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ABSTRACT

Elementary students (N=160, grades 2-3 and 5-6) were evaluated in a battery of four information-processing tasks, including: Inspection Time, Reaction Time, Coincidence Timing, and Mental Counters (Working Memory). Half of the children were certified as gifted in a case study analysis; the other half were selected from non-gifted programs of the same school district. For each of the two main factors (giftedness and grade), equal numbers of participants were drawn from four ethnic backgrounds: African-American, Latino, Filipino, and White. Large differences on all four information-processing tasks appeared as a function of grade and membership in the gifted program. The sole significant relationship involving ethnic background was that gifted African-Americans showed the fastest reaction times and nongifted African-Americans the slowest. Overall relationships between measures of processing and intelligence quotient were modest. (PB)

CHAPTER 4

Information-Processing in Gifted Versus Nongifted African-American, Latino, Filipino, and White Children: Speeded Versus Nonspeeded Paradigms

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Abstract

One hundred and sixty children were evaluated in a battery of four information-processing tasks: Inspection Time (backward masking paradigm), Reaction Time, Coincidence Timing, and Mental Counters (Working Memory). Half of the children were certified as gifted in a case study analysis; half were selected from the nongifted program in the same school district. Within each group (gifted vs. nongifted), half were in the 2nd-3rd grade, half in the 5th-6th grade. Finally, for each of the two main factors (giftedness and grade), there were an equal number of children from four ethnic backgrounds: African-American, Latino, Filipino, and White. There were large differences on all four information-processing tasks as a function of grade and membership in the gifted program. Only one significant interaction occurred involving ethnic background, in which gifted African-Americans showed the fastest RT's and nongifted African-Americans the slowest. Regression analysis revealed that measures of speed of processing, particularly Inspection Time, were the primary correlates of both IQ and membership in the gifted program. Overall, however, the relationship between the measures of processing and IQ were modest. Implications of these findings are discussed.

Information-Processing in Gifted vs. Nongifted African-American, Latino, Filipino, and White Children: Speeded vs. Nonspeeded Paradigms

A relatively little-used nontraditional method of selecting children from diverse backgrounds for gifted programs involves the analysis of information-processing abilities (Grinder, 1985; Sternberg, 1981). As Horowitz and O'Brien (1986) noted, "If different subcultures in the U. S. foster different styles of thinking on different strategies of information processing, then it should be possible to identify and describe these for each population" (p. 1148). Alternately, measures of information-processing may provide an unbiased method of selecting for giftedness.

Wagner and Sternberg (1984) identified information-processing as one of three main approaches to the concept of intelligence. The other two were the psychometric approach, which uses traditional standardized tests, and the Piagetian approach, which is based on Piaget's theory of cognitive development. In the information-processing approach, researchers attempt to analyze responses in terms of the basic component processes that underlie them. For example, information-processing begins initially with input of external stimulation. This input is then stored or held in a short-term storage or working memory system while analytical processes are performed. The results of this analysis are subsequently transferred to other systems, such as long-term memory, where new incoming information can be compared to one's present store of knowledge so that an appropriate response can be made. Theoretically, faster or more efficient information processors are better able to learn and to solve problems. Indeed, reviews of an extensive literature have supported the view that the speed or efficiency with which an individual can execute a small number of basic cognitive processes is highly related to one's performance on psychometric tests of intelligence such as the Wechsler Intelligence Scales and Raven Progressive Matrices Test (Jensen, 1982; Jensen & Reed, 1990; Larson & Rimland, 1984; Vernon, 1987; Vernon, Nador, & Kantor, 1985).

Thus far, two main variations of the information-processing approach have been advanced. Sternberg's (1981) theory emphasizes complex processes—"metacomponential" or executive skills, such as problem recognition, process selection, strategy selection, and solution monitoring. Sternberg's theory stresses the role of the ability to make inferences and apply previously made inferences to new domains, and of learning skills such as encoding and retrieval of information from long-term memory storage (Sternberg & Davidson, 1983). Although promising, this approach presently lacks a standard and widely accepted set of tasks to evaluate the various stages of processing. In addition, many of the skills are highly dependent on verbal ability, which may make them less suitable in selecting disadvantaged children.

A second information-processing approach, the one evaluated in the present study, attempts to tap into a basic ability that theoretically underlies performance on more complex tasks through the use of elementary cognitive tasks (Hunt, 1978; Jensen, 1982, 1987) that evaluate speed of information-processing. According to this view, gifted children are faster in their ability to encode and manipulate environmental input and to retrieve and analyze existing knowledge. Consistent with this speed of processing theory, Saccuzzo, Larson, and Rimland (1986) found that several measures of visual and auditory speed of processing, which contained little or no complex problem solving skills and required minimal language skills (only the ability to understand instructions) shared significant common variance with conventional standardized psychometric tests that did contain a high degree of intellectual content and involved complex problem solving.

Empirical support for a relationship between processing speed and individual differences in intelligence has come from reaction time studies that manipulate the level of uncertainty to which a subject must respond (Jensen, 1979; Jensen & Munro, 1979; Jensen & Reed, 1990; Lunneborg, 1978; Smith & Stanley, 1983; Vernon, 1981). Using parameters such as median reaction time, slope of reaction time as a function of the number of bits, and intraindividual standard deviations of reaction time performance, investigators have reported large differences between retarded persons and those of normal IQ, as well as between vocational-college students and university students (Jensen 1980; 1982). Based on his own findings and a survey of the literature, Jensen (1982) estimated the correlation between reaction time and individual differences on IQ tests to be between -.3 and -.4. The correlations vary widely across samples; however (Lunneborg, 1978).

A number of investigators have found support for a relationship between speed of processing and giftedness (Span & Overtoom-Corsmit, 1986). Cohn, Carlson, and Jensen (1985), for example, found that gifted children differed fundamentally from average children in their speed of information-processing as evaluated in a reaction time paradigm. Cohn et al. (1985) compared a group of "bright-average" 7th-grade children to a group of academically gifted children of comparable age who were taking college-level courses in mathematics and science. Large and significant group differences were found on each of nine elementary reaction-time measures of speed of information-processing.

