Effects of intellectual variables, age, and gender on divergent thinking in adulthood

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Divergent thinking was assessed in 400 adult women and men with tests of word association (associational fluency) and alternate uses (production fluency, flexibility, and originality). The participants were from four age cohorts: young (17–22 years old), middle-aged (40–50), young-old (60–70), and old-old (75+). The test battery also included two intellectual "process" variables (inductive reasoning, memory span), one "dynamic resource variable" (intellectual speediness), one "structural resource variable" (vocabulary), and two moderator variables (depression, education). Hierarchical multiple regression analyses showed that divergent thinking was significantly, linearly, positively, and moderately related to all of these variables except depression, which was not significantly related to divergent thinking. Effects of age group and gender were assessed in analyses of variance (alpha = .01). The age groups did not differ significantly in associational fluency, but the middle-aged group was the best on production fluency, flexibility, and originality. Gender had a significant effect on only one variable: Women had higher depression scores than men.

The study reported in this paper dealt with divergent thinking. In Guilford's (1967) theory of intelligence, "divergent" thinking is contrasted with "convergent" thinking in the following way: Divergent thinking is related to creativity, as usually conceptualised (e.g., Simonton, 2000), in that both involve the production of a variety of new, original solutions to a problem. Divergent thinking is therefore useful for solving problems that do not have a single, objectively correct solution but rather have several potentially workable solutions whose originality or other kind of value can be assessed. Greater originality is expected if the production of ideas is fluent (many ideas are produced) and flexible (several categories of ideas are produced) (Guilford, 1967). In contrast, convergent thinking is intended to produce a single solution to a problem—not merely the subjectively best solution but the only objectively correct solution. Given this difference, tests of divergent thinking ask for the production of many alternative answers and tests of convergent thinking require arriving at a single true answer.

Several tests have been developed to assess divergent thinking, and although their usefulness has been challenged, the challenges can themselves be challenged. For example, Sternberg (1985) questioned the usefulness of divergent thinking tests, but he may have been reacting to only their face validity, which is usually a trivial aspect of a test. Barron and Harrington (1981) also questioned their usefulness and concluded that "some divergent thinking tests, administered under some conditions and scored by some sets of criteria", are valid "in some domains" (p. 447). However, on the basis of the evidence they cited, this conclusion seems to have been much too cautious. Although they stated that many studies failed to demonstrate construct validity, they did not specify the number and they cited no specific studies. In contrast, they referred to more than 75 studies that demonstrated construct validity, including more than 50 reviewed in an unpublished article they cited and 25 they specifically reviewed.

Four issues were addressed in the present study. The first issue was about the nature of divergent thinking. Research with children and young adults has shown that training in fluency or flexibility yields an increase not only in the trained process but also in originality—originality of physical constructions in preschool children (Holman, Goetz, & Baer, 1977) and verbal productions in college students (Meadow, Parnes, & Reese, 1959). These results imply that originality is intrinsically related to fluency and flexibility. However, Goff (1992) found that creativity training increased older adults' fluency and flexibility but not their originality, implying that originality is a separate dimension of divergent thinking.

Other findings indicate that divergent thinking is different from general intelligence but is correlated with general intelligence (McCrae, Arenberg, & Costa, 1987). The second issue addressed in the present study was whether divergent thinking is related to a different set of intellectual variables.

The third issue was how divergent thinking is related to age. More research has been done on age differences in creativity than divergent thinking, but the presumed relation of creativity to divergent thinking implies that the age differences should be similar. The creativity research seems to have begun with

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historical surveys in which biographies of persons identified as highly creative were studied to determine the ages at which they made their creative contributions. Creative contributions were found to decline with age (e.g., Dennis, 1966; Lehman, 1953; for reviews of these and similar studies, see Botwinick, 1984, chap. 19; Gilhooly, 1988, chap. 9). The approach in other research has been to look at the creative process rather than the products of this process (e.g., Alpaugh & Birren, 1977; Bromley, 1956; for a relevant review, see Kausler, 1991, pp. 619–625). Like the biographical research, this research has shown a decline in creativity with increasing age. Therefore, divergent thinking should also decline with increasing age (Kausler, 1991, p. 620). In agreement with this hypothesis, some research has shown that divergent thinking begins to decline in middle age (Alpaugh & Birren, 1977; Guilford, 1967; McCrea et al., 1987; Ruth & Birren, 1985). However, some other research has shown that the decline begins after middle age (Baltes & Lindenberger, 1997; Jaquish & Ripple, 1981; Schaie & Hertzog, 1983). In short, prior research had not settled the issue of how early in adulthood the decline begins (Denney, 1990).

The fourth issue investigated here was how divergent thinking is related to gender. Gender differences were not assessed in any study we located, and although gender differences in creativity were assessed in several studies, the results have been inconsistent (Osborn, 1963, p. 22). Some researchers found no statistically significant gender differences (Agarwal & Kumari, 1982; Alpaugh & Birren, 1977; Bromley, 1956; Jaquish & Ripple, 1981) and others found gender differences, sometimes favouring women (Bharadwaj, 1985) and sometimes favouring men (Ruth & Birren, 1985, but using a test evidently biased in favour of male-typical knowledge).

