Person. individ. Diff. Vol. 6, No. 5, pp. 621–629, 1985
Printed in Great Britain.

0191-8869/85 $3.00 + 0.00

SPEED OF INFORMATION PROCESSING IN ACADEMICALLY GIFTED YOUTHS

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(*Received* 3 *December* 1984)

Summary—A group of bright–average 7th grade junior-high-school students was contrasted with a group of manifestly academically gifted students of comparable age who were taking college-level courses in mathematics and science. The groups differed significantly and markedly (showing an overall mean difference of 1.34 SD) on every one of the nine different reaction-time (RT) tasks measuring the speed with which persons perform various elementary cognitive processes. The results indicate that: (1) various RT measurements discriminate about as much between intellectually average and superior groups as past studies have found RT measurements to discriminate between average and subnormal groups; and (2) the academically gifted differ from their nongifted age-peers in more than just scholastic knowledge and advanced problem-solving skills—they differ fundamentally in speed of information processing on extremely simple cognitive tasks with average response latencies of between 0.3 and 1.5 sec.

INTRODUCTION

Since 1979, Jensen and coworkers have conducted a series of studies investigating the relationship between speed of information processing, as measured by various reaction-time (RT) tasks, and standard psychometric measures of general intelligence—for a review, see Jensen (1982a, b). Significant correlations were consistently found between response latencies and intraindividual variation in RT for the information-processing variables and psychometric *g*. In addition, quite impressive mean differences in RTs have been found between 'natural' groups that fall in different (although often overlapping) regions of the normal distribution of intelligence. By 'natural' groups is meant groups which are not primarily selected on the basis of psychometric test scores, but which incidentally differ in mean IQ. Such groups studied have been the institutionalized retarded (Jensen, Schafer and Crinella, 1981), sheltered workshop *S*s of low borderline intelligence (Vernon, 1981), unskilled manual workers (Sen, Jensen, Sen and Arora, 1983) and vocational college students and university students (Vernon, 1983; Vernon and Jensen, 1984). Some of the same RT paradigms have also been used with preschool children (Telzrow, 1983) and with school children in different grades (Jensen and Munro, 1979; Carlson and Jensen, 1982; Carlson, Jensen and Widaman, 1983).

The present study includes still another 'natural' group: manifestly academically gifted youths, who, at 12–14 yr of age, are succeeding in college courses in mathematics and science. They are contrasted with their age peers in the 7th grade in junior high school.

A two-faceted question of theoretical interest has prompted this study. Most previous studies of RT and intelligence have contrasted groups of average or superior intelligence with groups of various degrees of subnormal ability. Although marked differences in mean response latencies have been found between such groups, there has been a lingering doubt that similar discrimination would be found between groups at the average and at the upper extreme of the intelligence distribution. It has been a common view that the relationship between speed of information processing in elementary cognitive tasks and general intelligence, as conventionally measured, is a threshold phenomenon—that above some rather average level of basic information-processing capacity, variation in mental speed is no longer an important feature of intellectual prowess. According to this view, the essential difference between students who are considered as academically 'average' and those who are considered as 'gifted' is a difference in the amount of scholastic knowledge and specific high-level problem-solving skills and strategies that they possess largely as a result of differences in opportunity for learning outside of school, academic interests and study habits.

Hence, academically gifted children would be seen as being like the average in basic information-processing capacity, but with something extra in the way of special knowledge and high-level skills added on at the top, so to speak. We were interested, therefore, in discovering the extent to which children who are manifestly superior in academic aptitude and achievement differ from their academically average age-mates in a variety of very elementary cognitive tasks, which are so simple that individual differences in performance can be measured reliably only in terms of *speed* of information processing, as indexed by response latency or RT. Since these tasks contain virtually nothing in the way of intellectual or scholastic content, it is unlikely that complex problem-solving strategies are involved. The extreme easiness of the tasks is seen in the fact that the average latencies, or response times, range between about 0.3 and 1.5 sec, and the error rates are practically negligible. [Previous studies have shown no significant correlations between individual differences in speed and accuracy on any of the speed-of-processing tasks used in this study (e.g. Vernon, 1983).]