A second line of investigation, the study of speed of visual information-processing, also has supported a relationship between processing speed and performance on complex cognitive tasks. In the typical visual paradigm, the subject makes a discrimination for a briefly exposed "target" stimulus, such as identifying which of two lines presented to the right and left of central fixation is longer. The target stimulus is followed by a spatially overlapping non-informational mask (e.g., a uniform line that completely superimposes the lines of the target stimulus). An extensive literature on the masking task itself reveals that it limits the duration that the informational impulse provided by the target is available for processing in the central nervous system (Felsten & Wasserman, 1980). Speed of processing, or "Inspection Time" as it is usually called (Vickers, Nettelbeck, & Willson, 1972), is estimated by either systematically varying the exposure duration of the target and estimating the minimum duration needed for criterion accuracy (Lally & Nettlebeck, 1977; Nettelbeck & Lally, 1976), or by keeping the stimulus duration constant and varying the interval between the target and mask (Saccuzzo, Kerr, Marcus, & Brown, 1979; Saccuzzo & Marcus, 1983).

Numerous studies have reported a statistically significant difference between mentally retarded and non-retarded (average IQ) individuals in inspection time as evaluated in a backward masking paradigm. Such differences occur in spite of wide variations in the nature of the stimulus, method of stimulus presentation, and technique used to estimate visual processing speed (Saccuzzo & Michael, 1984). There are, moreover, clear-cut developmental differences. The general finding is a direct relationship between chronological as well as mental age and performance (Blake, 1974; Liss & Haith, 1970; Saccuzzo et al., 1979). Finally, the evidence supports a significant relationship between degrees of normal intelligence and visual processing speed; however, the magnitude of the relationship remains controversial (Mackintosh, 1981; Nettelbeck, 1982).

Though an early study reported an astonishing -.92 correlation between scores on the Performance Scale of the Wechsler Adult Intelligence Scale (WAIS) and Inspection Time (Nettelbeck & Lally, 1976), most subsequent investigators found a less spectacular, but significant, relationship between Inspection Time and intelligence, with a median correlation of about -.45. These positive findings have been criticized, however, on methodological grounds—small sample sizes (usually no more than 25 subjects); the inclusion of mentally retarded persons, which greatly inflates the correlation due to the extremely disparate range of performance relative to the sample size; and analyses based only on extreme scoring subjects, which, again, is well-known to inflate correlations (Irwin, 1984; Nettelbeck, 1982).

Nettelbeck (1982) took a careful look at his own and others' work in the area. Nettelbeck's analysis revealed a relatively small but consistent association between intelligence and Inspection Time. Irwin (1984) similarly found modest but significant correlations between Inspection Time and intelligence test performance. More recently, Nettlebeck (1987) provided an estimate of -.50 as the relationship between Inspection Time (IT) and intelligence. This estimate was subsequently confirmed by Kranzler and Jensen (1989) in a meta-analysis. Based on an extensive literature review and meta-analytic procedures, Kranzler and Jensen estimated that for adults, with general measures of IQ, the IT-intelligence correlation is about -.54 after correction for the effects of artifactual sources of error, and

-.30 prior to correction. Despite these promising findings, more work is needed to determine if gifted children can be distinguished from nongifted children on IT tasks, and whether they can be so distinguished in an unbiased manner.

A few studies have attempted to examine racial differences in speed of information processing. In a reaction time study, Lynn and Holmshaw (1990) compared 350 black South African 9-year-old children with 239 white British children on 12 reaction time tests. While the black children had slower decision times and greater variability than the white children, there were also tremendous IQ differences between the groups. The black children's mean Raven IQ corresponded to the first percentile and was equivalent to an IQ of about 65. The white children, by contrast, were in the 56th percentile, with an equivalent Raven IQ of 102. Because the black sample in this study was lower in IQ than is generally found for U.S. samples, these results have little, if any, generalizability to American black and white populations.

A study of racial differences in a backward masking paradigm is similarly limited. Bosco (1972) compared the performance of first- and sixth-grade black and white school children. There were clear differences in socioeconomic status between the whites, who were selected from a suburban area, and the blacks, who were selected from the inner city. Since race and socioeconomic background were confounded, the issue of the relationship between race and IT was unresolved.

To date, studies of information-processing and intelligence have focused on speed, with relatively little attention given to other information-processing tasks that might also underlie intelligent behavior. One such task is coincidence timing (CT), a task that requires subjects to respond at the instant two objects intersect or "coincide" (Dunham, 1977; Poulton, 1950).

Smith and McPhee (1987) traced the history of coincidence timing (Dorfman, 1977; Poulton, 1950; Thomas, Gallagher, & Purvis, 1981). As Smith and McPhee noted, coincidence timing relates to such everyday tasks as stepping on and off escalators, picking up an object on a conveyor belt, and predicting when one's changing of lanes on the freeway will coincide with a gap in traffic. In more primitive societies, coincidence timing also had survival value, as in predicting where to aim a spear to hit a moving animal. Coincidence timing tasks require subjects to attend to changing conditions, integrate information over time, and use that information to predict a future event (Smith & McPhee, 1987).

Smith and McPhee conducted the first published attempt to determine if a correlation exists between psychometric intelligence, as evaluated by the Standard Raven Progressive Matrices Test, and a coincidence timing task. These investigators administered a 10 minute CT task to 56 males and females of "high" to "moderate to high" socioeconomic status. Subjects were required to press a key at the very moment a moving target touched (coincided with) a stationary line. There was a significant negative correlation (-.294) between the number of errors on the CT task and Raven scores. In addition, there was a significant negative correlation (-.359) between intrasubject standard deviation (consistency of performance) and Raven scores.

As Larson (1989) noted, the correlation between Raven scores and coincidence timing adds a new dimension to the well-known correlation between psychometric intelligence and information-processing tasks in that, unlike previous tasks such as reaction time, coincidence timing does not require speed of processing, but rather attention and estimation. Thus, the task has potential for adding to the range of relatively simple tasks devoid of intellectual content that may be related to, and perhaps underlie, tests involving complex problem solving such as the Raven. Larson (1989) confirmed Smith and McPhee's finding of a significant relationship between the CT task and psychometric intelligence, as measured by the Armed Forces Qualifying Test (AFQT), in a group of 127 male Navy recruits. To date, however, it has yet to be determined if a coincidence timing task can distinguish gifted and nongifted children, or whether there are ethnic differences in this skill.

