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Analogical Reasoning with Novel Concepts: Differential Attention of Intellectually Gifted and Nongifted Children to Relevant and Irrelevant Novel Stimuli

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ABSTRACT

Intellectually gifted and nongifted students in grades 6, 7, and 8 were given a modified verbal analogies test in which typical verbal analogy problems were preceded by novel or familiar statements about one of the analogy terms. The test required subjects to integrate this new information into an otherwise familiar problem-solving task. Both gifted and nongifted students gave significantly more attention to novel information than to familiar information. Gifted students gave significantly less attention to irrelevant novel information than did nongifted students, but did not differ from nongifted students in their attention to relevant novel information. Whereas intellectually gifted students gave significantly more time to relevant than to irrelevant novel information, nongifted students allocated as much time to irrelevant novel information as they did to relevant novel information. Performance on this task was significantly correlated with teachers' ratings of intellectual ability for gifted, but not for nongifted students.

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From early infancy through adulthood, individual differences in response to novelty seem to be related to individual differences in intelligence. More intelligent individuals typically show greater preference for novelty, more attention to novelty, and more highly developed abilities for dealing with novelty. Fagan and McGrath (1981), for example, found substantial positive correlations between the amount of time infants spent gazing at novel visual stimuli (relative to time spent gazing at familiar stimuli) between the ages of 5 to 7 months and vocabulary scores at 7 years ($r=.57$, $p<.01$). Lewis and Brooks-Gunn (1981) found similar correlations between visual attention measures at 3 months of age and Bayley intelligence test scores at 24 months of age. Response to novelty also appears to be related to intelligence in adulthood. In a task requiring adult subjects to reason within a novel conceptual system, Sternberg (1982) isolated specific component processes underlying task performance, and correlated the time spent on each component process with scores on standardized measures of inductive reasoning. The component processes that correlated most highly with inductive reasoning scores were precisely those processes involved in dealing with the most novel aspects of the task.

Noting the strength and pervasiveness of this relationship between intelligence and response to novelty, Berg and Sternberg (in press) have suggested that response to novelty may be a source of developmental continuity in intelligence. Whether or not this proves to be the case, the ability to deal with novel tasks or situations is central to the views of intelligence held by most psychologists and laypersons (Berg & Sternberg, 1984; Sternberg, Conway, Ketron, & Bernstein, 1981). Piaget (1950) proposed that the primary processes of equilibration through which the individual seeks to master his or her environment involve assimilation of and accommodation to novel information; Cattell (1971) described fluid intelligence in terms of flexible adaptation to new intellectual problems; Raaheim (1974) has defined intelligence as the ability to transform novel information or situations into something more familiar; and Sternberg (1982) has suggested that intelligence includes the ability to adapt to novel circumstances and the ability to learn and reason not only with new concepts but with new kinds of concepts.

Although numerous studies support the view that response to novelty is an important aspect of intelligence, McCall (1979) has noted that response to novelty appears to be rather unstable across ages and, within age, across different stimulus modalities. This instability may reflect a fundamental weakness in our theories about novelty and intelligence. In most real-world situations, intelligent response to novel information requires that the individual first evaluate the information to determine its relevance, then allocate attention on the basis of this determination. If we consider response to novelty as a means of achieving understanding and mastery of the environment, the relative intelligence of prolonged attention to a novel stimulus will vary as a function of its perceived relevance. Unfortunately, typical measures of response to novelty ignore the differential relevance of novel stimuli. Thus, insofar as stimulus relevance may vary across subjects and across measures for any given subject, the instability noted by McCall may be inevitable.

To determine stimulus relevance, the individual must encode stimulus attributes, combine and integrate these attributes into a coherent entity, and compare these integrated attributes with existing information in long-term memory. Recent research by Davidson and Sternberg (1984) has found that intellectually gifted individuals encode, combine, and compare information more selectively than nongifted individuals, and identify relevant and irrelevant information more accurately.

This greater ability of gifted individuals to distinguish between relevant and irrelevant information has important implications for measures of response to novelty. If attention to novelty depends upon the perceived relevance of the stimuli, then the greater attention of more intelligent individuals to novel stimuli may simply reflect their greater ability to recognize the relevance of these stimuli. If this is true, then gifted and nongifted students would be expected to differ in their attention to novel stimuli only when they differ in their perception of stimulus relevance. On the other hand, if differential attention to novelty also reflects a greater preference for novelty among intellectually gifted individuals, then differences should persist even when information is equally relevant (or irrelevant) for all individuals.

