysis* (Simonton, 1975c, 1976f), depend on the ability to predict the peak productive age of individual creators (also see Simonton, 1975a, 1976e). Finally, questions about the causal determinants of creative productivity also have theoretical importance. The present article discusses a number of different theoretical models that have been advanced to explain longitudinal fluctuations in productivity, and some of these models can be subjected to empirical test. The combination of these theoretical models with preceding empirical work leads to the formulation of the following six hypotheses.

I am grateful to Susan Youel Simonton for discussing with me at length the weighting scheme for musical works. I also wish to thank Robert Albert, Frank Barron, and Kenneth Craik for discussing with me an earlier draft. The statistical analyses were made possible by a grant from the Computer Center of the University of California, Davis.

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Hypothesis 1

Creative productivity per time unit is a curvilinear inverted-U function of age.

Expressed differently, this hypothesis predicts that productivity tends to first rise to some peak productive age and then to decline to a relatively low level of output. The underlying assumption behind this prediction is that

the psychological processes responsible for creative productivity also tend to rise and fall with increased age. For example, Beard (1874) proposed a two-factor theory of creativity that predicts just such a longitudinal function. He began by assuming that true creativity requires the conjunction of *enthusiasm* and *experience*. Enthusiasm without experience yields original rather than truly creative work, whereas experience without enthusiasm yields routine rather than creative work. Beard further postulated that these two parameters have different time-wise distributions: Enthusiasm increases rapidly up to the middle 30s and thereafter wanes, whereas experience continues to increase into the last years of life (albeit at an ever decelerating rate). He therefore proposed that the peak productive age occurs between 38 and 40 years, since during that age interval enthusiasm and experience are properly balanced. Nevertheless, since several other theories also predict a curvilinear age function, it is not necessary to be committed to Beard's view (see Lehman, 1953, pp. 328–329). The rise and decline could just as well be ascribed to negative transfer or to the exhaustion of a particular style or method of viewing a particular esthetic or scientific problem. Yet it is not the expressed purpose of the present project to determine which psychological model is most justified by the facts. Instead, the more limited aim is to verify the assertion that creative productivity is indeed a curvilinear function of age. To be sure, the extensive empirical labors of Lehman (1953) seem to have firmly established this relationship, yet not everyone accepts Lehman's findings (e.g., Dennis, 1956; Riley & Foner, 1968, p. 437). Even though few dispute the claim that creative achievement is very likely to increase with age, many hold that any decline in the later years of life cannot be attributed to psychological causes. Three factors in particular may be cited as possible alternative explanations for any apparent productive decline: physical illness, competition, and compositional fallacy.

Physical illness. Although increases in productivity can probably be safely attributed to mental variables, decreases in productivity may quite possibly be the consequence of purely biological realities. Clearly any genius will invariably be handicapped by serious physical illness or injury. Moreover, since health is very likely to weaken with advanced age, there can be little doubt that this factor alone can contribute to productive decline. However, if biology rather than psychology is totally responsible for any observed losses in creative output, then productivity should *not* be an inverted-U function of age, after partialing out the effects of physical illness. Hence, such control is necessary to increase the plausibility of a psychological explanation.

Competition. Dennis (1956, 1958) took Lehman to task for failing to control for possible changes in competition during the creator's productive career (cf. Lehman, 1956, 1960). All indicators of creativity show that the number of creators in any given historical period in modern times is increasing at an exponential rate (Price, 1963, chap. 1; Simonton, 1975b, 1975c, 1976c). Consequently, the competition for the plaudits of posterity should become ever more fierce as any given creator gets older. Hence a creative genius might be just as creative in his or her later years and yet exhibit an apparent decline due solely to the more intense competition with younger colleagues. An earlier study has attempted to rule out this alternative explanation by controlling for time (Simonton, 1975a), but obviously a more powerful direct control can be accomplished by actually measuring competition. Thus competition must be added to physical illness in any list of necessary control variables when estimating the functional relationship between age and creative productivity.

Compositional fallacy. A second criticism leveled by Dennis (1966) against Lehman's (1953) research concerns the fact that not all eminent persons live to the same ripe old age. Yet in determining the curves for creative achievement, Lehman combined individuals with quite disparate life spans into a single aggregate. Since all those creators who had the misfortune of dying young could not have possibly produced works from the grave, the average productivity per age period was inevitably biased downward. In other words, a decline in the aggregate data may not hold for those creators enjoying long life spans. This methodological artifact is known as a

"compositional fallacy" (Riley, Johnson, & Foner, 1972, pp. 605–607), and it casts severe doubts on any observed decline, unless appropriate controls are instituted. Dennis (1966) attempted to circumvent this confounding factor by restricting the sample to octogenarians, but his approach raises the question of generalizability. Recently it has been shown that multivariate techniques can resolve this critical issue (see Simonton, 1975a). Later in the present article, I introduce another solution that exploits cross-sectional time series.

Hypothesis 2

The proportion of major creative products relative to minor creative products per time unit is a positive linear function of age.