A question raised by Larson (1989) is whether some variable might underlie performance on reaction time, inspection time, and coincidence timing. One such common variable, according to Larson, may be working memory—the hypothetical cognitive work space for problem solving. As Larson (1989) noted, working memory provides a theoretical bridge between simple cognitive tasks and psychometric tests, based on concepts such as "representational agility and/or fidelity" (p. 366). In the present study, we attempted to provide a direct test of Larson's theoretical bridge hypothesis through the use of a microcomputerized task of working memory called mental counters (Larson, 1986).

Method

Subjects:

Eighty children who had been certified as gifted by a school psychologist were compared to a matched sample of eighty nongifted children. For each of these two samples (gifted and nongifted) there were forty 2nd- to 3rd-grade children and forty 5th- to 6th-grade children. Each of the four subgroups of forty children had 10 African-American, 10 Filipino, 10 Latino/Hispanic, and 10 White children. The nongifted children were matched to the gifted children on the basis of age, race, and school district.

Procedure:

Giftedness was determined individually for each child by a school psychologist in a comprehensive case study analysis. This analysis considered recommendations by parents or teachers, a behavior checklist, achievement, standardized tests scores, and the presence of risk factors including economic disadvantage, cultural differences, English as a second language, and negative environments. Each child was given a battery of microcomputerized tests as follows: Inspection Time (IT), Choice Reaction Time (CRT), Coincidence Timing (CT), and Mental Counters (MC). These tests were presented on an IBM PC/XT microcomputer with a black and white monitor and standard keyboard. The tests were administered in counterbalanced order in one session, which lasted approximately one hour. Subjects were administered a standard Raven in a separate, second session. All subjects, and their parents, provided voluntary written informed consent for their participation. Nevertheless, one school district refused to allow the administration of the Raven; 18 children (11 gifted) did not receive the Raven. The specific parameters for each task in the information-processing battery are described below.

Inspection Time (IT). The inspection time (IT) task was a non-adaptive procedure based on the methods of Larson and Rimland (1984) and Saccuzzo and Larson (1987) and described in detail by Larson and Saccuzzo (1989). A target stimulus consisting of two horizontal lines of unequal length (17.5 mm and 14.3 mm) was briefly presented in the center of the computer monitor. The two lines appeared to the right and left of central fixation, with the longer appearing right or left on a random basis. Immediately following termination of the target, a backward visual noise mask, consisting of a single horizontal line that completely superimposed spatially on the target, was presented. The mask is known to limit the duration of the sensory signal delivered to the central nervous system by the target (Felsten & Wasserman, 1980). Targets were presented at one of five completely randomized stimulus durations: 16.7, 33.4, 66.8, 102.2, and 150.3 msec, which corresponded to 1, 2, 4, 6, and 9 refresh cycles on the video monitor. There were 10 trials per stimulus duration, for a total of 50 trials. The subject's task was to make a forced-choice discrimination, indicating which of the two lines of the target is longer, by pressing one of two keys on the microcomputer keyboard. The task began with a set of instructions, examples, and practice to criterion prior to the test proper. Subjects were given computer-generated visual feedback on their performance.

Choice Reaction Time (Hick Paradigm). A Hick paradigm for a 1,3, and 5 choice reaction time task, as described by Saccuzzo et al. (1986) and Larson and Saccuzzo (1989), was used to evaluate choice reaction time performance. A horizontal arrangement of lights was presented at the bottom of the monitor. All subjects were presented with 1-,3-, and 5-choice conditions, with order of presentation completely randomized. Open squares on the monitor were used as stimulus lights. Subjects responded by pressing the space bar as soon as a square was illuminated. The subject's forefinger rested lightly on the space bar, so that there was essentially no movement time involved. Previous research has shown that this "no movement" reaction time task is as effective as more traditional reaction time tasks involving movement (Kostas, Saccuzzo, Larson, 1987), and has the advantage of minimizing errors that occur due to the necessity of pressing two keys in the movement time paradigm. In this procedure, the subject views the monitor on which there are one, three, or five line drawn squares. After a random period of time from 1.5 to 2.5 seconds, one of the squares is illuminated. Reaction time is defined as the number of milliseconds between the onset of the stimulus (i.e., where one of the stimulus squares is illuminated) and the instant the subject presses the space bar.

Coincidence Timing. The Coincidence Timing task was identical to that used by Larson (1989), based on the description provided by Smith and McPhee (1987). For each of three conditions, the subject's task was to press the space bar on the computer keyboard at the exact moment that a horizontally moving dot crossed a vertical line in the middle of the monitor. Condition 1 consisted of a dot that moved in a straight horizontal line at the speed of 0.10 meters per second, with random delays in the starting time. Condition 2 was identical to Condition 1 but at a speed of 0.15 meters per second. In Condition 3, the path of the dot was random (jagged), with a random delay and speed of 0.10 meters per second. The total distance traversed by the moving dot from orgin to crossing the line was 0.13 meters.

As in Larson (1989), there were 30 trials at each condition. Each trial consisted of a cycle in which the dot moved left to right across the screen, then right to left so that the dot crossed the centerline twice. Finally, since skill in tasks such as coincidence timing may be related to the type of skills that children develop playing video games such as Nintendo (Salthouse & Prill, 1983), each of the 160 children in the study were asked to estimate the number of hours per week that they spend playing video games in a self-report procedure prior to implementation of the information-processing tasks.