METHOD

Subjects

Gifted (*G*)

The G group consisted of 60 *S*s with a mean age of 13 yr 6 months (SD = 1 yr 3 months). At junior-high-school age these *S*s obtained scores on the Scholastic Aptitude Test (SAT) which were approximately at the national average for college freshmen, who, on average, are 4–5 yr older. The G group was recruited as volunteers from the *S* pool selected for the Project for the Study of Academic Precocity. These academically gifted youths are successfully completing college-level courses in mathematics and science. They are a highly selected group representing the top 2–3% of the public schools population in academic aptitude. This is roughly equivalent to IQs above 130.

Nongifted (*NG*)

The NG group of 70 *S*s had a mean age of 13 yr 2 months (SD = 5 months). The NG *S*s were selected without reference to ability from a junior high school in a predominantly white middle- and upper-class neighborhood. As a group, they were above average in scholastic achievement, showing scores on the California Test of Basic Abilities (CTBA) approx. 1 SD above the statewide norms.

The G and NG groups did not differ significantly in mean age ($t = 1.69$, $P > 0.05$).

Psychometric Tests

The Raven *Standard Progressive Matrices* (SPM) was given without time limit to *S*s in groups G and NG.

The *Scholastic Aptitude Test*, Verbal and Mathematics (SAT-V and SAT-M) and the *Test of Standard Written English* (TSWE) were obtained only in group G. Standardized scores on the three tests were combined into a composite score, PRED, developed as a predictor of academic performance in college mathematics and science in the Study of Mathematically Precocious Youth: PRED = 2 × SAT-M + SAT-V + 0.5 × TSWE.

The Mathematics and Reading Comprehension subtests of the CTBA were obtained only in group NG.

Speed-of-information-processing Tasks

The identical battery of speed-of-processing tasks was used in previous studies by Vernon (1983) and Vernon and Jensen (1984). In addition, the Sentence Verification Test, used by Vernon (1985), was included. To insure direct comparability of all the speed-of-processing measurements, the same RT apparatus and procedures were used in testing the G and NG groups; these apparatus were also used in the Vernon and Jensen studies. The nine information-processing tasks are described here briefly. The code label for each task, shown in parentheses, is consistent with previous publications.

Short-term memory scanning (DIGIT)

Using a test developed by Sternberg (1966), each *S* is shown a string of from 1 to 7 digits for 2 sec on the display screen of a response console connected to a Rockwell AIM 65 microcomputer. After a 1-sec interval, a single probe digit appears and the *S*'s task is to indicate as quickly as possible whether or not the probe was a member of the string of digits that had previously appeared. The *S* responds by raising his index finger from a central 'home' button on the response console and pushing one of two other buttons, labeled 'yes' and 'no', respectively. *S*'s *reaction time* (RT) is automatically recorded as the speed with which his finger was removed from the 'home' button after a probe digit appeared. [The interval between releasing the 'home' button and pushing a response button was automatically recorded as *movement time* (*MT*).] Altogether, 84 digit strings were presented, in a random order with respect to their length and whether they required a 'yes' or a 'no' response.

Physically same–different words discrimination (SD2)

In this binary (hence 2) *same* vs *different* choice discrimination task, the *S* is shown 30 pairs of common words on the display screen of the same response console used in the previous test. The words are either 'same' or 'different', that is, the words are literally, or physically, the same or different (e.g. DOG–DOG or DOG–LOG). In each test, half the word-pairs are the same and half are different. The *S*'s task is to respond to the words as quickly as possible by moving his index finger from the 'home' button and pushing one of the two response buttons, now labeled 'same' and 'different'. RTs and MTs are recorded as in the DIGIT test.

Synonyms–antonyms discrimination (SA2)

In this binary choice discrimination task, the *S* is shown 26 pairs of common words. In half of the pairs the words are of highly similar meaning, or synonyms (e.g. BIG–LARGE) and in half the pairs, the words are of roughly opposite meaning, or antonyms (e.g. HOT–COLD). All of the words are common, high-frequency words, so that when the pairs are given as an untimed paper-and-pencil test to school children in the age range of those in the present study, there is virtually error-free performance by all *S*s. In this task, the *S* responds in the same manner as in the SD2 task.