Still another article of contention between Dennis and Lehman revolved around the distinction between quality and quantity of creative productivity. On the one hand, Lehman (1953, pt. 2) maintained that the production of major works declines very rapidly after the peak productive age of around 40 years, whereas the production of minor works may wane much less rapidly. This view is consistent with Beard's (1874) theory that experience may produce routine works after enthusiasm has passed. On the other hand, Dennis (1966) offered what might be called a *constant-probability-of-success* model. Making the observation that the major works of any genius seem to appear in those periods of life in which the genius is also most productive, Dennis went on to infer that the production of major works is largely a chance affair. The greater the number of works a genius produces in any given time, the greater the likelihood that some works will be regarded as masterpieces by posterity. Therefore, to Dennis, quality is mostly a probabilistic repercussion of quantity. Happily, these two alternative perspectives lead to empirically distinguishable predictions regarding the *percentage* of major works produced over the creator's career. Lehman's model implies that this proportion will be a curvilinear inverted-U function of age, whereas Dennis's model implies that this proportion will remain fairly constant and hence will be neither linearly nor curvilinearly related with age.

Yet Hypothesis 2 proposes still another possibility, namely that the proportion of major works actually *increases* with age. The basis for this third prediction is another two-factor model superficially similar to that of Beard's (1874). It is being assumed that the *ability* to create major works increases steadily with age but that the *motivation* to create works declines after the peak productive age. Because motivation decreases, fewer total works will be produced; but since ability is still growing with age, the upshot is an increase in the number of major works relative to minor works. In short, because of a failure of will, the older genius may be less productive, yet because of an actual gain in skill, those works that are produced are of a consistently higher quality. Note that if Hypothesis 2 is supported by the data, then it is possible to further specify the likely psychological processes behind the productive decline. That is, if Hypotheses 1 and 2 are empirically substantiated, then a motivational cause becomes more plausible than an intellectual one.

Hypothesis 3

Creative productivity per time unit is a positive linear function of social reinforcement.

Reinforcement theory enjoys such a prominent place in modern psychology that this particular prediction hardly needs explanation. Nevertheless, the existence of several alternative positions makes the veracity of Hypothesis 3 less of a foregone conclusion. For example, recent research on attribution theory, particularly that on *overjustification effects* (e.g., Lepper, Greene, & Nisbett, 1973), would lead to a different conclusion: If creative productivity were intrinsically rather than extrinsically motivated, social rewards might lead the creative genius to attribute his or her behavior to external causes. Alternatively, the creator might be reinforced for imitating past behavior rather than initiating further advances in art or science.

Hypothesis 4

Creative productivity per time unit is a curvilinear inverted-U function of biographical stress.

The experimental literature on problem solving and correlational studies on intelligence testing both suggest the possibility of a curvilinear relation between emotional arousal and performance (e.g., Evans & Frederiksen, 1972; Freeman, 1940). Here I am proposing that a comparable function holds for creative productivity. When biographical stress is very low, there is insufficient motivation behind the creative process. But as such stress increases, so does productivity. Indeed, it may be argued that many creative products constitute ways of coping with the minor anxieties and aggravations of everyday life. Yet when stress continues to increase beyond a certain optimum point, the result is a decline in creative productivity. Since creativity entails the use of uncommon associations (Mednick, 1962), and since excessive arousal lowers the probability that such responses will occur (Spence, 1956, pp. 221–235), the likelihood of arriving at creative ideas is drastically reduced (Martindale & Greenough, 1973).

Hypothesis 5

Creative productivity per time unit is a negative linear function of war intensity.

Although warfare has been shown to influence the development of personal ideologies (Simonton, 1976f), no consistent relationship has been found between war and either creativity or eminence (Naroll et al., 1971; Simonton, 1975c, 1976b, 1976d, 1976e; Schaefer, Babu, & Rao, Note 1). This broadly replicated null result counters any suggestion that warfare may discourage creative activities, whether through economic hardship, political repression, or militaristic regimentation (cf. Toynbee, 1946). Nonetheless, no study to date has investigated whether war has an immediate impact on productivity within the life history of individual creators (cf. Roe, 1972). Since wars seldom endure the entire productive life of individuals, it is possible that any decrease in productivity during the war years is adequately compensated by a burst of productivity during peace time. In brief, war may delay the production of any work rather than inhibit production altogether. Therefore, Hypothesis 5 may still have a chance of being right despite the overwhelming indirect evidence currently against it.

Hypothesis 6

Creative productivity per time unit is a negative linear function of internal disturbances.

Unlike the case for war, past research has successfully shown that internal disturbances have an impact on creativity (Simonton, 1975c). However, previous investigations have usually distinguished between two kinds of internal disturbances, those pertaining to civil unrest among the populace and those pertaining to dissensions among the ruling elite (also see Simonton, 1976e, 1976f). The rationale for this distinction was that these two types of internal disturbances probably have contrasting effects on the *development* of creators. Yet here the focus is on the productive careers of creators, and consequently it may be proposed that all forms of civil unrest and political instability have the same general negative impact on creative productivity. The basis for this prediction is similar to that for war: Internal disturbances probably result in excessive economic, political, and personal strains that are by no means conducive to the creative process.

The above six hypotheses are stated in the most general form possible so as to be applicable to any field of creative endeavor within the arts and sciences. This wide scope notwithstanding, the present article deliberately restricts the representativeness of the sample on which the predictions are to be tested. It concentrates solely on composers of classical music rather than on all creative disciplines. Three main reasons led to this decision. First, music has long been recognized as a truly international language that requires no inspired translations as in literature, no expensive pilgrimages to widely spaced museums as in art, and no specialized mathematical skills as in science. Consequently, a high degree of consensus has been reached regarding what constitutes a *major* versus a *minor* work, a distinction of great importance in testing Hypothesis 2. Second, biographical data on the lives and works of the great classical composers are very extensive, perhaps only exceeded by biographies of literary figures. Particularly crucial is the ready availability

of complete catalogues of all works, major or minor, for all eminent composers. Third and last, musicians are somewhat unique in their lack of versatility relative to other creative disciplines. Because of the highly specialized expertise required for musical composition, even the greatest composers tend to be solely composers, whereas the greatest scientists often indulge in philosophy; philosophers, in literature; writers, in art; and artists, in science (White, 1931). This comparative single-mindedness of composers immensely simplifies the longitudinal assessment of productivity, since it is not necessary to worry about the composer's having laid aside music in order to devote full time to an ambitious effort in an unrelated discipline. For the above three reasons, therefore, it seems best to begin the investigation of creative productivity in a discipline in which some potentially severe methodological difficulties are effectively minimized. Naturally, the substantive repercussion of this decision is that any findings must be generalized with extreme care until replicated for creative endeavors other than classical music.