The foregoing overviews indicate that prior research had not definitively established the dimensionality of divergent thinking nor its relations to other intellectual variables, age, and gender during adulthood. The present study was designed to provide evidence about these relations by assessing four divergent thinking variables, four other intellectual variables, and two possible moderator variables in women and men from four adulthood age periods. The four intellectual variables were selected to represent two intellectual ''processes'', one ''dynamic resource'', and one ''structural resource'' (Salthouse, 1985, 1988). The process variables were inductive reasoning, which is an index of fluid intelligence (or fluid mechanics—Baltes, 1993), and memory span, which is an index of ''short-term acquisition and retrieval'' (Horn, 1978a, b). The dynamic resource variable was speed of mental processing (Horn, 1978a, b); and the structural resource variable was vocabulary, which indexes verbal knowledge or crystallised intelligence (or crystallised pragmatics—Baltes, 1993). The possible moderator variables were depression and amount of education, which have been shown to be related to cognitive performance (depression: e.g., La Rue, Dessonville, & Jarvik, 1985; Luszcz, Bryan, & Kent, 1997; education: e.g., Chi & Ceci, 1987) and which might fit the taxonomy of variables. Depression, or rather its absence, might be a kind of dynamic resource variable and education might index general knowledge, which is a kind of structural resource variable; because of these possible classifications—and for stylistic simplicity—we refer herein to depression and education as ''intellectual'' variables.

Except for depression and perhaps education, these variables reflect various kinds of convergent thinking and therefore we expected them to be positively related to but factorially independent of divergent thinking. This expectation was verified in our study by exploratory factor analyses and multiple regression analyses. The taxonomy also turned out to be consistent with the data in some other respects indicated in the Discussion section.

Method

Participants

The research participants were from a large-scale cross-sectional study of cognition conducted by Reese, Puckett, and Cohen in 1986–90. In this study, 400 adults were given a battery of 24 questionnaires, tests, and tasks divided equally between two sessions and given in a fixed order designed to minimise carry-over effects. The battery yielded scores on well over a hundred different variables. The participants were from four age cohorts defined by age at last birthday: 17–22, 40–50, 60–70, and 75 or more years old, here designated young, middle-aged, young-old, and old-old. The selection criteria were age and gender. Additional selection criteria would have been hearing, vision, reading, and health adequate for participation, but all except one of the volunteers met these criteria. The exception was a 99-year-old man who was included in the study despite visual problems; he was the oldest participant in the study and he took all the tests in the battery reported in this paper except Letter Sets (inductive reasoning) and Finding A's (intellectual speediness), which required better vision than he had.

No attempt was made to match the age/gender groups on education, health, or other variables that might influence performance. The reason is that matching, or ''control by equation'' (Baltes, Reese, & Nesselroade, 1988, pp. 216–218; Bitterman, 1960), must yield samples that are not representative of one or more of the age/gender populations (Krauss, 1980).

Demographic variables

Thirteen demographic variables were assessed via self-report (except where indicated otherwise in the following list) in a structured, face-to-face interview given as the first task in the first session. They are defined in the following list and the age group statistics for the 400 participants who took one or both of the divergent thinking tests are presented in Table 1.

(a) Age in years (to two decimal places) at the first testing session was used for correlations of age with other variables. Age in years at last birthday was used for assignment to age group.

(b) Gender (examiner's report).

(c) Current marital status.

(d) Predominant marital status during adulthood.

(e) Location of current residence (rural vs. urban).

(f) Location of usual residence during the preceding 10 years (rural vs. urban).

(g) and (h) Population (to nearest thousand according to a Rand–McNally atlas) of the Greater Metropolitan Area in which the participant (g) was currently residing and (h) had usually resided during the preceding 10 years (less than 500 was coded as 0, more than 998,499 was coded as 999).

Table 1
Demographic characteristics of the age groups

	Age group			
Variable	*Young*	*Middle-aged*	*Young-old*	*Old-old*
Sample size	100	92	113	95
Age mean (years)[a]	20.2	44.4	66.0	80.5
Age range (years)[a]	17–23	40–51	60–71	75–99
Gender: % women	50.0	53.3	55.8	52.6
Current marital status (%)				
Single	95	8	6	7
Married	3	66	65	42
Divorced	2	25	14	6
Widowed	0	1	15	45
Predominant marital status (%)				
Single	98	18	8	10
Married	2	70	80	73
Divorced	0	12	8	4
Widowed	0	0	4	13
Residence location (%)				
Currently urban	93	84	91	95
Usually urban	83	83	91	95
Population[b]				
Current residence	16	35	46	44
Usual residence	33	42	49	46
Current occupation (%)				
(1) Manager/Professional	1	22	6	3
(2) Tech/Sales/Service	38	36	17	6
(3) Worker	5	12	3	0
(4) Student/Houseperson	47	14	1	0
(5) Unemployed	9	15	4	0
(6) Retired	0	1	69	91
Career occupation (%)				
(1) Manager/Professional	1	28	38	41
(2) Tech/Sales/Service	14	33	32	27
(3) Worker	1	15	17	18
(4) Student/Houseperson	84	24	13	14
Drug status (%)[c]				
None	97	94	92	95
Sedative	0	4	6	3
Other	3	2	2	2
Drug done mean[d]	1.0	1.2	1.2	1.0
Health index mean	2.0	2.1	1.8	1.8

Note: See text for definitions of nonobvious variables.
[a]Age at first session. [b]Percentage of participants who were from urban areas with population greater than 250,000. [c]Percentage of participants per category. See Item (k) in the Method section for definitions. One young-adult record was eliminated because of examiner error. [d]Only for the 23 participants who reported possibly being currently affected by drugs. Possible range: 1 (''A little'') to 3 (''A lot'').