Dual tasks (DT2 and DT3)

These tasks are intended to test the efficiency of short-term memory (STM) storage and information processing. This test combines the stimuli of the previous tests. The *S* is presented with a string of 1–7 digits (for 2 sec), which he is told to rehearse for later recall. When the digits leave the screen, they are replaced by a pair of words to which the *S* responds on the pushbutton console as being either 'same' or 'different'. After responding, the *S* presses down the 'home' button again, which triggers the appearance of a single probe digit. *S* then responds 'yes' or 'no' to indicate whether the probe was a member of the string of digits that appeared before the words. *S*'s RTs and MTs to both the words and the digits are recorded. Hence there are four types of RT measurements in these dual tasks:

DT2-DIGIT is the RT to the probe digit when it is presented after the *S* has responded to a physically same or different word pair;

DT3-DIGIT is the RT to the probe digit when it is presented after the *S* has responded to a synonym or antonym word pair;

DT2-Words is the RT to the physically same–different word pairs when they appear in the dual task;

DT3-Words is the RT to the synonym–antonym task when it appears in the dual task.

Simple and choice RTs

This test has been used extensively by Jensen (e.g. 1979, 1982a, b; Jensen and Munro, 1979). The apparatus for the test is a response panel with a central 'home' button and 8 lights and buttons arranged in a semi-circle of 6″ radius around the 'home' button. The *S* presses down the 'home' button, hears a warning 'beep', and waits (for a random interval of 1–4 sec) for one of the 8 lights to come on. As soon as one of the lights does go on, *S* removes his index finger from the 'home' button and presses the button adjacent to the light. The *S* is instructed to do this as quickly as possible on each of 60 trials: 15 trials each with either 1, 2, 4 or 8 lights/buttons exposed. RT is the interval between the onset of a light and the *S*'s removing his finger from the 'home' button. Movement time (MT) is the interval between *S*'s leaving the 'home' button and pressing a button adjacent to the light.

Sentence-verification test (SVT)

All of the reaction stimuli for this test consist of one of the following 'sentences', in addition to four other sentences formed by reversing the letters A and B:

A before B
A after B
A not before B
A not after B.

One sentence of this type appears on the display screen for 2 sec. After a random interval of between 0.5 and 1.5 sec, a pair of letters appears (AB *or* BA), and the *S* responds on pushbuttons labeled *True* or *False* according to whether the letter positions correspond to the descriptive statement. RT is the interval between onset of the letter-pair and the *S*'s releasing the 'home' button in order to touch the *True* or *False* button. The task is *S*-paced, each trial initiated by the *S*'s depressing the 'home' button. RT and MT are recorded on each trial.

RESULTS

Correlations Between Processing Variables and Psychometric Tests

Although the main object of this study is comparison of the G and NG groups, the within-group correlations between *S*'s response latencies on the various processing tasks and *S*'s scores on the untimed paper-and-pencil psychometric tests are shown in Table 1 for comparison with previous studies.* The correlations are generally in the same range of magnitude as found in previous studies. Detailed comparisons of such correlations across groups are hardly worthwhile, however, when groups differ considerably in range of talent, which affects the reliabilities of the variables and their intercorrelations. Because the various processing tasks each require different cognitive process, most of which are reflected to some degree of performance on complex psychometric tests, the combination of the processing variables yields a fairly substantial multiple correlation, *R*, even within groups that have a quite restricted range of talent. In the present groups, the response latencies on the simple processing tasks account for about one fourth of the total within-groups variance on the psychometric tests. The proportion of variance accounted for would, of course, be greater in an unrestricted or random sample of the general population.

Differences Between Groups

The G and NG groups were specially selected so as to differ in manifest academic talent, the G group being volunteers from a program for academically gifted youths who are enrolled in college courses in mathematics and science. *S*s in the NG group, although generally above average in scholastic achievement with reference to California state norms, were not specially selected for ability, nor was there any attempt to screen out gifted children. On the 60-item Raven SPM test, the G and NG groups differ significantly ($P < 0.001$) by 12.8 raw score points, equivalent in SD units to 1.9σ, where σ is the square root of the average within-group variances. (G group, $\bar{X} = 52.5$, SD = 6.4; NG group, $\bar{X} = 39.8$, SD = 7.1.) The G group scores only 2 raw score points below the mean for undergraduates at the University of California, Berkeley, even though the university

*Although all *S*s in both groups were given all of the speed-of-processing tests, the testing schedules did not allow complete samples on the psychometric tests, for which the sample sizes (for G and NG groups, respectively) are as follows: Raven SPM 29, 65; CTBS Reading 0, 48; CTBS Math 0, 50; PRED 55, 0.