Method[1]

Sample: 10 Classical Composers

Two criteria were used in selecting the composers for the current inquiry. First, due to the high correlation between eminence and the reliability of biographical data (Cox, 1926; Simonton, 1976a), eminence seemed to provide a sound sampling criterion. Hence I consulted Appendix A of Farnsworth's (1969, p. 228) *The Social Psychology of Music*, which presents a list of major Western classical composers in rank order of eminence. The eminence rankings are based on a survey of the members of the American Musicological Society, who were asked to name composers born before 1870 who "composed music most worthy to be called to the attention of children and lay contemporaries, i.e to be preserved as part of the musical heritage" (p. 227). The second criterion was founded on the pragmatic recognition that considerable labor is required to compile complete chronologies of biographical events and both major and minor works (see, e.g., Cox, 1926, pp. 745–759). Accordingly, I sampled only the top 10 composers on Farnsworth's list. Thus the composers for the present investigation were, in rank order, Bach, Beethoven, Mozart, Haydn, Brahms, Handel, Debussy, Schubert, Wagner, and Chopin. Although it is not necessary to claim that these particular composers constitute *the* top 10, there can be no doubt these particular individuals are likely candidates for placement in any list of the top dozen or so classical composers by almost any criterion (see, e g., Farnsworth, 1969, chap. 6, Moles, 1968, pp. 28–29). The critical fact is that all of these composers are sufficiently famous to render it feasible to collate abundant biographical data from American university libraries.

Time Unit: 5-Year Age Periods

Each composer's productive life was divided into consecutive 5-year age periods, each period beginning with a multiple of five (i.e , 5–9, 10–14, 15–19, 20–24, etc.) The first observation of the time series for any composer was the 5-year age period during which that composer began production, and the last observation of the same time series was that 5-year age period during which the composer died. The total number of units for statistical tests was 100, the sum of the number of 5-year periods across all composers Because the length of the time series varied from composer to composer, each composer contributed to the analysis only over his own productive life span Thus composers who died young, such as Schubert and Mozart, did not confound the analysis of the later years of such long-lived composers as Haydn and Handel. This use of separate time series for each composer, while concomitantly estimating effects across all composers, was the chief device utilized to counter the potential compositional fallacy mentioned under Hypothesis 1

Dependent Variables

Compositional productivity. There were a number of possible ways to operationalize the key dependent variable in the present study, and not all would necessarily lead to equivalent results. As a consequence, I defined two very distinct measures of creative productivity that would allow cross-validation of any empirical findings.

The first indicator of creative productivity was that of *total works* After obtaining complete catalogue listings for all 10 composers, each work was assigned to one of the 5-year analytical units according to the date of composition. Since it would be absurd to count an art song on an equal footing with an entire opera, a weighting scheme was conceived This weighting scheme had to allow for such factors as the number of movements, the size of the instrumental and/or vocal forces, and the harmonic and/or structural complexity of the musical forms. In order to obtain a scheme that could be applied quite objectively, a very elaborate coding system had to be developed. Since detailed description is impossible here (see Footnote 1), it is sufficient to present the following representative musical forms with their corresponding weights (in parentheses): masses (50), opera seria (40 per act), symphonies and orchestral suites (40), opera buffa

[1] Because it is not possible to present all the methodological details behind this project a 6-page supplement is available from the author upon request.

(35 per act), cantatas (30), concerti (30), incidental music (25), chamber works (20), serenades and divertimenti (20), solo and duo sonatas (15), overtures and tone poems (10), art songs (5), instrumental solos (5), dances and marches (3), and revisions or arrangments (1). The productivity measure of total works was then defined as the count of the number of works composed during each 5-year age period, with each work weighted according to the devised scheme. Whatever the roughness of this measure, it must be considered more realistic than tallying all works equally, great or small. On the other hand, even though the weighting scheme is objective in application, the choice of the weights themselves was based on a number of intuitive assumptions. Although I believe the chosen weights to be quite defensible, their subjective derivation suggests the desirability of a second operationalization.

The second indicator of creative productivity was that of *total themes*. The sources for operationalizing this measure were the two extensive thematic dictionaries compiled by Barlow and Morgenstern (1948, 1950). These dictionaries contain over 18,000 instrumental and vocal themes from virtually every classical composition sufficiently important to be recorded by the middle of this century. The indicator of total themes was then defined as the number of themes composed in each 5-year age period. If, as in the case of the larger musical forms, more than one theme was credited to a given work, all themes listed for that work were still separately tallied. Thus this productivity indicator also weighted each work, only this time the weighting was objectively determined by the number of themes per work. Therefore, it is not surprising to find that these two productivity measures have a product-moment correlation of .64 ($p < .001$). Nonetheless, it is not necessarily true that larger musical forms have more themes; variation, fugue, and sonata forms, especially, all demand the exhaustive development of relatively few themes. Hence the two measures of compositional productivity are by no means equivalent.