(i) Current and (j) career occupation. The categories used were: (1) *Manager/Professional*: Managerial & Professional Specialties (codes 3–199 in the *Standard Occupational Classification Manual*, 1980). (2) *Technical/Sales/Service*: Technical, Sales, & Administrative Support (codes 203–389) and Service (codes 403–469). (3) *Worker*: Farming, Forestry, & Fishing (codes 473–499), Precision Production, Craft, & Repair (codes 503–699), and Operators, Fabricators, and Laborers (codes 703–889). (4) *Student/Houseperson*: Full-time students and otherwise unemployed part-time students (all were in the Young group) and otherwise unemployed housepersons (1 in the Young group for Current, none for Career). (5) *Unemployed*: Not working but seeking employment. (6) *Retired*: Not working and not seeking employment. (The last three categories are not coded in the *Standard Occupational Classification Manual*.)

(k) Drugs taken and possibly affecting performance at the time of testing. The questionnaire included None and the

following categories and examples: (1) Sedatives: "Librium, Valium, etc."; (2) Alcohol: "beer, liquor, wine, etc."; (3) Tranquillisers: "Chlorpromazine, Haldol, etc."; (4) Sleeping pills: "Phenobarbital, Seconal, etc."; (5) Other: "Quaaludes, Marijuana, etc". Categories (2) through (5) are combined as "Other" in Table 1.

(l) Drug dose (1 = a little, 2 = a moderate amount, 3 = a lot). Table 1 gives data only for the 23 participants who reported being possibly affected by drugs at the time of testing.

(m) Health index (0 = poor, 1 = fair, 2 = good, 3 = excellent). The health index was the mean of three items: "How would you rate your health?" (Excellent, Good, Fair, Poor); "How much concern do you have about your health?" (Not concerned, Mildly concerned, Concerned, Very much concerned); and "How impaired are you in your everyday activities because of your health?" (None, Little, Some, A lot).

The data in Table 1 indicate that except for the gender distributions, the age groups were reasonably typical of the respective age-range populations. Details about residence and recruitment procedures are reported elsewhere (Reese, Lee, Cohen, & Puckett, 2000).

Other variables

Four intellectual variables other than divergent thinking and two moderator variables were assessed. They are identified in the following paragraphs and the mean scores of the age groups are presented in the Results section in the top panel in Table 4.

(a) *Inductive reasoning* was assessed with the Letter Sets test (Session 1, Task 3), using the standard scoring procedure (Eckstrom, French, Harman, & Derman, 1976). This test consists of 15 items, each with five four-letter sets; in four sets the letters are combined consistently with a rule (different for each item) and in the other set the combination is inconsistent with this rule. The participant is asked to find the rule and to identify the set that does not fit.

(b) *Memory span* was assessed with the forward and backward Digit Span tests from the Wechsler Adult Intelligence Scale–Revised (Session 1, Tasks 4 and 5), using the standard scoring procedure: 1 point for each correct trial, summed across the forward and backward tests (Wechsler, 1981). In our study the Pearson correlation between scores on the forward and backward tests was moderately strong, $r = .57$, $p < .0001$, and although it increased across age groups, the increase was nonsignificant, $r = .46, .52, .59, .64$, ps for adjacent age groups $> .50$, p for young versus old-old $> .07$.

(c) *Intellectual speediness* was assessed with the Finding A's test (Session 2, Task 1), using the standard scoring procedure (Eckstrom et al., 1976). This is a speed test in which the participant crosses out words that contain the letter "a"; the test has two parts, each with a 2-minute time limit for assessing 820 words arranged on four pages with five 41-word columns per page. The participant is informed that each column contains five words to be crossed out.

(d) *Vocabulary* was assessed with the vocabulary test from the WAIS-R (Session 1, Task 9), using the standard scoring procedure (Wechsler, 1981).

(e) *Depression* was assessed with the Center for Epidemiological Studies Depression Scale (Session 2, Task 10), using the standard scoring procedure (U.S. Department of Health, Education and Welfare, 1980). This scale is believed to be valid in the normal (nonclinical depression) range.

(f) *Education* was self-reported in the demographic interview (Session 1, Task 1) and was coded in years: 1–12 years through high school (12 years assigned for high school diploma or equivalent) plus 1–4 years of undergraduate college education (4 years assigned for bachelor's degree) plus 1–4 years of postgraduate education (4 years assigned for Ph.D., Ed.D., and M.D.; no participant had any other doctoral degree).

Divergent thinking variables

The divergent thinking variables were obtained from two tests: word association and alternate uses. Eleven of the 400 participants did not take the word-association test and 8 did not take the alternate uses test, but all 400 took at least one of these tests. The variables assessed with these tests are identified in the following paragraphs and the mean scores of the age groups are presented in the bottom panel in Table 4.

(a) *Associational fluency*, or "verbal productive thinking" (Horn, 1978a, b), was assessed with a 12-item word-association test constructed for this study (Session 1, Task 2). The stimulus items, in order of presentation, were *husband*, *answer*, *garden*, *hand*, *doctor*, *trouble*, *order*, *sweet*, *office*, *thief*, *problem*, and *table*, each with a 30-second time limit. The criteria for selecting the items were high frequency, at least one paradigmatic and one syntagmatic association within the first six associates in the Postman (1970) or Palermo and Jenkins (1964) association norms, and at least five associates within the first 90% of the associates (i.e., the relative frequency accumulated over the five most frequent associates was 90% or less). Each stimulus item was read to the participant and was printed on a card that remained visible throughout the 30-second response period. Responses were given orally and were tape recorded for later transcription. The score was the mean number of associations per item (total number of associations, divided by 12). For each item, only the first instance of a repeated association was counted.