Table 1. Correlation of speed-of-processing variables (median response latency) with psychometric tests

	G group		NG group		
Variable	Raven SPM	PRED	Raven SPM	Reading	Math.
SA2	−0.52	−0.30	−0.25	−0.08	−0.13
DT3-Words	−0.53	−0.20	−0.32	−0.27	−0.28
DT2-Words	−0.19	−0.23	−0.25	−0.18	−0.22
SD2	−0.25	−0.19	−0.25	−0.10	−0.23
DT2-DIGIT	−0.32	−0.33	−0.27	−0.11	−0.11
DT3-DIGIT	−0.44	−0.20	−0.21	+0.01	−0.08
DIGIT	−0.42	−0.28	−0.14	+0.05	−0.01
SVT	−0.12	−0.19	−0.29	+0.04	−0.13
RT Mean[a]	−0.15	−0.06	−0.30	−0.19	−0.03
Multiple R[b]	0.60	0.42	0.50	0.51	0.47

[a]Mean RT for 1, 2, 4 and 8 light/button alternatives; 60 RT trials in all.
[b]The effect of chronological age has been removed from the multiple correlation R.

students are, on average, 5–6 yr older than the G *S*s. It is little wonder, therefore, that the G *S*s can perform successfully in college-level courses. But how do they compare with their NG age-mates on the speed-of-information-processing tasks?

Mean group differences on processing tasks

Previous studies have shown that trial-to-trial *intraindividual variability* in RT is also related to intelligence, the more highly intelligent *S*s generally showing lesser intertrial variability in RT. Intraindividual variability is measured as the SD of a *S*'s RTs over all trials; it is symbolized as $RT\sigma_i$. Despite the lower test–retest and split-half reliability of this variable than of the mean RT over trials in previous studies, it has usually shown as high correlations with psychometric g as does mean RT. Table 2 shows the mean difference in RT and $RT\sigma_i$ between the G and NG groups, expressed in SD, or σ, units, where σ is the square root of the average within-group variance. The significance of the differences was tested by two-tailed t-tests. All of the differences and point–biserial correlations, except those indicated by asterisks, are significant beyond the 0.001 level. The group differences are also expressed in terms of the point–biserial correlation, r_{pb}, for which the groups were quantized as G = 0, NG = 1. Because the G group is 4 months older than the NG group, and there is a slight negative correlation of age with RT and $RT\sigma_i$, Table 2 also shows the point–biserial correlation between groups and processing variables with age partialed out [$r_{pb}(-\text{age})$]. It can be seen that the slight group difference in age has a practically negligible effect; statistically controlling age decreases the point–biserial correlation, on average, by 0.01, and never more than 0.02. The corresponding effect of controlling age for the σ differences amounts to a decrease of 0.04σ.

Table 2. Mean difference (in σ units) and point-biserial correlation (r_{pb}) between G and NG groups (NG–G) in RT and intraindividual variability ($RT\sigma_i$) on the various processing tasks

	σ Diff.		r_{pb}		$r_{pb}(-\text{age})$[b]	
Task	RT	$RT\sigma_i$	RT	$RT\sigma_i$	RT	$RT\sigma_i$
SA2	1.46	1.02	0.60	0.45	0.58	0.44
DT3-Words	1.64	1.28	0.64	0.54	0.63	0.53
DT2-Words	1.51	1.05	0.61	0.47	0.60	0.46
SD2	1.34	0.91	0.56	0.41	0.54	0.40
DT2-DIGIT	1.34	0.77	0.56	0.36	0.55	0.34
DT3-DIGIT	1.28	0.86	0.54	0.39	0.53	0.37
DIGIT	1.50	0.45*	0.60	0.21*	0.59	0.20*
SVT	1.26	0.73	0.53	0.34	0.52	0.32
RT: 0 bit[a]	0.91	1.45	0.43	0.60	0.41	0.59
RT: 1 bit	1.28	1.26	0.55	0.54	0.53	0.52
RT: 2 bits	1.18	0.78	0.56	0.37	0.54	0.35
RT: 3 bits	1.32	0.78	0.56	0.37	0.54	0.35
Mean	1.34	0.96	0.56	0.43	0.55	0.42

[a]Bit = $\log_2 n$, where n is the number of light/button alternatives in the RT task. On each of these four RT tasks, the *median* RT over 15 trials is obtained for each *S*.
[b]Chronological age (in months) partialed out of r_{pb}.
*$P = 0.012$; all other σ differences and point-biserial rs in the table are significant at $P < 0.001$.

To determine the maximum discrimination between the G and NG groups that could be attained by combinations of the processing variables, three discriminant function analyses were performed. Each analysis resulted in only one significant discriminant function.