Major versus minor compositions. In order to test Hypothesis 2, I first needed to discriminate between major and minor compositions. For current purposes, a major composition was distinguished from a minor one by its being more famous or notable. To determine the fame of each composition, 15 different citation sources were employed (cf. Simonton, 1975a). These sources were chosen for their apparent selectivity, breadth, and diversity of orientation; the sources included music histories, music appreciation texts, score anthologies, thematic dictionaries, record anthologies, a concert guide, general cultural histories, and a standard encyclopedia (see Footnote 1). A major composition was then defined as one cited in at least 2 of the 15 citation sources, whereas a minor composition was one cited either once or not at all. Thus by applying this definition, the productivity indicator of total works could be subdivided into major works and minor works; the indicator of total themes, into major themes and minor themes. The *quality proportion* required for Hypothesis 2 can then be defined as the measure of major compositions divided by the measure of total compositions. The outcome is two quality proportions, one for themes and the other for works

Within-subjects mean deviations. According to the present hypotheses, the only concern was with fluctuations in productivity within each composer and not with variations across all composers. As the measures were defined above, cross-sectional and time-wise components of the variance were confounded. Therefore, the productivity score for each composer was measured as a deviation from each composer's mean score. The effect of this transformation was to preserve the within-subjects (or time-wise) variance in the productivity measures while concomitantly making the between-subjects (or cross-sectional) variance zero.

Independent Variables: Substantive

Age. The age of each composer at each 5-year period was defined as his age at the *onset* of that period These values were then measured as deviations from the overall mean age to produce the variable called *age linear*.[2] The second variable, *age quadratic*, was defined as the square of age linear.

Biographical stress. Holmes and his colleagues (e.g., Holmes & Rahe, 1967) have developed a self-report measure of life changes to determine how stress may cause psychosomatic complaints. A life-change score is created by a weighted measure of separate life changes, the weights having been determined empirically. This scale had to be considerably modified in order to be applicable to biographical data, especially since many of the minor life changes (e.g., in eating or sleeping habits) are not reliably recounted in biographies. Moreover, since composers lead somewhat unusual lives, a few items were added in a manner consistent with the original scale. The resulting instrument, though complicated, could be applied objectively to each composer (see Footnote 1). Representative life changes (with weights in parentheses) were litigations and lawsuits (30), detention in jail or exile to avoid arrest (63), major loan (20), troubles with creditors (30), change in schools (20), job change (20), change in permanent residence—city or town (30), change in permanent residence—nation (40), beginning and/or end of a reciprocated love affair (30), death of a close family member (63), marriage (50), divorce (73), and death of spouse (100). The total number of life-change points accumulated during each 5-year age period was then tabulated and put into mean-deviation form to yield the measure called *biographical stress linear* (see Footnote 2). The square of this variable was *biographical stress quadratic*. In order to assure that no event appropriate to this measure was omitted, a large number of biographical sources were used (see Footnote 1). These sources were also employed for the next two measures.

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[2] To lessen multicollinearity resulting from product terms, all interval main-effect variables composing the terms had to be placed into mean-deviation form before the multiplicative term was generated (Althauser, 1971).

Physical illness. To assess the role of health in creative productivity a special scale was invented that could be objectively applied to biographical data (see Footnote 1). The scale was as follows (points in parentheses). major illness (1 point each, 1 extra per year), special treatment or cure (1), serious injury (2), operation (2), physical impairment or handicap (3 per year), heart attack or stroke (4), serious impairment of vision or hearing (5 per year), physical paralysis (5 per year), and total blindness or deafness (10 per year).

Social reinforcement. The variable required for testing Hypothesis 3 was defined for each 5-year age period by tallying 1 point for each of the following social rewards (see Footnote 1) honorary doctorate, public monument erected in honor (or medal cast), membership in honorary society, listing in a *Who's Who*, public celebration of birthday, knighting, prize (except student prizes for school work), "freedom of the city" or "key to the city," and society founded in one's honor.

Competition. The number of competitors for the applause of posterity was gauged by using the "Chronology of Composers" in the biographical dictionary of musicians compiled by Illing (1963, pp. 133–175) This chronology lists composers in order of their birth year and additionally provides from zero to three stars as an indication of eminence. Since the more eminent composers are likely to be more productive and thereby offer more severe competition, any indicator of competition should probably weight the more eminent composers more heavily. Hence the measure of competition for any given 5-year age period was defined as follows: (a) 1 point for each composer (other than the composer subject) listed in the chronology who was alive and who was at least 20 years old during that 5-year period and (b) 1 extra point for each star received by each composer in the preceding tabulation.

War intensity. *The Encyclopedia of Military History* by Dupuy and Dupuy (1970) was used for tabulating the amount of warfare during each 5-year age interval of each composer's life. The coding scheme was as follows (cf Simonton, 1975c): (a) 1 point for each year that the nation of the composer's permanent residence was at war within any given 5-year age period and (b) 1 extra point for each battle, siege, invasion, city or fortress captured, territorial conquest, or raid directly involving the nation of permanent residence. For the last 5-year age period of each composer's life, this measure was tabulated only up to the date of the composer's death (e.g., battles occurring after the composer had died were not counted). Also, the concept of *nation* was defined in a largely cultural-linguistic rather than political sense (cf. Simonton, 1975c). To be specific, for our purposes the nations were England, Germany-Austria, France, Italy, and Russia (the last for Chopin, who lived under the Czarist Regime in Poland). This same qualification was applied to the next measure as well.