Mental Counters (MC). In the Mental Counters(MC) task (Larson, 1986), subjects are asked to keep track of the values of three independent "counters" that change rapidly and in random order. The task requires subjects to simultaneously hold, revise, and store three counter values that change rapidly. The counters themselves are represented as dashes on the video monitor (three side-by-side horizontal dashes in the center of the screen). The initial counter values are zero (0,0,0). When a small target (0.25 inch, hollow box) appears above one of the three dashes, the corresponding counter must be adjusted by adding one. When the target appears below one of the three dashes, the corresponding counter must be adjusted by subtracting one. The test items vary both in the number of targets and the rate of presentation. In the present study there were two different rates of presentation (0.633 seconds and 1.42 seconds), and 8 targets, such that the values of the initial counters changed 8 times. Order of presentation of speeds was counterbalanced. Prior to the test proper, subjects were given instructions, examples, and practice to criterion (three consecutive correct responses). The maximum and minimum counter values varied between +3 and -3, respectively. The subject's task was to select, from among four choices, the correct list of final values for the three counters. Selection was made by pressing the proper key on the keyboard. Feedback was given only during practice, and not during the test proper.

Results

Video Games.

Data for self-reported hours per week spent playing video games such as Nintendo were evaluated in a 2(GATE: gifted vs nongifted) X 4(Ethnic Background) ANOVA. The only significant finding was a main effect for GATE, $F(1,152) = 4.208$, $p < .042$. This result revealed that the gifted children spent significantly less time per week (about half) playing video games than the nongifted children, with means of 3.82 hours vs 6.04 hours, respectively. Thus, if prior practice at such tasks did make a difference, it would have been far in favor of the nongifted children, since they spent much more time playing video games. Notably, there were no ethnic differences in the number of hours spent playing these games.

Raven.

Table 1 shows the Raven scores for gifted vs nongifted children as a function of ethnic background. The table shows the average Raven Z scores based on the U.S. smoothed norms provided by Raven et al (1986). These data were subjected to a 2(GATE) X 2(Grade) X 4(Ethnic Background) ANOVA. As might be expected, there was a significant main effect, $F(1,135) = 42.69$, $p < .001$, for Gifted ($M = 1.11$, $SD = .92$) vs Nongifted($M = .02$, $SD = 1.0$) children. The only other significant finding was a GATE X Ethnic Background interaction, $F(3,135) = 3.58$, $p < .05$. Newman-Keuls post hoc multiple comparison tests of this difference revealed the gifted White, African-American, and Filipino children did not differ significantly among themselves and all three of these groups were significantly higher than the gifted Latino children and each of the four nongifted groups, none of whom differed significantly among themselves. It should be noted, however, that of the 11 gifted children who did not receive Raven, 6 were in the Latino group. The absence of these children may have artificially lowered the overall mean for the Latino children.

Table 1.

Raven Z-Scores as a Function of Ethnic Background for Gifted versus Nongifted Children

	Latino/Hispanic		White		African-American		Filipino	
	Gifted	Nongifted	Gifted	Nongifted	Gifted	Nongifted	Gifted	Nongifted
M	0.51	0.36	1.36	0.01	1.34	-0.38	1.09	0.16
SD	1.17	0.79	0.78	0.81	0.58	0.92	0.95	1.31

For each of the four information-processsing variables, all *F* values, significance levels, means, and standard deviations are presented in Table 2 to conserve space. Whereas Grade reflects differences between 5th and 6th versus 2nd and 3rd graders, GATE reflects differences between Gifted versus Nongifted children, and Condition reflects the condition under study, such as Stimulus Duration, Choices, and Fast vs. Slow.

Table 2
Summary of significant findings

Significant Effects	*df*	F	Level	*M*	*SD*
Inspection Time					
Main Effect: Grade	1/140	36.73***	5th - 6th Grade	66.17	13.19
			2nd - 3rd Grade	57.50	14.68
Main Effect: GATE	1/140	7.84**	Gifted	63.78	14.62
			Nongifted	59.83	15.01
Main Effect: Stimulus Duration	4/560	80.12***	Duration 1	52	10.7
			Duration 2	57	13.4
			Duration 3	57	15.7
			Duration 4	68	17.2
			Duration 5	74	18.3
Grade X Inspection Time	4/560	8.73***			
GATE X Inspection Time	4/560	3.76**			
Reaction Time (msec)					
Main Effect: Grade	1/135	56.83***	5th - 6th Grade	383	90.55
			2nd - 3rd Grade	564	133.47
Main Effect: GATE	1/135	6.21*	Gifted	422	113.75
			Nongifted	467	139.70
Main Effect: Choices	2/278	141.99***	One Choice	384	117.71
			Three Choices	454	127.01
			Five Choices	479	142.00
Grade X Choices	2/278	4.17*			
GATE X Choices	2/278	5.08**			
GATE X Ethnicity	3/139	3.23*			
Coincidence Timing (Errors)					
Main Effect: Grade	1/140	36.27***	5th - 6th Grade	18.34	7.51
			2nd - 3rd Grade	29.16	17.87
Main Effect: GATE	1/140	19.95***	Gifted	19.80	8.89
			Nongifted	27.73	18.01
Main Effect: Condition	2/280	94.76***	Slow, NonVariable	16.95	11.39
			Fast, NonVariable	25.18	14.69
			Random	29.32	18.21
Grade X Condition	2/280	3.75*			
GATE X Condition	2/280	3.58*			
Mental Counters					
Main Effect: Grade	1/112	48.00***	5th - 6th Grade	10.84	4.11
			2nd - 3rd Grade	6.46	3.76
Main Effect: GATE	1/112	7.08**	Gifted	9.68	4.34
			Nongifted	8.34	4.59
Main Effect: Condition	1/112	66.00***	Slow	10.17	5.07
			Fast	7.87	3.95
Grade X Condition	1/112	8.99**			
GATE X Condition	1/112	6.41**			

* $p < .05$
** $p < .01$
*** $p < .001$

Inspection Time (IT).

The data for IT were analyzed in a 2(Grade) X 2(GATE) X 4 (Ethnic Background) X 5 (Levels of Stimulus Duration) mixed repeated measures ANOVA, with percent correct at each duration used as the dependent measure. There were significant main effects for Grade, GATE, and Stimulus Duration (See Table 2). There were also two significant interactions: Grade X Inspection Time, and GATE X Inspection Time.

Figure 1. Inspection Time: Grade by stimulus duration interaction.