The present study specifically examined the amount of attention that intellectually gifted and nongifted intermediate-school students (grades 6, 7, and 8) devoted to relevant and irrelevant novel and familiar information, and the accuracy with which they processed this information. The study employed a well-structured context (the solution of a set of relatively easy verbal analogy problems) in which the contextual relevance or irrelevance of new information could be fixed with some certainty for all subjects. The experimental task required subjects to incorporate new information into an otherwise typical verbal analogies test. Each verbal analogy was preceded by novel or familiar information about one of the analogy terms, and subjects were instructed to solve each analogy *as if* the information were true. Thus, the experimental task required subjects to encode the new information, integrate the information into the problem-solving task, determine the relevance of the information to the specific problem at hand, and then either apply or disregard the information in solving the problem.

The selection of age groups for the present study was based on both theoretical and practical considerations. First, the intermediate-school years (approximately 11 to 14 years of age) are of particular theoretical interest, as they span the transition from concrete to formal operations. Furthermore, the use of this age range avoids many of the problems that could have arisen with much older or younger students. For example, the academic experiences of older intellectually gifted students are apt to be quite different from their nongifted peers, thus confounding the effects of giftedness with the effects of educational experience. Although differences in educational experience undoubtedly exist even among intermediate-school students, they are apt to be less extreme. There probably is even less discrepancy between the educational experiences of gifted and nongifted elementary-school students, but studying children at these younger ages would introduce a new set of problems. In particular, because the test was administered on microcomputers, it was desirable for all subjects to have had at least some prior exposure to computer equipment. Whereas many elementary-school students may be unfamiliar with computers, the intermediate-school curricula in the two schools selected for this study included at least some microcomputer training for all students.

Verbal analogy problems were chosen for the present study because of their familiarity to most students, because of their importance in theories of intelligence (see Sternberg, 1977), and because they permitted the use of well-defined criteria for determining the contextual relevance of new stimuli: Relevant information presented facts that had some bearing on the analogical relationship, whereas irrelevant information did not. The performance of intellectually gifted and nongifted students was compared, and task performance was correlated with teachers' ratings of intellectual ability and with psychometric ability measures.

METHOD

Subjects

Subjects were 161 6th, 7th, and 8th-grade students (80 males and 81 females) from two public intermediate schools in Southeastern Connecticut. The gifted sample consisted of students who had already been identified by the schools as eligible for enrollment in their academic enrichment programs for intellectually gifted students. Admission to the programs in both schools was limited to students who satisfied the following criteria: (a) had IQ scores of at least 135; *or* (b) had above-average IQ scores, *and* above-average academic performance, *and* had letters of recommendation from their teachers, *and* performed adequately in a preadmission screening interview. The gifted sample consisted of 54 students who had met these requirements. The nongifted sample consisted of 107 students who had not been identified as eligible for the programs. In School #1, virtually all gifted students in the school were included in the sample ($n=38$), along with an approximately equal number of randomly selected nongifted students ($n=36$). In School #2, subjects were self-selected, resulting in a smaller gifted sample ($n=16$) and a larger nongifted sample ($n=71$). Gifted and nongifted students were distributed approximately equally among the three grade levels. Mean subject ages and standard deviations were comparable for gifted and nongifted students at each grade level (for grade 6, gifted $M=11.6$, $SD=.40$, nongifted $M=11.7$, $SD=.39$; for grade 7, gifted $M=12.7$, $SD=.28$, nongifted $M=12.8$, $SD=.30$; for grade 8, gifted $M=13.8$, $SD=.33$, nongifted $M=13.8$, $SD=.31$).

Verbal Analogy Items and Presentation Design

A self-paced, microcomputer-administered verbal analogies test was developed for this study. Each of 72 simple verbal analogies was paired with a 3-word precue statement that contained either novel or familiar information about the third term in the analogy, and was either relevant or irrelevant to the analogy solution. Eighteen precued analogies were written for each of four item conditions: (a) novel relevant precued items; (b) novel irrelevant precued items; (c) familiar relevant precued items; and (d) familiar irrelevant precued items. Sample items from each of these four novelty/relevance conditions are shown in Table 1.