Internal disturbances. The "Appendix to Part Three" of Sorokin's *Social and Cultural Dynamics* (1937, Vol. 3, pp. 578–620) lists such events as revolutions, revolts, riots, coups d'etat, and the like. Each internal disturbance was weighted (by a geometric average) according to social area, duration, the size of the masses involved, and intensity (cf. Simonton, 1975c). These weighted values were then tabulated into each 5-year period according to the composer's nation of permanent residence As in the case of war intensity, internal disturbances occurring after the composer's death were not tabulated in the last 5-year age interval.

Independent Variables: Control

The following variables are defined not for any substantive interest but rather to avoid possible methodological artifacts.

Preproductive excess years. It often happened that a composer did not actually begin productivity in the first year of the initial 5-year age period of his biographical time series. After all, each composer made no effort to comply with my analytical framework by trying to start productivity on his 5th, 10th, or 15th birthday. Since this lack of fit between the onset of the time series and the onset of actual productivity could bias the results, a special dummy variable was operationalized as follows (a) For the initial 5-year age period, the dummy equaled −1 point for each year prior to the onset of the first composition and (b) for all succeeding 5-year age periods, the dummy equaled 0. This dummy variable was called *preproductive excess.* For example, Mozart did not begin to compose until he was 6 years old, and hence the preproductive excess dummy equaled −1 for the age period beginning at 5 years old and 0 for all successive 5-year age periods.

Posthumous-excess years. The 10 composers were often just as nonobliging about when they died, frequently dying before the last 5-year age period had been completed. Obviously, productivity must perforce cease after any composer's death, no matter how prolific. Therefore, a dummy variable called *posthumous excess* was defined as follows: (a) for the terminal 5-year age period the dummy equaled −1 point for each year left after the death year and (b) 0 points for all 5-year age periods prior to the last. For instance, since Beethoven died at age 57, the posthumous excess dummy equaled −2 for the final 5-year period and 0 for all preceding 5-year age periods in his biographical time series.

Date. One difficulty with transhistorical studies is that spurious relationships can emerge due to time-wise trends in the numerous variables (see Simonton, 1976a). Therefore, it is usually advisable to control for such potential artifacts by introducing time directly into the regression equation as a control variable. The current control, called *date,* was simply defined for each 5-year age period as the date that the 5-year interval begins.

Dating bias. Not all compositions can be precisely dated, since sometimes the biographers and catalogue compilers must offer educated guesses. The question then arises whether musicologists tend to favor dates with round numbers. To concretely illustrate, will 1700 have a higher probability of use than 1699 when providing the approximate date for a composition known to have appeared around the turn of the 17th

to 18th centuries? If so, then a dating bias can influence the results. Within each time series, every other 5-year age period contains a rounded-number date, and therefore those periods might tend to have more compositions tallied in them than the alternate periods. Hence, a special dummy variable called *dating bias* was defined for each 5-year period as follows: (a) 1 point if the 5-year age period included a date that is an integer multiple of 10 (i.e., the last digit is 0) and (b) 0 points if otherwise. Thus values of 1 and 0 alternated for this dummy throughout each of the 10 time series. Observe that this control variable also provided a convenient check on the reliability of the biographical data (cf. Simonton, 1975c).

Date × *Dating Bias interaction.* If any dating bias occurred at all, it would likely be more conspicuous for the earlier historical periods As noted earlier, the reliability of biographical data tends to increase over time (Simonton, 1976a). Therefore, an interaction term was created by transforming the variable date into mean-deviation form (see Footnote 2) and then multiplying it by the dummy variable, dating bias. The resulting product term permits direct statistical evaluation of any tendency for earlier composers to have their compositions approximately dated more often than those of later composers.

Results

Quality Versus Quantity

If Hypothesis 2 is correct, or if Lehman's (1953) curvilinear prediction is justified, then we cannot collapse major and minor compositions into a single indicator of total compositions, whether works or themes. On the other hand, if the constant-probability-of-success model advanced by Dennis (1966) is substantiated, then we can devote the remainder of the analysis to total themes and total works only. In other words, if quality of productivity is nothing more than a probabilistic consequence of quantity, then the distinction between major and minor compositions may be safely ignored without adverse methodological or theoretical consequences. So how does Hypothesis 2 stand against the facts?

If the quality proportion for works is regressed on all of the previously defined 14 independent variables, not one single statistically significant result emerges. In particular, the percentage of major works is completely constant over time, exhibiting neither a linear nor a curvilinear relationship with age. Turning to the quality proportion for themes, a similar result is obtained. With one exception, none of the defined independent and control variables explains any of the variance in the percentage of major themes. The lone exception, however, is important, since there does appear to be a significant *negative* relationship between age and the proportion of major themes, $b = -.04$; $\beta = -.32$; $F(1, 85) = 4.48$, $p < .05$. That is, the proportion of major themes actually tends to decrease with increased age, a sharp contrast not only with Hypothesis 2 but additionally with any of the other delineated models. Nonetheless, it must be emphasized that this longitudinal age trend for themes hardly explains more than 1% of the variance, and consequently it may be ignored for methodological purposes. Indeed, my own immediate suspicion was that this apparent negative trend was due to Schubert's unprecedented and astounding burst of thematic creativity (in the form of art songs) in his late teens. This hunch is confirmed by the fact that the negative linear age function for thematic quality loses significance if Schubert's five time units are dropped from the sample.