(b) *Production fluency*, (c) *flexibility*, and (d) *originality* were assessed with a two-item "alternate uses" test (Session 2, Task 5). In this test, the participants were asked to respond first to "coat hanger" and then to "brick", giving "unusual uses" without an effective time limit for either item. Specifically, the participant was told, "I'm going to name an everyday object, and I'd like you to tell me as many unusual uses of the object you can think of". Three minutes were to be allowed for each item, with up to two prompts to continue if the participant stopped responding, but all participants received the two prompts and stopped responding a third time before three minutes had elapsed. The responses were tape recorded and later transcribed.

Details of the scoring procedures are given elsewhere (Reese et al., 2000). Briefly, the gists of the transcribed responses and the superordinate categories of the gists were identified and were counted to obtain, respectively, the *fluency* and *flexibility* scores. The total number of different gists identified was 1127 for coat hanger and 947 for brick; the total number of different superordinate categories identified was 14 for coat hanger and 16 for brick. Examples for coat hanger are the transcribed responses "Make an antenna for a car radio" and "Hook it up to the radio and use it as an antenna". The gists were identified as "Car antenna" and "Radio antenna" and the superordinate category was identified as "Equipment", which for a coat hanger was defined as an object that functions passively or that

is acted on in the course of some use. Examples for brick are the transcribed responses ''Use it to chock a car wheel'' and ''Put it behind a wheel or something, you know, to keep things from rolling''. The gists were identified as ''Car chock'' and ''Keep things from rolling'' and the category was identified as ''Instrument'', which for a brick was defined as an object used to aid some action or used with some other object.

Originality was scored on the basis of the statistical unusualness of subordinate-level categories (Mervis & Rosch, 1981) of the gists rather than on the basis of the statistical unusualness of the gists themselves, which we believed might be too closely associated with vocabulary size. The data confirmed this belief and the effectiveness of our solution; as indicated later (in Table 3), vocabulary was significantly related to production fluency, which is based on gists, and was not significantly related to originality based on subordinate-level categories of gists. We used subordinate-level categories because superordinate categories are too general for assessing originality. Examples of subordinate-level categories are ''Antenna'' for ''Car antenna'' and ''Radio antenna'' and ''Chock'' for ''Car chock'' and ''Keep things from rolling''. The number of participants in the overall sample who used each subordinate-level category was counted and this number was assigned to each subordinate-level category that a participant used. The participant's originality score was based on the sum of these numbers, divided by the number of subordinate-level categories the participant used. The score that was recorded and analysed was the complement of this quotient, so that higher scores indicated more originality.

Procedure

The participants were tested individually in two sessions about two or three days apart (range = 0 to 9 days); the means were 1.97, 2.42, 2.52, and 2.77 days for the respective age groups. On average, each session lasted about an hour or two (range = 0.8 to 4.6 hours); the Session 1 means were 1.47, 1.57, 1.61, and 1.64 hours for the respective age groups and the Session 2 means were 1.54, 1.73, 1.80, and 1.79 hours (session durations were recorded for only about two-thirds of the participants). The only statistically significant correlations of these procedural variables with the divergent thinking variables were negligible—Session 2 duration correlated $-.184$ ($p < .004$) with associational fluency and .148 ($p < .020$) with originality (largest other $|r| = .075$, $p > .24$).

Results

Because of the large sample size, the probability of a Type I error was set at .01 except for tests of simple effects, for which it was set at .05 (Reese, 1970).

Preliminary analyses

Reliabilities of the divergent thinking measures. The scoring of production fluency and flexibility required some subjective coding decisions; therefore, the inter-scorer reliabilities (Pearson correlations) were assessed with a 22% sample of the protocols scored by independent scorers. For the coat hanger and brick items, respectively, they were .95 and .89 for production fluency and .88 and .90 for flexibility.

The scoring of originality had a subjective aspect—identification of the subordinate-level categories of the gists—but this aspect occurred in the development of a dictionary of subordinate-level categories. The dictionary (in Reese et al., 2000) was developed by a joint effort of the four investigators and a graduate research assistant. After the dictionary had been developed, the scoring of originality was completely objective because the dictionary gave the subordinate-level category for each of the 2074 gists that were identified.

Internal consistency reliabilities of the four divergent thinking measures were also assessed. The index used for associational fluency was Cronbach's alpha based on the fluency scores counted separately for each of the 12 items; the index used for production fluency, flexibility, and originality was the Pearson correlation between the scores for the coat hanger and brick items, corrected with the Spearman–Brown formula. All of the obtained internal consistencies were statistically significant (ps $< .001$). The internal consistencies for associational fluency (.93), production fluency (.83), and flexibility (.71) were high and fully adequate. The internal consistency for originality was low (.40), but still at a level judged to be adequate when sample sizes and group differences are large, as in the present study (Thorndike & Hagen, 1955, pp. 139–140). Thus, the tests provided internally consistent information, though less so for originality than for the other three divergent thinking variables.