The first discriminant analysis included the RTs of the first eight of the tasks listed in Table 2. The resulting discriminant function correctly classified 83.3% of all the *S*s; 91.7% of the G group and 76.4% of the NG group were correctly classified.

The second discriminant analysis included the $RT\sigma_i$ of each of the first eight of the tasks listed in Table 2. The resulting discriminant function correctly classified 78.6% of all the *S*s; 96.7% of the G group and 63.4% of the NG group were correctly classified.

The third discriminant analysis included the 16 variables that can be derived from the RT task, namely, at each of the four levels of information (0, 1, 2, 3 bits): median RT, $RT\sigma_i$, mean MT and $MT\sigma_i$. The resulting discriminant function correctly classified 87.1% of all the *S*s; 91.7% of the G group and 83.3% of the NG group were correctly classified. (The shrunken multiple *R*s corresponding to each of the three discriminant analyses are 0.64, 0.56 and 0.73, respectively.) In all three analyses, a larger percentage of NG than of G were misclassified by the discriminant function, a not surprising result in view of the greater heterogeneity of the NG group and the possibility that it could have included *S*s who could qualify as academically gifted by the same psychometric criteria as were used to select those in the G group.

Interaction of Group Difference and Task Complexity

Previous research (e.g. Vernon, 1983; Vernon and Jensen, 1984) has shown a positive correlation between the degree of complexity of the processing tasks and their correlations with psychometric *g*, at least within the range of complexity of the tasks used in these studies. Also, mean differences in RT between groups that differ in psychometric *g* (e.g. college students and vocational students) increase as a function of task complexity. An objective index of task complexity is the mean response latency, the more complex task having the longer latency.

To determine whether this empirical generalization holds for the mean differences in response latency for the G and NG groups, the mean group difference in latency for each processing task was plotted as a function of task complexity as indexed by the mean latency of the two groups. (The correlation between the mean latencies of each group is 0.98.) The results, shown in Fig. 1, are highly similar to the results of the same type of analysis applied to other groups that differ in psychometric *g*. The correlation of 0.94, with 6 *df*, is significant ($P < 0.01$), as is Spearman's rank–order correlation (ρ) of 0.81 ($P < 0.05$).

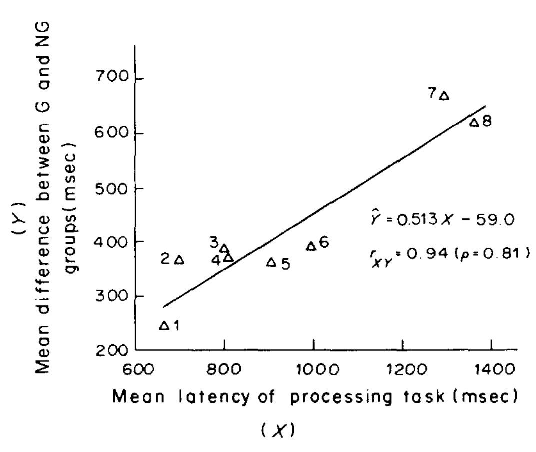

Fig. 1. Mean difference between G and NG groups in response latency on the various processing tasks as a function of task complexity as indexed by the overall mean latency for each task. The tasks are: 1, DIGIT; 2, SVT; 3, DT3-DIGIT; 4, DT2-DIGIT; 5, SD2; 6, DT2-Words; 7, DT3-Words; 8, SA2.

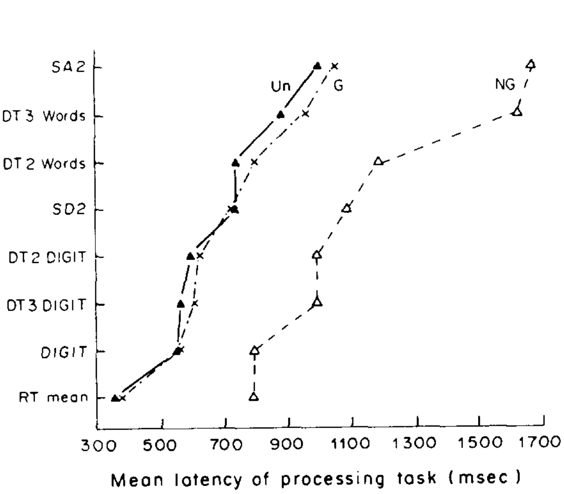

Fig. 2. Mean latency of various processing tasks in three groups: university students (Un), gifted (G) and nongifted (NG).