So on the whole we may conclude that Dennis's (1966) constant-probability-of-success model fits the data better than either the model specified for Hypothesis 2 or the model forwarded by Lehman (1953). This conclusion is further endorsed when we discover that major works comprise only 35% of total works, whereas major themes constitute 80% of total themes. Thus even though the two productivity measures were sliced into drastically different proportions according to the fame criterion adopted, both measures still display the same constant quality proportion over the composers' productive careers.

Final documentation of Dennis's (1966) position comes from an examination of the correlations between major and minor compositions. The zero-order correlation between major and minor works is .35 ($p < .01$), whereas that between major and minor themes is .56 ($p < .01$). So when the 10 musicians produced more minor compositions, they also tended to produce more major compositions. To be sure, much of the positive association between major and minor compositions may be attributed to a general age trend plus other artifactual factors, such as the analytical framework and any dating bias. To rule out this possibility requires only a partialing out of

Table 1
Cross-Sectional Time-Series Analysis. Determinants of Thematic Productivity per 5-Year Age Period

Variable	β	b	SE	F
Age linear	.54	1.58	.35	19.88**
Age quadratic	−.54	−.08	.02	25.05**
Physical illness	−.23	−.90	.40	5.00*
Competition	−.41	−.85	.40	4.58*
Social reinforcement	.01	.83	5.58	.02
Biographical stress linear	−.05	−.02	.06	.14
Biographical stress quadratic	.17	.00	.00	2.03
War intensity	.05	.20	.36	.31
Internal disturbances	−.00	−.02	.48	.00
Preproductive excess	−.05	−3.28	7.05	.22
Posthumous excess	.15	8.61	5.54	2.41
Dating bias	.02	2.07	8.84	.06
Date	.44	.38	.18	4.61*
Date × Dating Bias interaction	−.14	−.18	.15	1.41

Note. For the equation $R^2 = .40$, $F(14, 85) = 4.04$, $p < .001$.
* $p < .05$.
** $p < .001$.

the substantive variables age linear and age quadratic and the dummy control variables preproductive excess, posthumous excess, and dating bias. The resulting fifth-order partial correlations are .32 and .45 for works and themes, respectively (for both, $p < .01$). In other words, even in scrutinizing only the departures from second-order polynomial age trends and certain methodological expectations, major and minor compositions still fluctuate together in the productive careers of the 10 composers. Therefore, overlooking the small negative linear age trend for the thematic quality proportion, it seems justified to confine all subsequent analyses to the two main indicators of compositional productivity, total themes and total works.

Determinants of Total Productivity

Themes. Table 1 shows the results of regressing the productivity indicator of total themes on all 14 substantive and control variables.[3] The multiple regression equation accounts for around 40% of the variance in productivity, but of that amount almost 80% can be attributed to the two age variables. Age quadratic is by far the most significant factor, since it accounts for at least 18% of the variance in thematic productivity. Since the regression coefficient for age linear is positive and that for age quadratic is negative, they combine to produce a slight "inverted-backward-J" curve. That is, the thematic productivity of our composers did tend to rise and then fall, but the decline did not tend to reach the level of the initial ascent. This result can be received as partial support for Hypothesis 1. When a series of dummy variables are defined for each age period in order to estimate the peak interval, the average high point across all composers falls in the 30–34-year age period (cf. Dennis, 1966; Lehman, 1953, chap. 4).

Returning to Table 1, only three other significant results can be seen. First of all, there appears to be a significant negative relationship between the number of themes produced in any 5-year age period and the degree of physical illness. As anticipated, there was also a significant positive correlation between age and physical illness ($r = .37$, $p < .01$). Although by themsevles these findings can hardly seem surprising, the conclusion is that thematic productivity exhibits

[3] The Durbin-Watson test was used to determine whether the time-wise observations were sufficiently independent to permit unbiased statistical tests (see Simonton, 1977). Since the test values were not significant (1.82 and 1.59 for total works and total themes, respectively), it was not necessary to employ generalized least squares estimation procedures (cf. Simonton, 1975c).

a curvilinear age function even after controlling for any decline in physical health. Hence the plausibility of a psychological basis is bolstered.

The second significant association is that between competition and the number of themes per 5-year age period. That is, the greater the number of composers alive during any period in a given composer's life, the less likely that particular composer was to have a theme composed in that period cited in a thematic dictionary. This outcome was expected, as was also the high positive correlation between competition and date ($r = .87$, $p < .01$). Nevertheless, it should be emphasized that increased competition over time is also not sufficient to explain any productive decline for total themes; the curvilinear age function appears even after controlling for competition.

The third and final significant relation concerns the effect of date. As the 5-year age period comes more close to the present, the number of themes cited tends to increase (once other variables are controlled). Rather than ascribe this association to improved compositional skills, this finding can probably be best attributed to a bias in favor of more "modern-sounding" themes (cf. Simonton, 1976a). At least a similar bias has been confirmed empirically for philosophical beliefs (see Simonton, 1976e).