Dimensionality of divergent thinking. We used two steps to test the assumption that associational fluency and production fluency, flexibility, and originality are aspects of a single kind of thinking that is different from other intellectual abilities. In the first step, we ran an exploratory factor analysis (principal components with varimax rotation and Kaiser normalisation), which showed that the four putative divergent thinking variables constituted one factor and that the other six intellectual variables constituted other factors (for details, see Reese et al., 2000). Consistent with these results, hierarchical multiple regression analyses, summarised in the next subsection, showed that three of the four divergent thinking variables were significantly but only moderately related to five of the other six intellectuals variables.

In the second step, we tested the linearity and strength of relations among the divergent thinking variables, using hierarchical multiple regression analyses in which the age groups were combined and the linear, quadratic, and cubic components of each ''independent'' variable were entered in that sequence. The results are summarised in Table 2. All of the obtained correlations were positive, as expected, but not all were linear. (a) Associational fluency and (b) originality were linearly related to each of the other three divergent thinking variables, (c) production fluency was curvilinearly related to the other three, and (d) flexibility was linearly related to associational fluency and originality and curvilinearly related to production fluency. The presence of curvilinear relations indicates that these variables constitute separate dimensions of divergent thinking.

Relations of divergent thinking to other intellectual variables

The linearity of relations among variables is often not tested in correlational research. However, testing it is important because although the usual index of relation—the Pearson correlation coefficient—is a valid estimate of the accuracy of prediction

Table 2
Hierarchical regression tests of linearity of relations among the divergent thinking variables

Criterion variable	*Component*	*R*	*Increment in R^2*	*F change*[a]	*df*	*p*
Relations with associational fluency						
Production fluency	Linear	.423	.179	82.84	1, 379	.001
Flexibility	Linear	.451	.204	97.04	1, 379	.001
Originality[b]	Linear	.279	.078	31.87	1, 379	.001
Relations with production fluency						
Associational fluency	Linear	.423	.179	82.48	1, 379	.001
	Quadratic	.462	.035	16.82	1, 378	.001
Flexibility	Linear	.884	.782	1400.09	1, 390	.001
	Quadratic	.906	.039	84.35	1, 389	.001
	Cubic	.909	.006	13.42	1, 388	.001
Originality	Linear	.465	.216	107.45	1, 390	.001
	Quadratic	.485	.019	9.53	1, 389	.003
Relations with flexibility						
Associational fluency	Linear	.451	.204	97.04	1, 379	.001
Production fluency	Linear	.884	.782	1400.09	1, 390	.001
	Quadratic	.895	.019	37.59	1, 389	.001
Originality	Linear	.469	.220	109.82	1, 390	.001
Relations with originality						
Associational fluency	Linear	.279	078	31.87	1, 379	.001
Production fluency	Linear	.465	.216	107.45	1, 390	.001
Flexibility	Linear	.469	.220	109.82	1, 390	.001

Note: Data are included only for components that significantly increased R^2 (alpha = .01).
[a]F for increment in R^2. [b]For the quadratic component, $R = .295$; increment in $R^2 = .009$; p for increment in $R^2 = .049$.

whenever a linear prediction equation is used, it is a valid estimate of the strength of relation only if the true relation is linear (e.g., Blommers & Lindquist, 1960). In the present study, the linearity and strength of relations among the variables were tested with hierarchical multiple regression analyses in which the age groups were combined and the linear, quadratic, and cubic components of each independent variable were entered in that sequence. These analyses are summarised in the first six panels in Table 3. Depression was not significantly related to any of the divergent thinking variables, but the other intellectual variables were significantly related to all except originality. All of the significant relations were moderate, linear, and positive. The strongest relations were for vocabulary (the mean of the significant correlations was 0.309), followed closely by education (mean 0.275) and inductive reasoning (mean 0.273) and less closely by intellectual speediness (mean 0.210) and memory span (mean 0.186).

Relations of variables to age and gender

Variables other than divergent thinking. The top panel in Table 4 shows the age group means on the six intellectual variables other than divergent thinking. The pairwise differences in this panel (and the bottom panel) were assessed with Fisher's LSD test; the Newman–Keuls, Sheffé, and Tukey tests are more popular, but they are too conservative with respect to Type II errors (Reese, 1970). As can be seen, the main effect of age group was significant for all six variables. Vocabulary and education peaked in middle-age and the means for the other four variables were highest in the young group and generally decreased steadily thereafter.

The main effect of gender was significant only for depression ($p < .0001$); women had a higher mean (13.58) than men (9.28). However, the main effect of gender "approached" significance for memory span, $F(1, 392) = 5.44$, $p < .021$, favouring men (14.72 vs. 13.84), and for intellectual speediness, $F(1, 391) = 6.16$, $p < .014$, favouring women (52.81 vs. 49.48) (smallest other $p > .06$). The age group by gender interaction was not significant for any of the variables (smallest $p > .10$).

Divergent thinking variables. The bottom panel in Table 3 shows hierarchical multiple regressions of the divergent thinking variables on age. As can be seen, associational fluency was significantly related to the linear component of age and had virtually no relation to the quadratic component of age. In contrast, production fluency, flexibility, and originality had no significant relation to the liner component of age but were significantly related to the quadratic component of age. The least-squares regression equations—linear for associational fluency and curvilinear for the other variables—are shown graphically in Figure 1, with divergent thinking scores transformed into standard scores ($M = 50$, SD = 10). As can be seen, the regression line for production originality was somewhat different from the lines for production fluency and flexibility, which were virtually identical, and all three of these lines reflect stronger age differences than the straight line for associational fluency.