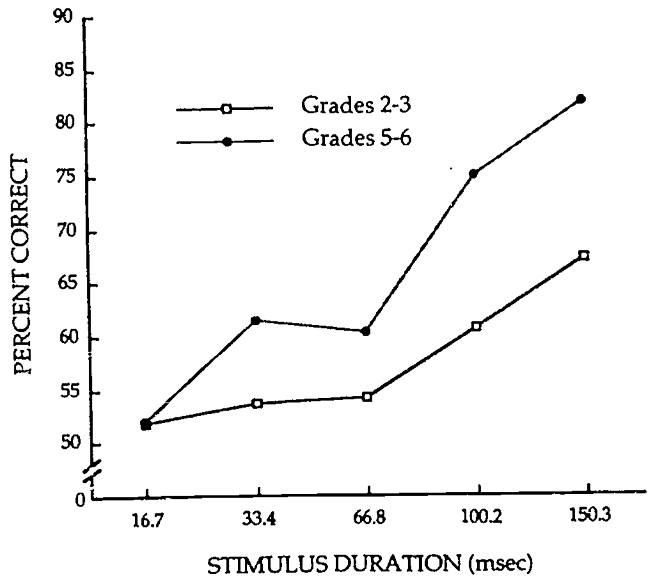


Figure 1 illustrates the Grade X Inspection Time interaction. As inspection of Figure 1 reveals, and as confirmed by post-hoc multiple comparison tests, the children in grades 5-6 had significantly better performance ($p < .01$) at each of the five levels of inspection time except the first/fastest speed, where both groups performed approximately at chance level.

Figure 2. Inspection Time: GATE by stimulus duration interaction.

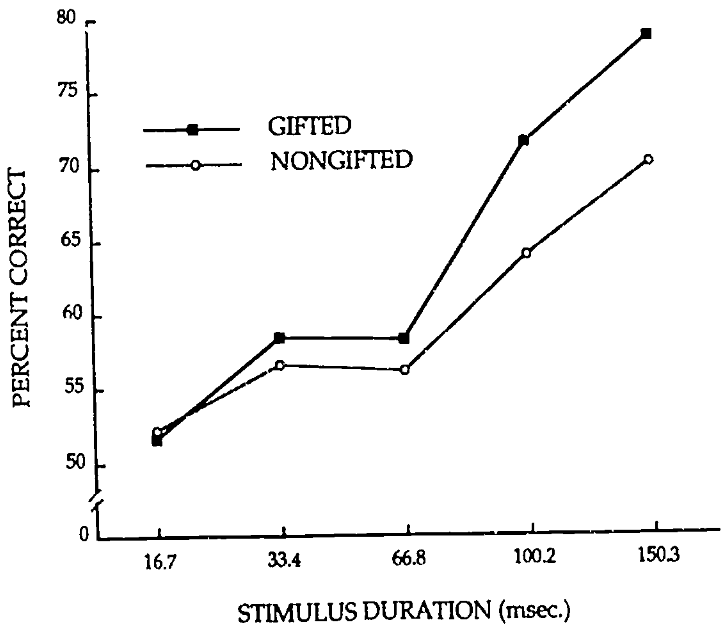


Figure 2 illustrates the GATE X Inspection Time (IT) interaction. As this figure shows, and as confirmed by post-hoc multiple comparisons tests, the gifted children had significantly ($p<.01$) better performance at the two slowest speeds (IT4 and IT5). The groups did not differ significantly ($p > .05$) at the three fastest speeds, where the tendency of the younger children to perform at chance obscured differences between gifted and nongifted children at Speeds 2 (IT2) and 3(IT3), and all subjects were at chance at the fastest speed (IT1).

Reaction Time.

The median reaction time for each subject was analyzed in a 2(Grade) X 2(GATE) X 4(Ethnic Background) X 3(Choices) mixed repeated measures ANOVA. There were significant main effects for Grade, GATE, and Choices (See Table 2). There also were three significant interaction effects: Grade X Choices, GATE X Choices, and GATE X Ethnicity.

Figure 3. Reaction Time: Grade by level of choice interaction.

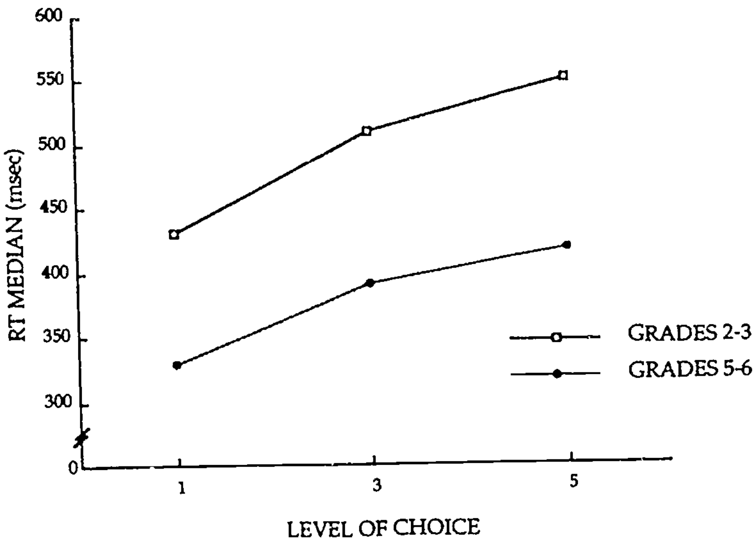


Figure 3 illustrates the Grade X Choices interaction. While the children in grades 5-6 outperformed the children in grades 2-3 at each level of choice, the difference between the groups increased as the number of choices increased.

Figure 4. Reaction Time: Gate by level of choice interaction.