Two test forms were constructed from the 72 items and precues. Each test form presented 36 of these items with precue statements (9 precues and analogies in each of the 4 conditions shown in Table 1). The remaining 36 items (9 from each condition) were presented *without* their precue statements (yielding estimates of each subject's solution time and accuracy in the absence of precue information). The items presented with precues in Form A were presented without precues in Form B, and the items presented with precues in Form B were presented without precues in Form A. Within each school and subgroup (gifted or nongifted), half of the subjects received Form A and half received Form B. (In School #1, 18 gifted students and 19 nongifted students received Form A, and 18 gifted and 19 nongifted received Form B; in School #2, 8 gifted and 35 nongifted students received Form A and 8 gifted and 36 nongifted students received Form B.) The test was divided into two sections, with each subject first receiving 36 uncued items, followed by 36 precued items. All items were admin-

Table 1. Sample Items from the Four Novelty/Relevance Conditions

Item Category	Precue	Analogy
Novel Relevant	Radishes are Candies	Pretzel is to Salty as Radish is to Crunchy *Sweet Bitter Tasty
Novel Irrelevant	Lemons are Animals	Lime is to Green as Lemon is to Hard Red *Yellow Round
Familiar Relevant	Pistols are Weapons	Dagger is to Knife as Pistol is to Outlaw *Gun Holster Steel
Familiar Irrelevant	Zebras are Wildlife	Leopard is to Spot as Zebra is to *Stripe Hoof Tail Mark

*Indicates keyed response.

istered on microcomputers, and presentation order of items in each half of the test was randomized for each student. Precue conditions (novelty/relevance) were not blocked. The uncued items were used to obtain baseline processing time and solution accuracy for each student.

Experimental Variables

The major independent variables of interest were precue novelty, precue relevance, and subject giftedness. The dependent variables (all repeated measures) were (a) the mean time each subject devoted to reading novel or familiar 3-word statements (in the absence of any knowledge of the information's relevance); (b) the mean solution time (latency) from analogy onset to selection of an answer option for each of the four novelty/relevance conditions; (c) mean precued analogy solution time minus mean uncued analogy solution time for each condition; (d) subject's total errors on precued analogies in each condition; and (e) total errors on precued analogies in each condition minus total errors on the comparable uncued items.

The precued minus uncued solution time (variable *c*, above) was of particular interest as an estimate of the amount of time devoted to the evaluation and integration of new information (i.e., *selective* encoding, combination, and comparison). Unless subjects' baseline (uncued) performance is subtracted from performance on the precued task, the effects of novelty and relevance may be obscured by larger differences between gifted and nongifted students in general problem-solving and processing speed.

Each student also received a 7-item subset of the mathematical insight problems previously used by Davidson and Sternberg (1984). These items (adapted from problems compiled by Fixx, 1972) require the use of highly selective encoding, comparison, and combination, employing familiar arithmetic operations in new and unusual ways. The following is a typical problem.

> Water lilies double in area every 24 hours. At the beginning of summer, there was one water lily on a lake. It took 60 days for the lake to become completely covered. How many days did it take for the lake to become half-covered?

To arrive at the correct answer to this problem (59 days), the student must selectively encode the information, recognizing that the only relevant facts are that (a) the lake was covered after 60 days, and that (b) water lilies double in area every 24 hours. Through selective combination and comparison of these facts with previously learned information, the student may recognize that (c) regardless of the specific number of water lilies required to cover the lake, half of that number will leave the lake half-covered, and that (d) on any given day, the number of water lilies on the lake is twice what it was on the previous day. Hence, the lake must have been half-covered one day before it was completely covered. The arithmetic operations involved in solving this problem are negligible, even for a 6th grader. The solution depends upon recognizing that the number of lilies at the beginning of the summer is irrelevant to the solution. With this insight, the problem is easy. Without this insight, students find solution almost impossible.

Each student also completed the verbal analogies and number series subtests of the Thorndike-Hagen (1971) Cognitive Abilities Test. In School #1, teachers' ratings of general intelligence, verbal ability, and quantitative ability were obtained for every student. Teachers' ratings were not available for students in School #2.

Procedure

The experimental verbal analogies were administered on Commodore 64 (School #1) and Apple II+ (School #2) microcomputers. To determine baseline error rates and solution latencies, the first half of the test consisted of 36 items presented without precue statements. After all of these uncued items were completed, the remaining 36 items were presented, with each analogy preceded by either a novel or a familiar precue statement (9 items in each of the four novelty/relevance conditions). Presentation order for items and answer options within each half of the test was randomized for each subject. In the second half of the test, precued item order was randomized across experimental conditions. The test was entirely self-paced, with the inter-item interval controlled by the subject. Instructions for each half of the test stressed that accuracy was more important than speed, but mentioned that both speed and accuracy would be recorded and that subjects should try to work at a fairly rapid pace.