When the same analysis is applied to intraindividual variability (i.e. the mean $RT\sigma_i$) on each task, the resulting picture is highly similar, showing $r_{XY} = 0.88$, $\rho = 0.95$, and $\hat{Y} = 1.07RT\sigma_i - 142.96$.

How do the G and NG groups compare with a group ($N = 50$) of University of California (Berkeley) undergraduates on the processing tasks? The mean response latencies of the university (Un) group, reported in Vernon and Jensen (1984), is shown along with those of the G and NG groups in Fig. 2. We see that all three profiles are of similar shape, but the Un and G groups are very close in absolute levels of performance, whereas the NG group shows considerably longer latencies. Precise indices of profile similarity are afforded by the intraclass correlation, r_i, which reflects differences both in shape and in absolute difference; by the Pearson correlation, r, which reflects differences in shape only, and by Spearman's rank–order correlation, ρ, which reflects only differences in rank–order. Applied to the profiles, these three similarity indices are as follows:

	r_i	r	ρ
Un × G	0.98	0.99	0.98
Un × NG	0.09	0.93	0.98
G × NG	0.21	0.96	1.00

Simple and choice RTs

As the RT–MT paradigm (also known as the Hick paradigm) involves the least intellectual or symbolic content of any of the processing tasks, being based on the speed with which the *S* removes his finger from a 'home" button when a light goes on, it merits a closer look with respect to the differences between the G and NG groups. The mean RT and MT as a function of bits are shown in Fig. 3. Two-tailed *t*-tests show all of the NG–G differences in RT and MT to be significant at $P < 0.001$. Because RT reflects speed of information processing, theory predicts that the NG group should show a relatively greater increase in RT with increasing information (bits) than the G group. This is observed in Fig. 3. The mean slope of the regression of RT on bits is 32.7 for G and 46.3 for NG, a difference of -0.70σ, which is highly significant ($t = 4.0$, $P < 0.001$). (The slight difference in slopes for MT is nonsignificant).

A parallel comparison is made for mean intraindividual variability in RT ($RT\sigma_i$) in Fig. 4. As noted elsewhere (Jensen, 1982a, pp. 103–104), whereas RT is linearly related to bits, $RT\sigma_i$ is linearly related to n, the number of stimulus alternatives. The NG–G mean differences in $RT\sigma_i$ are significant ($P < 0.001$) at every level of n; the difference in slopes, however, is nonsignificant ($t < 1$).

DISCUSSION AND CONCLUSIONS

The results of this study have given clear answers to the two main questions to which it was addressed.

First, the evidence contradicts the idea that RTs are only capable of discriminating individual differences in psychometric *g* when persons of subnormal or borderline intelligence are contrasted with persons of average or above-average intelligence. The present results show that an intellectually gifted group differs from a bright–average group in speed on various RT tasks about as much as average groups have been found to differ from the mentally subnormal (Baumeister and Kellas, 1968). The G and NG groups differed an average of 1.3σ on the various RT measures, as compared with a difference of 1.9σ on a measure of psychometric *g* (the Raven SPM), differences corresponding to approx. 20 and 30 points, respectively, on an IQ scale (with $\sigma = 16$). The G group in this study, it must be noted, is not judged as gifted only in terms of a psychometric criterion, but in terms of manifest ability to perform successfully in college courses in mathematics and science at an average age of some 5–6 yr younger than their college classmates.

Second, the study shows that the academically gifted do not differ from their more average age-mates only in possessing a greater amount of scholastic knowledge, or more complex problem-solving strategies, better study habits or more bookish interests. The academically gifted also show a markedly greater speed of information processing even in extremely simple, 'nonintellectual' elementary cognitive tasks. These tasks have virtually no intellectual content, with the possible exception of the synonyms–antonyms (SA2) test. But the words used in this test are

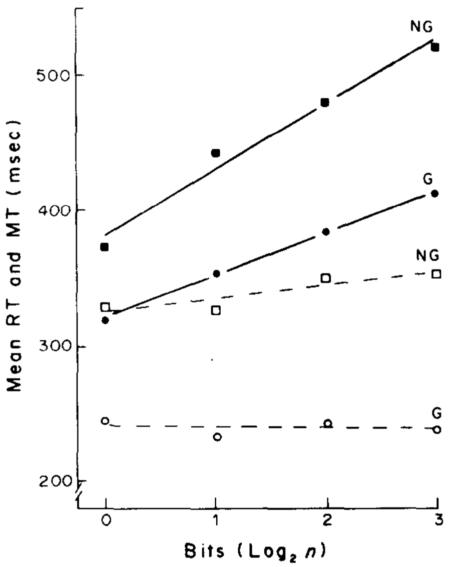

Fig. 3. RT (——) and MT (---) in NG and G groups as a function of bits of information corresponding to 1, 2, 4 and 8 light/button alternatives.