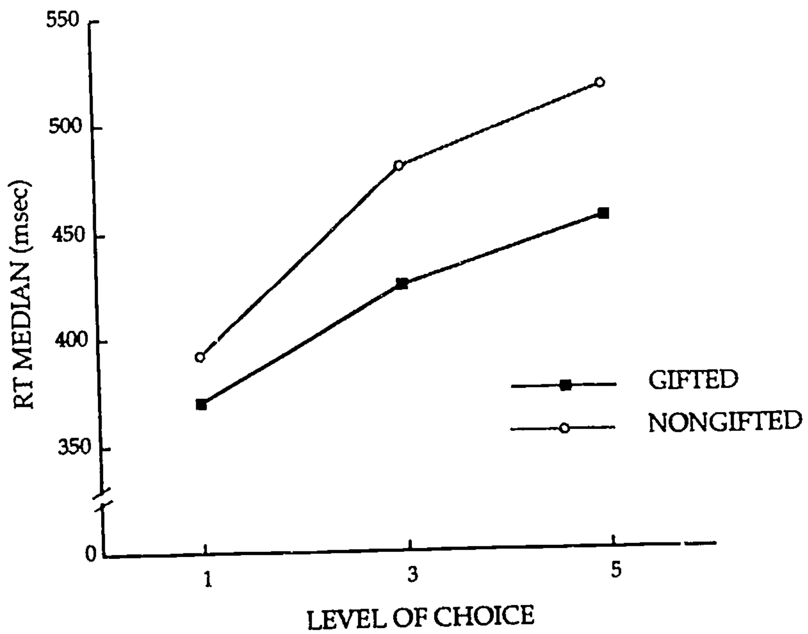


Figure 4 illustrates the GATE X CHOICES interaction. The groups did not differ ($p > .05$) at the one choice condition, but were significantly different at the 3 and 5 choice conditions ($p < .01$).

Figure 5. Reaction Time: GATE by ethnicity interaction for reaction time median.

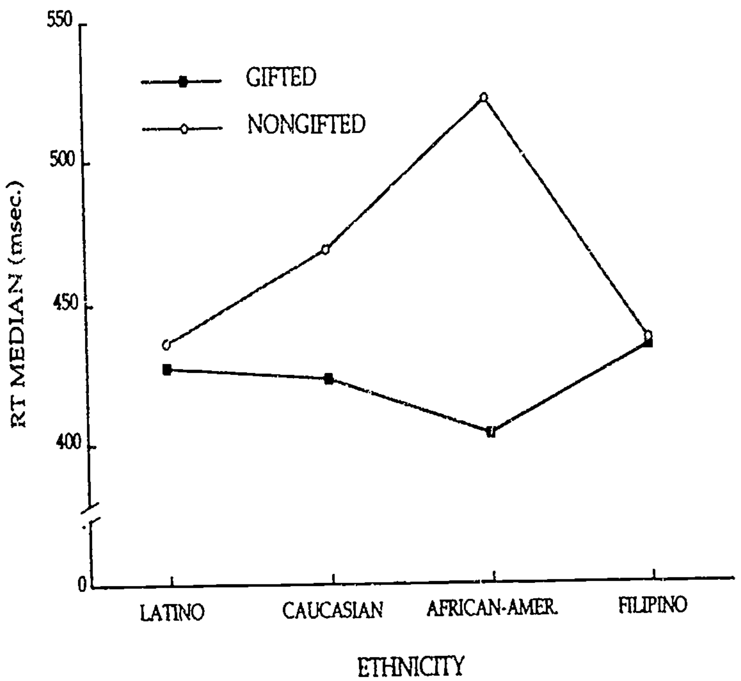


Figure 5 illustrates the GATE X Ethnicity interaction. Post-hoc multiple comparison tests of this effect revealed a statistically significant difference between gifted African-Americans and the nongifted African-Americans. The other differences between gifted and nongifted groups for each ethnic background did not reach statistical significance.

The individual variability of reaction time (RT Variance) was also analyzed in a 2(Grade) X 2(GATE) X 4(Ethnic Background) X 3(Choices) mixed repeated ANOVA. For this analysis, the only significant finding was the main effect for Grade, $F(1,138) = 11.02$, $p < .001$. The GATE X Ethnic Background effect did not reach statistical significance ($p > .081$).

Coincidence Timing (CT).

Two dependent measures were used to evaluate the coincidence timing data: Coincidence Timing Errors (CTE), which refers to the mean of the absolute value of the difference between the response position and the true position of the line; and Coincidence Timing Standard Deviation (CTSD), which refers to the standard deviation of the distribution of response positions. The error (CTE) and Standard Deviation (CTSD) data were separately analyzed in a 2(Grade) X 2(GATE) X 4(Ethnic Background) X 3(Conditions) mixed repeated measures ANOVA. Results were nearly identical for both dependent measures. For CTE there were significant main effects for Grade, GATE, and Condition (See Table 2). There were two significant interactions in the CTE data, the Grade X Condition, and the GATE X Condition.

Figure 6. Grade by condition interaction (CTE).

Figure 6 illustrates the Grade by Condition interaction for the Coincidence Timing errors. In this interaction, while the children in grades 5-6 outperformed children in grades 2-3 at all levels, they did so at a greater rate for the variable condition (Condition 3).

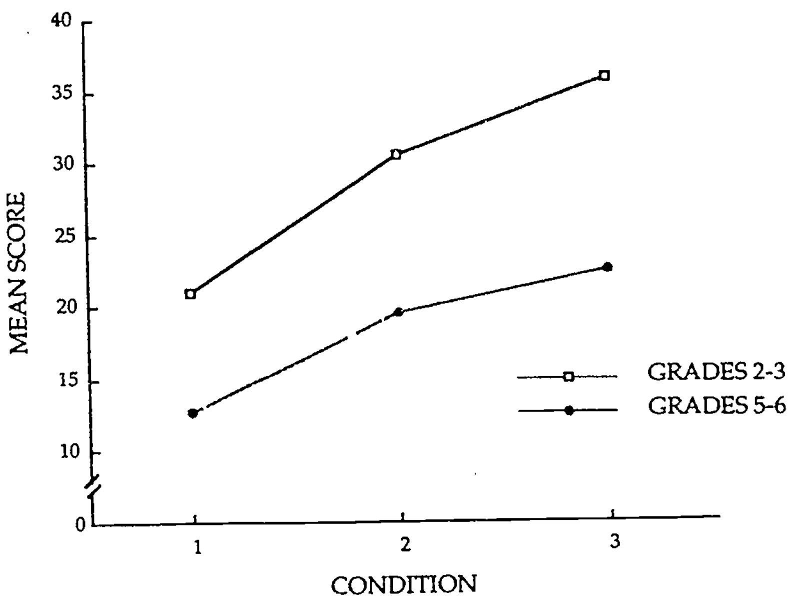


Figure 7. Gate by condition interaction (CTE).