To assess the joint effects of age and gender on divergent thinking, we began with a multivariate analysis of variance including all four divergent thinking variables. This analysis revealed significant main effects of age group and gender and

Table 3
Hierarchical regression tests of linearity of relations of the six intellectual variables and age with the four divergent thinking variables

Criterion variable	*Component*	*R*	*Increment in R^2*	*F change*[a]	*df*	*p*
Relations with inductive reasoning						
Associational fluency	Linear	.280	.078	31.63	1, 372	.001
Production fluency	Linear	.256	.066	26.40	1, 375	.001
Flexibility	Linear	.281	.079	32.08	1, 375	.001
Originality	Linear	.064	.004	1.54	1, 375	.22
Relations with memory span						
Associational fluency	Linear	.177	.031	12.48	1, 387	.001
Production fluency	Linear	.181	.033	13.27	1, 390	.001
Flexibility	Linear	.199	.040	16.14	1, 390	.001
Originality	Linear	.018	.000	< 1.00	1, 390	.73
Relations with intellectual speediness						
Associational fluency	Linear	.277	.077	32.19	1, 386	.001
Production fluency	Linear	.172	.029	11.81	1, 389	.001
Flexibility	Linear	.180	.033	13.10	1, 389	.001
Originality	Linear	.101	.010	4.00	1, 389	.05
Relations with vocabulary						
Associational fluency	Linear	.312	.097	40.60	1, 376	.001
Production fluency	Linear	.284	.081	33.28	1, 379	.001
Flexibility	Linear	.332	.110	46.97	1, 379	.001
Originality	Linear	.058	.003	1.29	1, 379	.26
Relations with depression						
Associational fluency	Linear	.050	.002	< 1.00	1, 381	.34
Production fluency	Linear	.058	.003	1.31	1, 384	.26
Flexibility	Linear	.057	.003	1.26	1, 384	.27
Originality	Linear	.023	.001	< 1.00	1, 384	.66
Relations with education						
Associational fluency	Linear	.335	.112	48.93	1, 387	.001
Production fluency	Linear	.235	.053	22.77	1, 390	.001
Flexibility	Linear	.255	.065	27.20	1, 390	.001
Originality	Linear	.042	.002	< 1.00	1, 390	.42
Relations with age						
Associational fluency	Linear	.131	.017	6.71	1, 387	.010
	Quadratic	.134	.001	< 1.00	1, 386	.56
Production fluency	Linear	.070	.005	1.90	1, 390	.17
	Quadratic	.229	.052	19.52	1, 389	.001
Flexibility	Linear	.095	.009	3.59	1, 390	.06
	Quadratic	.235	.055	19.00	1, 389	.001
Originality	Linear	.090	.008	3.16	1, 390	.08
	Quadratic	.162	.026	7.30	1, 389	.007

Note: Data for linear component are included regardless of statistical significance. Data for quadratic and cubic components are included only if increment in R^2 was significant (alpha = .01), except for quadratic component of age (bottom panel).

no significant age group by gender interaction: respectively, Pillai's trace = 0.139, 0.041, 0.033; multivariate $F(12, 1125; 4, 373; 12, 1125) = 4.54, 3.99, 1.03$; $p < .001, <.004, >.41$. In follow-up analyses, each divergent thinking variable was analysed in a separate univariate analysis of variance with age group and gender as independent variables.

The univariate analyses of variance revealed significant main effects of age group for production fluency and flexibility, but not for originality and associational fluency (production fluency: $F(3, 384) = 7.63$, $p < .001$; flexibility: $F(3, 384) = 7.73$, $p < .001$; originality: $F(3, 384) = 3.38$, $p < .019$; associational fluency; $F(3, 381) = 2.79$, $p = .041$). For both of the latter variables, however, the main effect of age group met a lenient criterion of significance (alpha = .05) and the regression analysis (Table 3) indicated strictly significant relations to age. We therefore analysed the simple effects for these variables as well as for production fluency and flexibility.

The age group means are shown in the bottom panel in Table 4. As can be seen, the young group exhibited more associational fluency than the other age groups, but the difference was significant only for the young versus old-old contrast. The table also shows that production fluency, flexibility, and originality were greatest in the middle-aged group and least in the old-old group, but that not all of the

Table 4
Age group means (and standard deviations) on the intellectual and divergent thinking variables

	Age group				
Variable	*Young*	*Middle-aged*	*Young-old*	*Old-old*	*p*
Intellectual variables					
Inductive reasoning	20.08^{x}	17.09^{x}	12.39^{x}	7.16^{x}	.0001
	(5.18)	(5.58)	(5.78)	(4.06)	
Memory span	15.74^{xy}	14.49^{x}	14.30^{y}	12.60^{xy}	.0001
	(3.90)	(4.06)	(3.74)	(3.85)	
Intellectual speediness	57.40^{x}	54.30^{y}	48.73^{xyz}	44.14^{xyz}	.0001
	(14.15)	(13.83)	(12.56)	(13.11)	
Vocabulary	49.63^{xy}	56.38^{xz}	54.11^{y}	52.16^{z}	.004
	(12.40)	(11.49)	(13.64)	(13.27)	
Depression[a]	14.73^{xyz}	11.05^{x}	9.61^{y}	10.32^{z}	.0001
	(8.95)	(10.30)	(7.24)	(8.10)	
Education (years)	13.19	14.03^{x}	13.68^{y}	12.63^{xy}	.010
	(1.71)	(2.82)	(3.11)	(4.06)	
Divergent thinking variables					
Associational fluency[b]	6.43^{x}	6.20	6.08	5.60^{x}	.041
	(2.38)	(2.11)	(1.98)	(2.02)	
Production fluency	5.66^{x}	7.35^{xy}	6.30^{y}	4.91^{y}	.0001
	(3.84)	(4.51)	(3.28)	(2.52)	
Flexibility	3.56^{x}	4.21^{xy}	3.70^{y}	3.18^{y}	.0001
	(1.63)	(1.69)	(1.31)	(1.15)	
Originality[b]	17.82^{x}	22.22^{y}	20.38^{z}	7.90^{xyz}	.019
	(38.2)	(29.1)	(29.7)	(37.8)	