Works. When productivity as measured by total works is regressed upon the same independent variables appearing in Table 1, the outcome is fairly similar. In the first place, physical illness does have a detrimental impact on total works produced during each 5-year age period, $b = -9.88$; $\beta = -.21$; $F(1, 85) = 4.26$, $p < .05$. But more critically, both age linear and age quadratic again emerge as significant determinants of productivity, $b = 9.34$, $\beta = .27$; $F(1, 85) = 4.96$, $p < .05$, and $b = -.80$; $\beta = -.44$; $F(1, 85) = 16.38$, $p < .001$, respectively.[4] As before, the quadratic function contributes the most to explaining the variance; about 12% of the total variance is due to the inverted-U component, whereas the equation as a whole explains an additional 26%. While an inverted-backward-J curve is also characteristic of total works, the peak does not arrive in the same 5-year interval as found for total themes. By defining appropriate dummy variables for the consecutive 5-year intervals, it was found that the peak productive age falls in the period 45–49. There is obviously a considerable difference between a maximum in the late 40s and the maximum in the early 30s found for themes. This discrepancy may be explained by Beard's (1874) model by assuming that (a) pure thematic productivity requires a larger proportion of musical enthusiasm and (b) the production of larger forms requires a larger proportion of musical experience (for relevant evidence on this point see Lehman, 1953, Tables 10 and 11; Simonton, 1975a). At any rate, the discrepancy does not afford any basis for rejecting Hypothesis 1, especially since the productive decline again withstood control for physical illness. And because the age functions were estimated for each 5-year age period solely using those composers alive in that age period, the observed productive decline cannot be attributed to a compositional fallacy.

Disagreements. Still, there are three ways that results for total works depart significantly from those found for total themes. First, date has no relationship whatsoever with the number of works produced during each 5-year age period. Second, competition also has no relationship at all with the number of works produced during each age interval. And third, unlike the case for total themes, the posthumous-excess dummy variable *is* statistically significant for total works, $b = 193.44$; $\beta = .29$; $F(1, 85) = 8.70$, $p < .01$. This latter result signifies that a composer who died before completing his last 5-year age period produced fewer works than might be expected on the basis of the previous 5-year periods.

Yet the perplexing issue is why these three discrepancies appear between the two operationalizations of compositional productivity. I think the main causes are twofold. For one thing, the two indicators differ regarding the comprehensiveness with which they account for the composer's productivity. On the one hand, total works entails every single work

[4] Since Haefele (1962, pp. 235–236, 295) presented evidence for a secondary peak in the later years of life, a fourth-order polynomial age function was also tested, but no additional variance was explained over the second-order polynomial.

each composer produced no matter how esoteric, including such obscure works as compositions for glass harmonica and musical clocks. On the other hand, total themes includes only those themes from works sufficiently notable to be recorded on 78-rpm and long-playing disks (the criterion of the thematic dictionary used). And judging from the contrasting splits that resulted from applying the major/minor composition distinction, there can be little doubt that total themes is a more selective criterion than total works. This selectivity difference alone could account for some of the discrepancies. Certainly competition would be more prone to affect the likelihood of having one's compositions recorded by subsequent generations, but it would not be likely to influence the actual compositional productivity of any composer. Expressed differently, a composer is not likely to produce *less* when competition increases, yet he has no control over the fact that those works that are produced will be less able to edge out other competitors for the limited space in music libraries. Partial support for this explanation comes from the fact that if one looks at major works alone, competition does have a marginally significant negative impact, $b = -3.02$; $\beta = -.34$; $F(1, 85) = 2.982$, $p < .1$. This same difference in comprehensiveness may also help explain the discrepancy regarding the role of date. While it may be reasonable to expect the tendency to favor more modern-sounding themes to have an effect on what themes are recorded, it certainly would not be reasonable to expect the composer's total productivity to be so affected.

The second possible reason for the discrepancies may be the inherent contrast bebetween works and themes. As noted earlier, the peak productive age is later for total works than for total themes, a longitudinal difference that was ascribed to contrasting psychological demands. To produce great themes may require more emotional enthusiasm than experience, whereas to produce larger musical structures may require more experience than enthusiasm. Because total works peaks later, it may be more affected by the artificial problem of excess posthumous years in the terminal 5-year period.

Agreements. Fortunately, the three discrepancies discussed above do not have any direct bearing on the hypotheses being tested: Hypothesis 1 still stands and Hypothesis 2 still must be rejected in favor of Dennis's (1966) alternative model. Furthermore, the results for total works and total themes agree regarding the fate of the remaining four hypotheses. This additional consensus may be enumerated as follows:

1. Contrary to Hypothesis 3, social reinforcement has no apparent relationship with creative productivity, whether measured by total themes or by total works. However, one interesting point should be made about the time-wise distribution of such social reinforcement. This variable correlates .38 with age linear and .27 with age quadratic (for both, $p < .01$). Because these two age functions are themselves uncorrelated, this result signifies that the social reinforcements received by the 10 sampled composers are distributed in the form of a J curve over their productive careers. That is, the composers appear to have received most social rewards either early or late in their lives, with most honors coming in the later years. It may be speculated that the earlier burst of honors were given to child prodigies and the later burst to patriarchs, since a curiously similar function connects eminence and life span (Simonton, 1976a).

2. Biographical stress has no apparent relationship, linear or curvilinear, with either total works or total themes. So Hypothesis 4 must be rejected as well. Nonetheless, this null result has the asset of illustrating one of the virtues of a multivariate rather than bivariate analysis, since the zero-order correlations between biographical stress linear and either indicator of compositional productivity are positive and statistically significant (.22 and .27 for themes and works, respectively). Yet this correlation is the spurious outcome of the fact that biographical stress linear has a correlation of $-.33$ ($p < .01$) with age quadratic and consequently exhibits a definite inverted-U curve over each composer's life time. This spurious association disappears in the multiple regression equation, since age quadratic operates as a control variable when estimating the impact of biographical stress on

creative productivity (also see Simonton, 1976a, 1976e).