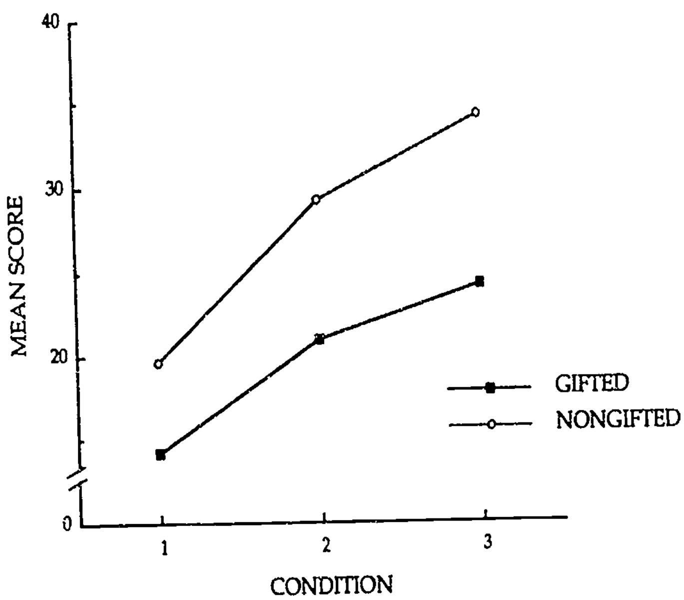


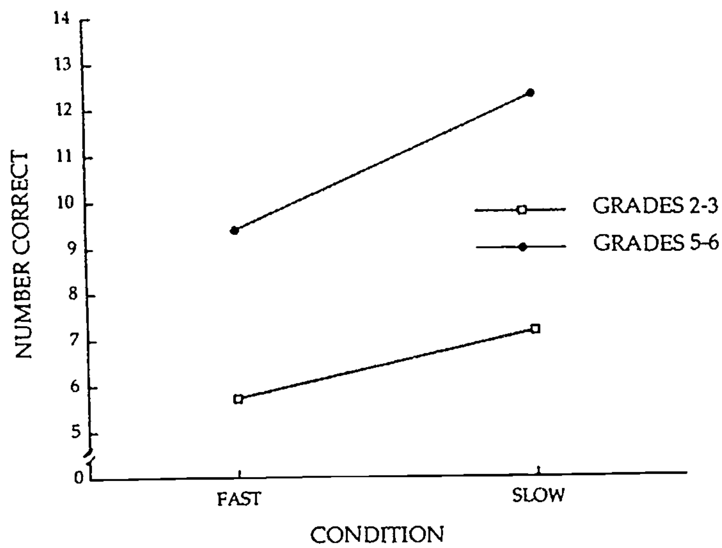
Figure 7 illustrates the GATE X Condition interaction, and again shows the greatest difference occurring between the groups under the variable condition (Condition 3).

The analysis of standard deviations produced all the same main effects as well as a GATE X Condition interaction. The only difference between the two measures was that the Grade X Condition interaction did not reach statistical significance for the standard deviation data. For both CT measures, there were no main or interaction effects involving ethnicity.

Mental Counters.

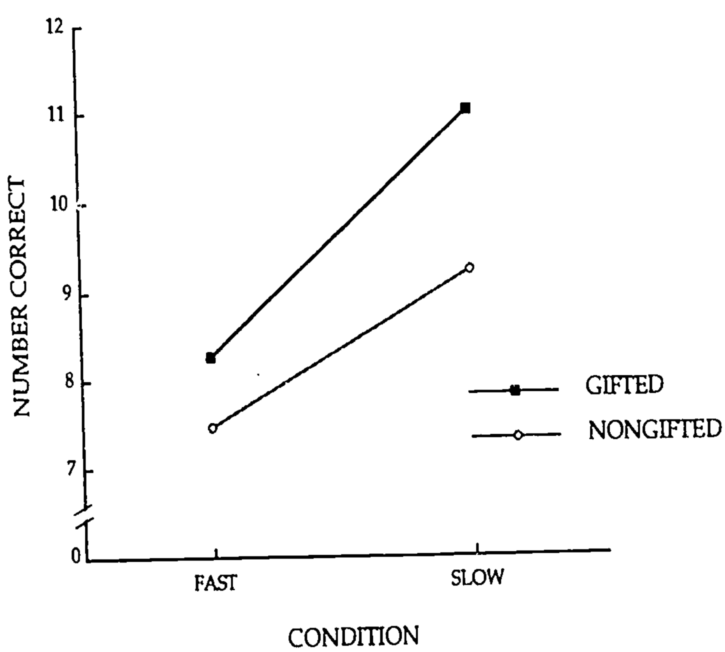
For the Mental Counters Test, the number of correct responses was analyzed in a 2(Grade) X 2(GATE) X 4(Ethnic Background) X 2(Conditions - Fast and Slow) mixed repeated measures ANOVA. Results were parallel to those obtained with Inspection Time and Coincidence Timing. There were the familiar main effects for Grade, GATE, and Condition. As with the prior analyses, there were two significant interactions: Grade X Condition, and GATE X Condition. Figures 8 and 9 illustrate these interactions.

Figure 8. Mental Counters: Grade by condition interaction.



In the Grade X Condition interaction, as shown in Figure 8, the children in grades 5-6 outperformed children in grades 2-3 at both conditions, but did so at a greater rate for the slow condition.

Figure 9. Mental Counters: Gate by condition interaction.



In the GATE by Condition interaction, as shown in Figure 9, the differences between the groups were significant ($p < .01$) only at the slow speed.

Other Analyses.