Note: (1) Means with the same superscript letter within a row were significantly different from each other (alpha < .05). (2) The last column contains the probability of the main effect of age group in age group × gender analyses of variance. (3) Each age group mean is the mean of the male and female subgroup means, unweighted by subgroup size. (4) Standard deviations are in parentheses.

[a]High score indicates strong depression (maximum = 60). [b]The tests of simple effects were statistically unjustified because the main effect was nonsignificant.

pairwise differences were significant. For production fluency and flexibility, (a) the middle-aged group had significantly higher means than each of the other age groups and (b) the young-old group had significantly higher means than the old-old group, but (c) the young group was significantly different from only the middle-aged group. For originality, the old-old group had a significantly lower mean than each of the other age groups, which did not differ significantly from one another.

The univariate analyses of variance also revealed that the main effect of gender was not significant for any variable, although it met a lenient criterion of significance for associational fluency, on which women outscored men (6.32 vs. 5.79), $F(1, 381) = 6.16$, $p < .014$; smallest other $p > .38$. The age group by gender interaction was nonsignificant in all four analyses, smallest $p > .15$.

Discussion

This study dealt with the nature of divergent thinking in adulthood and its relation to other intellectual variables, age, and gender. These issues are discussed in that order.

Dimensions of divergent thinking

Our results are consistent with the implication of Goff's (1992) study that divergent thinking consists of separate dimensions. On the one hand, our exploratory factor analyses (Reese et al., 2000) showed that originality was a dimension of divergent thinking, not only in the combined age groups but also in each of the separate age groups. Also, like production fluency and flexibility it was curvilinearly related to age (Table 3). On the other hand, it was different from the other dimensions of divergent thinking: Unlike the other dimensions, it was not significantly correlated with any of the six other intellectual variables (Table 3) and unlike production fluency and flexibility, it exhibited only a "marginally" significant main effect of age group in the age group by gender analyses of variance (Table 4).

Relations to other intellectual variables

As expected, divergent thinking was found to be different from the other intellectual variables but related to them. The strongest relations of divergent thinking were with the "structural resource" variables—vocabulary and perhaps education—for which the mean of the significant correlations (Table 3) was .292, and the two "process" variables: inductive reasoning and memory span (mean 0.229). The relations with the "dynamic resource" variables were weaker. Intellectual speediness had some relation (mean 0.210); but depression, the absence of which we tentatively classified in this category, was not significantly related to divergent thinking. The last result was unexpected, but its generality is as yet unknown. Lewinsohn, Seeley, Roberts, and Allen (1997) found no relation of depression to a composite of cognitive tests in older adults (50–96 years), but Luszcz et al. (1997) obtained significant relations to memory abilities in very old adults (70–96 years).