Instructions for the first half of the test (the uncued items) appeared on the display screen attached to each computer, and subjects could move forward or backward through the instructions by pressing the right-arrow or left-arrow on the computer keyboard. These instructions were followed by a series of four practice items. When the subject pressed the space-bar to indicate that the instructions had been read, the first practice item was displayed on the screen. After the subject answered each practice item, the correct answer was displayed on the screen, followed by a short paragraph explaining why that answer was correct. After all practice items were completed, a message on the display screen asked the subject to press the space-bar as soon as he or she was ready to begin the test. For each item in the test, the student first pressed the space-bar to display the verbal analogy item and four numbered answer options. The student entered his or her answer by pressing the appropriate numeric key (1–4). The screen was cleared immediately after each item was answered, remaining blank until the subject pressed the space-bar to display the next item.

After the subject completed the 36 uncued items, a new set of instructions appeared on the display screen, describing the precued analogies that would be administered in the second half of the test. These instructions indicated that each problem in the second half of the test would be preceded by a short statement, and that each analogy should be solved *as if* this statement were true. The instructions were followed by four new practice items. After each of the practice items was answered, the correct answer was displayed on the screen, with a fairly detailed account of why this was the correct solution (and why the other alternatives were incorrect). After the last practice item, the subject was instructed to press the space-bar to begin the second half of the test.

For each precued item, the subject pressed the space-bar once to display the precue statement; after reading the precue statement, the subject pressed the space-bar again to display the analogy item. To minimize the effects of memory on performance, the precue statement remained on the screen until the subject entered his or her answer. The screen was cleared immediately after each answer, remaining blank until the subject pressed the space-bar again to display the next precue. To encourage students to read each precue carefully before displaying the analogy item, students were told that the time they took to read the precue statements was less important in determining their "time scores" than the time they spent solving the problem after the analogy had been displayed.

For each of the 72 test items, the following information was recorded: (a) solution latency, defined as the interval between analogy onset and solution; and (b) solution accuracy (that is, whether or not the selected answer matched the answer key). In addition, precue reading time (defined as the interval between precue onset and analogy onset) was recorded for each of the 36 precued items.

After all of the precued items were completed, instructions were displayed for rating the novelty of all 72 precue statements (the 36 statements previously seen by the subject, plus the 36 statements that were used in the alternate form of the test). Subjects were instructed to rate the strangeness of each statement on a 5-point scale (from 1 = "not at all strange" to 5 = "really weird"). The rating scale remained on the screen throughout the rating task.

The total testing time per subject was approximately two hours (60 min for paper-and-pencil instruments, 40 to 60 min for the self-paced experimental analogies test and ratings). A fixed testing order was used. Students first completed the Thorndike-Hagen verbal analogies and number series, then the mathematical insights test, and finally the experimental analogies test. At School #1, each student was tested in two one-hour group sessions during regular classroom hours. In School #2, it was not possible to test during classroom hours; instead, each student completed all of the test instruments in a single two-hour session after school.

RESULTS

Preliminary Analyses

Preliminary analyses addressed four issues: (a) the extent to which the novel and familiar precues on the experimental verbal analogies test actually were perceived as novel and familiar by subjects; (b) item reliabilities (internal consistency) within each of the four novelty/relevance conditions; (c) comparability of the two alternate forms of the precued verbal analogies test; and (d) comparability of the two schools and of male and female subjects.

The results show that manipulation of precue novelty was successful. On a 5-point rating scale (1 = "not at all strange" to 5 = "really weird"), novel precues received a mean rating of 3.79, $SD=.60$, and familiar precues received a mean rating of 1.15, $SD=.31$, $t(160)=44.75$, $p<.01$.

Distributions of response latencies for precue reading time, precued analogy solution time, and precued minus uncued analogy solution time were examined for each level of grade (3 levels) by gender (2 levels) by test form (2 levels) by giftedness (2 levels) by precue novelty (2 levels) by precue relevance (2 levels). The distributions were markedly skewed, with heterogeneous variances across conditions. Logarithmic transformation of response latencies effectively normalized the distributions and served to homogenize variances for the precued analogy solution time and precued minus uncued analogy solution time (Bartlett's $\chi^2(95)=93.67$ for log precued solution time, 104.16 for log precued minus

Table 2. Solution Latency, Solution Accuracy, and Item Reliability for the Two Test Forms