Multiple regression analysis was used to determine the information-processing predictors of Raven IQ scores and of placement in the GATE program. First, the following variables were used to predict Raven scores in a stepwise multiple regression: the five levels of inspection time, (IT1, IT2...IT5); each of the three reaction time choices for both variability and median RT; each of the three conditions of coincidence timing for both errors (CTE) and standard deviation (CTSD); and the two levels of mental counters. Only one of these information-processing variables, IT4(Inspection Time, duration 4) entered into the equation and produced a significant F value, $F(1,102) = 13.38, p < .0004$. The multiple R between IT4 and the Raven was .34. Next, each of the above information-processing variables were used to predict GATE membership in a stepwise regression analysis. Three variables were significant in predicting GATE status: IT5, $F(1, 118) = 8.45, p < .005$, CTSD(condition 3), $F2, 117 = 6.65, p < .002$, and reaction time variance (5 choice condition), $F(3, 116 = 6.13)$, $p < .001$. The multiple R between IT5 and GATE membership was .258. Adding in CTSD (condition 3) increased the multiple R to .319. With the addition of reaction time variance (5 choice condition), the multiple R increased to .370.

Finally, an attempt was made to determine a possible cut-off score for the information-processing tasks to discriminate gifted from nongifted children. Given that IT5 was the best predictor of GATE membership, we began with this variable. First, a discriminant analysis was conducted to determine the best score to discriminate the gifted vs the nongifted children. For IT5, this score was 73.5 percent correct. Next, frequency tables were constructed to determine the frequency of gifted vs nongifted children who scored above or below the cut-off. Twenty-one out of 77 gifted children (27 percent) scored below the cut-off; thirty-two out of 79 nongifted children (40 percent) scored above the cut-off. Results were similar for other information-processing tasks, which suggested that the use of these tasks to make individual decisions would indeed be hazardous.

Discussion

The present study adds to the literature in being the first to examine the information-processing abilities of children and the relationship between IQ and information-processing as a function of three major variables: grade (age), giftedness (as determined by an individual case study analysis by a school psychologist), and ethnic background. Whereas most of the relevant studies in this field are restricted to one or at most two measures of information-processing, the present study examined four different measures, two of which depended heavily on speed of processing (IT and RT) and two of which did not depend exclusively on speed. All information-processing tasks, however, can best be described as elementary cognitive tasks (ECTs), in that they are essentially devoid of complex content and problem solving skills.

All of the tasks easily discriminated older children as a group versus younger children. This finding is consistent with known developmental differences in choice reaction time and backward masking paradigms, and further shows that such differences can be extended to coincidence timing and mental counters, which is believed to reflect working memory capacity.

The analyses of gifted versus nongifted differences in specific information-processing abilities yielded a number of critical interaction effects. For inspection time, gifted and nongifted children did not differ at the faster stimulus durations, where performance for both groups remained close to chance. As the stimulus duration increased, significant differences between the groups emerged. These differences are consistent with faster information-processing in the gifted children. In the reaction time paradigm, the differences between gifted and nongifted children occurred only for the three and five choice conditions, and were greater as the number of choices increased. Again. this significant interaction is consistent with faster processing (i.e., faster decision time) in the gifted group. Similarly, the greatest difference between gifted and nongifted children in coincidence timing occurred for the most variable condition. In the mental counters task, the fast condition was too difficult for all subjects; chance performance was the result for both groups. In the slower condition, however, the gifted children clearly outperformed the nongifted children. In sum, excluding simple reaction time and a level of difficulty so great that virtually all subjects were at chance, the gifted children showed a general superiority across all four elementary cognitive tasks.

The superiority of the gifted children was essentially independent of ethnic background. There were no ethnic differences for inspection time, coincidence timing, and mental counters. Median reaction data did reveal a significant interaction between ethnic background and GATE membership. The gifted African-Americans had the fastest reaction times of all, whereas the nongifted African-Americans had the slowest. This result is of interest in that previous RT studies with African-Americans have studied only low or, at best, low-average to average IQ African-Americans. The general result has been slower choice RT's in the African-Americans compared to Whites. The present results show that among gifted African-Americans, reaction times are at least comparable, if not faster, than among other ethnic backgrounds. This finding warrants further investigation as it is suggestive of two different subgroups of African-Americans based on reaction time.

Regression analyses were conducted to determine if the relationships between information-processing and IQ and between information-processing and GATE membership are due to speed of processing, or to a factor (or factors) other than speed. The results revealed that inspection time was the only significant predictor of Raven scores. This finding parallels that of Larson (1989), who used the same battery of information-processing tasks (except mental counters) on a group of 127 male Navy recruits. Larson found that inspection time was the only significant predictor of a measure of IQ based on the Armed Forces Qualifying Test (AFQT).

Three information-processing variables predicted GATE membership: Inspection Time (IT5), Coincidence Timing (CTSD, Condition 3), and Reaction Time (5 Choice RT). The additional information-processing predictors of GATE membership may be attributable to the absence of 18 Raven scores. On the other hand, this result more likely reflects the multi-dimensional approach of the case study analysis used to select gifted children, as opposed to the use of a score on a single test. In either case, it is clear that the predominant underlying factor is speed. Both IT and RT involve speed of processing. Moreover, while Condition 3 of the CT task involves randomness, this task is also faster than Condition 1 of the CT task and equal in speed to CT2. It is reasonable to conclude that the addition of randomness in CT Condition 3 favored faster processors. In any case, speed of processing clearly was the predominant factor in the gifted-nongifted differences that were found in the information-processing tasks.

An attempt to identify cut-off scores for the information-processing tasks failed to produce a reliable method of discriminating gifted vs nongifted children. Thus, while information-processing tasks may have relevance for our theoretical understanding of giftedness, there are no indications at present that such tasks could be used to make decisions about individuals. Much more work will be needed if such tests are to become practical. Moreover, the relationship between these elementary cognitive tasks and IQ or GATE membership remained low, with multiple correlations of .34 and .37, respectively. These correlations are in line with others reported in the literature. Therefore, it would appear that speed of processing by itself is insufficient to account for giftedness or intelligence level, and that the use of a variety of elementary cognitive tasks adds little. Thus, for a full account of individual differences in intelligence in terms of information-processing, it would appear necessary to go beyond the elementary cognitive tasks and examine more complex information-processing skills as suggested by Sternberg (1981). In order to account for what is being measured by complex IQ tests, it appears necessary to examine the full range of information-processing skills.