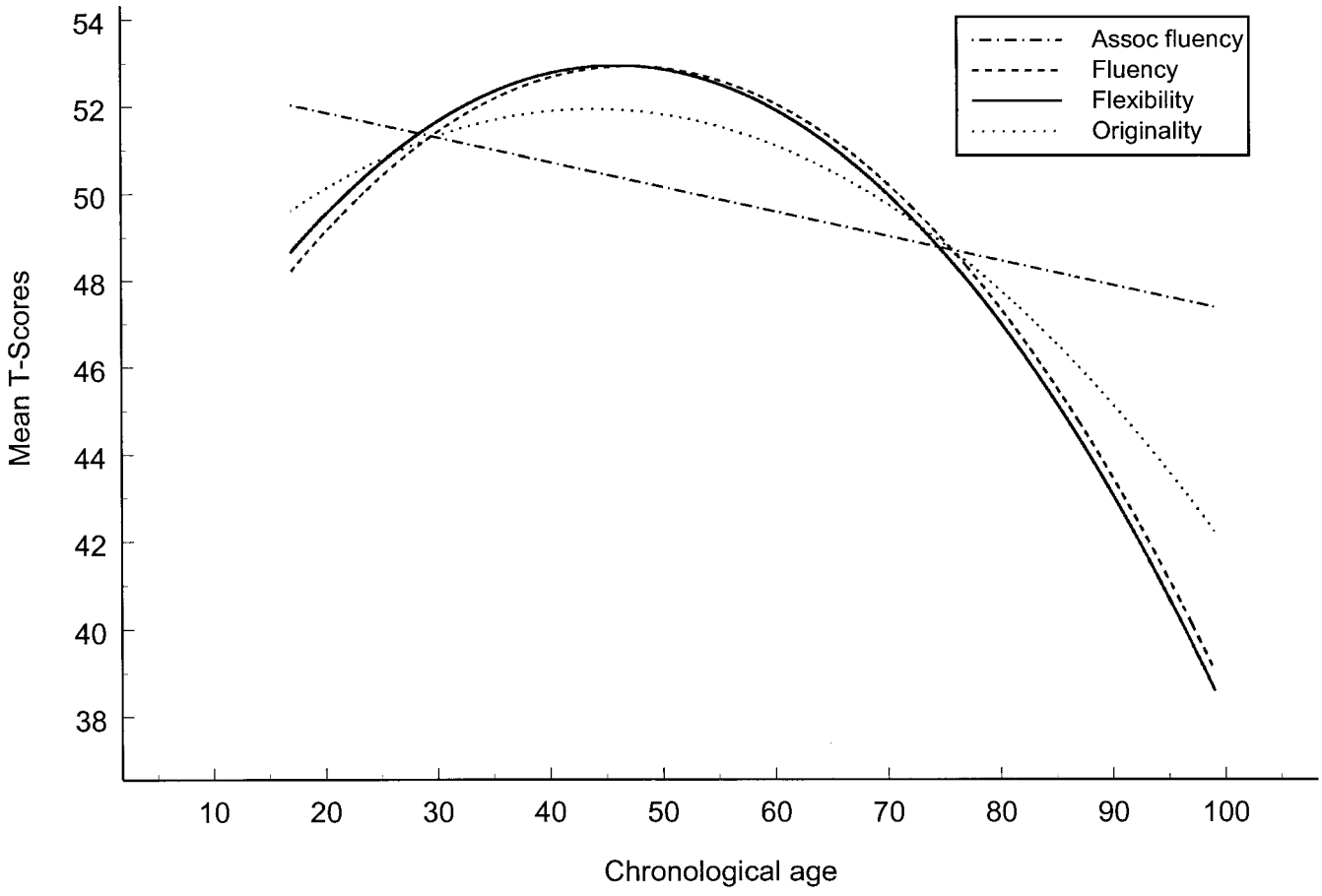

Figure 1. Plots of regressions of divergent thinking on age. The divergent thinking scores were standardised with means of 50 and standard deviations of 10; the curves were derived from statistically significant components of age (Table 3) as predictors in least-squares regression equations—linear for associational fluency and curvilinear for production fluency, flexibility, and originality.

Relations to Age

We found marked age group differences in divergent thinking as reflected by production fluency and flexibility, but not as reflected by originality and associational fluency, for which the main effect of age group did not meet our conservative criterion of significance (Table 4). However, both of the latter variables were positively and significantly correlated with age (Table 3). Production fluency, flexibility, and originality were curvilinearly related to age, but associational fluency was linearly related to age (Tables 3 and 4). Baltes and Lindenberger (1997) also obtained a curvilinear relation of associational fluency to age in a sample comparable to ours in size ($N = 315$) and age range (25–101 years) but different in nationality (German) and—presumably more importantly—with different measures of associational fluency (Baltes and Lindenberger did not assess divergent production).

For production fluency, flexibility, and originality, two major kinds of age group differences emerged: First, the middle-aged group had the largest mean on these variables, although not significantly larger in some comparisons; and second, the old-old group had the lowest mean on these variables, although not significantly lower in some comparisons. The curves for production fluency, flexibility, and originality (Figure 1) show these age differences very clearly. The peaking of divergent thinking in middle age is consistent with the findings of Jaquish and Ripple (1981), and the decline after middle age is in addition consistent with the findings of Lehman (1953), Guilford (1967), Alpaugh and Birren (1977), and McCrae et al. (1987).

Given that fluid intelligence increases until early middle age and then declines (e.g., Schaie & Labouvie-Vief, 1974), the age trends might suggest that divergent thinking is a kind of fluid intelligence. We included only one marker of fluid intelligence—inductive reasoning—and inconsistent with this suggestion, it was somewhat less strongly correlated with divergent thinking than was crystallised intelligence (indexed by vocabulary).

Relations to gender

Some previous research indicated gender differences in verbal creativity, especially for young participants. In the present study, however, gender had no significant effect on any divergent thinking variable, although it "approached" significance on associational fluency ($p < .014$). The interaction between gender and age group did not even approach significance for any variable. Thus, in the heterogeneous population that was sampled in the present study, gender is evidently not an important determinant of divergent thinking and not an important moderator of the effect of age on divergent thinking.

Conclusions

Measures of divergent thinking consist of at least three dimensions, or outcome variables—fluency, flexibility, and originality. Fluency and flexibility are highly correlated with each other and only moderately correlated with originality; therefore, fluency and flexibility presumably reflect mental operations that are at least highly similar and different from the mental operations underlying originality. Whatever these operations are, they evidently correlate moderately with structural resource variables and process variables, and less so with dynamic resource variables. This generalisation seems to be valid, at least with respect to the variables assessed in this study, because the sample size was relatively large and the demographics of the age-group samples were representative of the respective age-group populations.

Gender differences in divergent thinking are evidently negligible, but age-group differences are large. The age-group similarities and differences obtained in this study suggest that the operations underlying divergent thinking are the same at all adult ages but vary with age in how effectively or efficiently they are used. Specifically, effectiveness or efficiency peaks in middle age and declines markedly especially in the later portion of old age. The decline in old age is expectable, given its ubiquity in other research; but the peak in middle age is an important finding because except for vocabulary, which is a structural resource variable, most other cognitive variables exhibit statistically significant peaks in early adulthood, as in this study.

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