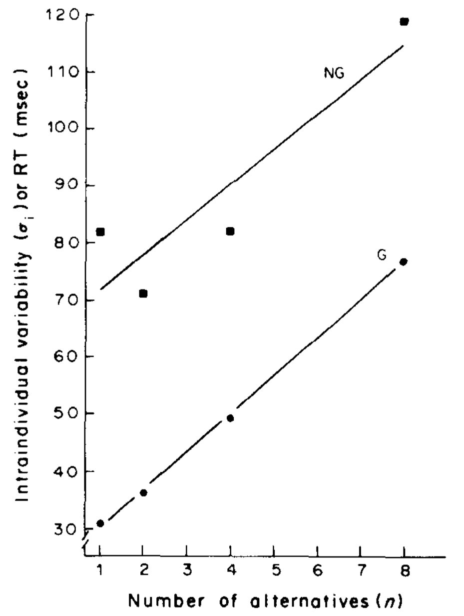

Fig. 4. Mean intraindividual variability in RT ($RT\sigma_i$) in NG and G groups as a function of number of light/button alternatives.

so common that even very few third-grade children ever fail any of the SA2 items when they are administered in the form of an untimed paper-and-pencil test. All of the reliable variance on the SA2 test is due to individual differences in the speed of retrieval of highly overlearned word meanings from long-term memory, which for the G group, on average, is about 620 msec faster than for the NG group (a difference of 1.46σ). But these groups differ by an average of 54 msec even in the speed with which they can lift their finger off a pushbutton when a light goes on. On all of the various information-processing tasks, the G and NG groups differ, on average, by less than 700 msec. But such seemingly small differences in speed of mental processing, when their effects are cumulated over the months and years of the individual's encounters with all the opportunities for information processing afforded by the environment, can result eventually in great differences in the amounts of general knowledge and intellectual skills we see manifested in the contrasts between the G and NG groups, not only in tests of scholastic aptitude, but in actual proficiency in intellectually-demanding courses.

Although a motivational interpretation of the results cannot be entirely ruled out on the basis of present evidence, such an interpretation would seem at best *ad hoc*. And it is inconsistent with the predictable effects of differences in level of motivation, or drive, in terms of the Yerkes–Dodson 'Law'. This law merely states the empirical generalization that the optimal level of drive for learning or performance of a task is inversely related to the degree of complexity of the task; that is, a lower level of drive is more advantageous for performance on more complex tasks. Hence, if it were hypothesized that the G group is the more highly motivated, one should predict *larger* differences between the G and NG groups on the simpler RT tasks than on the more complex tasks, when complexity is indexed by the overall mean response latency to the task. The results, however, are just the opposite of this prediction. As seen in Fig. 1, the NG–G difference increases with task complexity. And in the RT task (Fig. 3), the slope of the RT as a function of task complexity (bits of information) is significantly greater for the NG than for the G group. In order to maintain a motivational interpretation, it would seem necessary to hypothesize that the NG group is the more highly motivated—a most surprising and unlikely conjecture.

Probably the most surprising aspect of the present results is the relatively large magnitude, in σ units, of the group differences on the various elementary cognitive tasks. The differences are not a great deal smaller than the differences on ordinary psychometric tests. This finding raises the question of how much of the group difference is left to be explained by the kinds of more complex, higher-level 'metaprocesses' as postulated, for example, by Sternberg and Gardner (1982) as essential components of *g*. It would appear from the present results that more of the difference in intelligence between the G and NG groups must be attributed to differences in elementary cognitive processes than to higher-level problem-solving strategies, planning, executive control or the other types of metaprocesses which very likely play an important role in long-term real-life intellectual achievements. It does seem surprising that the G and NG groups should differ as much as they do on such very simple cognitive tasks.

Acknowledgement—This study was supported by the Institute for the Study of Educational Differences.

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