3. Contrary to Hypotheses 5 and 6, neither war intensity nor internal disturbances had any linear relation with the two productivity measures, whether themes or works. Since a pacifistic bias admittedly pervades both hypotheses, I thought it possible that the relationship might actually be curvilinear. Yet the quadratic terms for both political variables were also found to be unrelated to either total themes or total works (also see Naroll et al., 1971; Simonton, 1975c).

Controls. Two final observations are due regarding the several control variables. The first observation is that neither the dating bias dummy nor the Date × Dating Bias interaction was statistically significant. Accordingly, historians once again seem to have done a commendable job in providing dates, not favoring rounded-number estimates to any appreciable extent, even for earlier times (also see Simonton, 1975c). Second, the fact that the preproductive-excess dummy was not statistically significant for either productivity measure implies that the time-wise grid-work of consecutive 5-year age periods did not greatly violate each composer's ideographic uniqueness. The productivity in the first 5-year age period was usually so low that the fact that any particular composer did not begin productivity the year counting began has no practical consequence. As the posthumous-excess dummy demonstrated, only in the case of the last years of life can the superimposed analytical framework look artificial. So for the last 5-year age period the operationalization of a special dummy control variable has proven utility.

Discussion

The creative individual seems to exhibit a curious combination of dependence on and independence from the external world. On the one hand, creative productivity appears remarkably immune from a wide range of external forces. Such impersonal social factors as warfare and civil turmoil have no noticeable impact, nor do such personal influences as social honors and the tribulations of private life. On the contrary, we gain a picture of the creative genius as one whose productivity perseveres, no matter what the environment may bring in the way of rewards, anxieties, or distraction. Whatever the outside circumstances, creative productivity appears to be governed solely by a developmental age trend characterized by an inverted-backward-J curve. Only a biological limitation—physical illness—seems capable of dampening this overall time-wise movement. So, given this apparent disregard of the sociopsychological milieu, the creative process is perhaps driven more by intrinsic needs than by extrinsic pressures and constraints (also see Simonton, 1976e).[5]

On the other hand, the creative person does not appear to have much control over the ultimate social impact of his or her efforts. One case in point is the negative influence of competition: Even though competitors do not affect total productivity, they may lessen the probability that any given work will become famous. An even more outstanding instance, however, is the apparent verification of the constant-probability-of-success model (Dennis, 1966). In terms of the present sample, this result suggests that when a composer condescends to produce a rash of "pot boilers" or "pièces d'occasion" for monetary or promotional gains, the production of masterpieces is not necessarily sacrificed. Even more critically, this finding raises the issue of whether the creative genius even has much capacity to discern between major and minor works. Evidently, only posterity can make the final judgment, and therefore each creator is impotent to improve his or her chances of success with increased skill or maturity. Certainly illustrations of this impotence can be found among the subjects in the current inquiry. Thus Handel hoped to stake his fame on the merits of operas that are seldom heard today. And Beethoven's own favorites among his

[5] Here the discussion concentrates on the determinants of creativity during the productive period of an individual's life. Past research has shown that such social factors as political fragmentation, civil disturbances, political instability, and role-model availability can all affect the *developmental* period of a creator's life (Simonton, 1975c, 1976e, 1976f). But once the creative potential is thus acquired, the role of these external influences recedes into the background.

symphonies, sonatas, and quartets are not those most frequently performed and recorded by posterity. Hence, the creative genius seems unable to determine which works will earn future applause. All the creator can confidently do is to exploit the odds by being productive. Even if the chance of success remains constant, socially decided quality is at least a probabilistic consequence of personally motivated quantity.

Of course, I may have extrapolated a bit too far from a sample of only 10 composers. Even though some of the methodological problems may become more complicated, there is no reason why future research cannot attempt to replicate and extend the findings on samples of scientific, philosophical, literary, and artistic genius. Since only additional research can disclose the ultimate validity of the results, I would like to conclude with a brief statement regarding the broad usefulness of the statistical design employed in this paper. Essentially I have used what are known as *cross-sectional time series*, in which several subjects or cases are studied over a sequence of observations (Kmenta, 1971, pp. 508–517). In contrast, most research in psychology restricts attention to cross-sectional measurements at a single point in time. Yet as has been frequently suggested (e.g., Elms, 1975), it may be that many critical sociopsychological processes take years to unfold, thus necessitating a more longitudinal approach. Not only do cross-sectional time series provide such a longitudinal framework but, additionally, they add the advantage of generalizability not found in the single-subject time series so often substituted for cross-sectional designs (see Simonton, 1977). In other words, besides permitting assessment of time-wise movements within the lives of individuals, cross-sectional time series can estimate nomothetic effects across several cases. Thus a longitudinal framework does not have to be purchased with weakly tentative and perhaps idiographic conclusions.

Furthermore, cross-sectional time-series designs have rather broad substantive applicability. For example, creative productivity can be easily replaced by other dependent variables, including measures of political power or military leadership. Indeed, by exploiting content-analysis techniques, the study of the longitudinal determinants of personal motives or ideologies as reflected in letters and other biographical documents can be undertaken (see, e.g., Suedfeld & Rank, 1976). Moreover, cross-sectional time series are in no way confined to quasi-experimental archival studies, since multi-wave panel-survey data or time-sampled behaviors also fit well within this statistical paradigm. Cross-sectional time series can even be effectively employed for experimental designs with random case assignment and variable manipulation (Simonton, 1977). Hence, whatever the eventual substantive repercussions, I hope that this article offers a concrete illustration of a potentially valuable analytical perspective.

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Received January 12, 1977 ▪