	Novel Precues		Familiar Precues	
	Relevant	**Irrelevant**	**Relevant**	**Irrelevant**
Solution Latency				
Test Form A:				
Mean Latency	17.66	16.64	16.13	16.61
SD	2.23	3.11	2.44	2.57
Reliability	.67	.75	.69	.75
Test Form B:				
Mean Latency	18.20	17.67	15.69	16.50
SD	2.65	2.76	2.43	2.74
Reliability	.74	.82	.72	.72
Solution Accuracy				
Test Form A:				
Number Correct	4.43	7.79	7.86	8.12
SD	2.38	1.39	1.28	1.12
Reliability	.81	.63	.67	.65
Test Form B:				
Number Correct	4.13	7.83	8.06	7.58
SD	2.22	1.68	1.28	1.52
Item Reliability	.70	.75	.59	.65

Note. Kuder–Richardson Formula 20 was used to compute reliability of the solution accuracy data; Cronbach's coefficient alpha was used to compute reliability of the solution latency data.

uncued solution time, both $ps > .25$). Variances for log precue reading time, however, remained heterogeneous (Bartlett's $\chi^2(95) = 186.68$, $p < .01$).

For each test form, item reliability was computed for error data (Kuder–Richardson formula KR-20) and for log transformed solution latencies (Cronbach's coefficient α). Mean scores, solution latencies, and reliability coefficients for each experimental condition are shown in Table 2.

Comparability of schools, test forms, and gender was evaluated using a weighted (for unequal *ns*) three-way between-subjects analysis of variance (test form × school × gender) for each of five dependent variables: precue reading time (log seconds), precued analogy solution time (log seconds), precued minus uncued solution time (log seconds), precued error rate, and precued minus uncued error rate. Students in School #1 made significantly fewer errors than students in School #2 on the precued analogy items. For the 36 precued items, the mean number of errors in School #1 was 6.70, $SD = 4.01$, and in School #2 was 9.10, $SD = 4.10$, $F[1,157] = 11.90$, $p < .01$. Students in the two schools did not differ in precue reading time, precued solution time, precued minus uncued solution time, or precued minus uncued error rate. There were no significant effects of gender on any of the dependent variables, and no significant differences between the alternate test forms (all Fs < 1.0, all $ps > .10$).

Because of the substantial differences between samples and testing conditions in the two schools, and the significantly higher error rates in School #2, data from the two schools were treated separately in all subsequent analyses. Data were collapsed over test form and gender, using log transformations of reading times and response latencies.

Effect of Novelty on Reading Time

The effects of novelty and giftedness on precue reading times were analyzed using weighted three-way mixed analysis of variance (grade × giftedness × novelty). In School #1, students spent significantly more time reading novel precues than familiar precues, $F[1,68] = 41.82$, $p < .01$. In School #2, this effect was only marginally significant, $F[1,81] = 3.35$, $p < .10$. Means and standard deviations for the two schools are shown in Table 3.

In both schools, 7th grade students spent significantly less time reading both novel and familiar precues than did 6th or 8th grade students (for School #1, $F(2,68) = 6.01$, $p < .01$; for School #2, $F(2,81) = 3.43$, $p < .05$). No other significant main effects or interactions for precue reading time were found in either school.

Effect of Novelty and Relevance on Analogy Solution

The effects of novelty and relevance on precued solution latencies and on precued minus uncued latencies were analyzed using weighted four-way mixed analyses of variance (grade × giftedness × novelty × relevance). The log transformed precued solution latencies and precued minus uncued solution laten-

Table 3. Log Transformed Precue Reading Times for Experimental Analogies

		Novel Precues		Familiar Precues	
	n	*M*	*SD*	*M*	*SD*
School #1					
Nongifted					
Grade 6	12	1.48	0.32	1.06	0.38
Grade 7	11	0.30	0.30	0.07	0.33
Grade 8	13	1.02	0.17	0.71	0.23
Total	36	0.95	0.17	0.63	0.19
Gifted					
Grade 6	13	1.68	0.23	1.30	0.19
Grade 7	11	0.85	0.34	0.76	0.38
Grade 8	14	0.90	0.17	0.84	0.19
Total	38	1.15	0.15	0.97	0.15
School #2					
Nongifted					
Grade 6	24	1.42	0.20	1.08	0.21
Grade 7	26	0.71	0.28	0.56	0.28
Grade 8	21	1.14	0.31	1.02	0.29
Total	71	1.07	0.15	0.87	0.15
Gifted					
Grade 6	4	1.41	0.53	1.03	0.43
Grade 7	9	0.45	0.58	0.48	0.47
Grade 8	3	1.48	0.04	1.41	0.09
Total	16	0.88	0.36	0.79	0.29

cies for each condition are shown in Table 4. Also shown in Table 4 are the uncued solution latencies for items in each category (i.e., latencies obtained when items in that category were presented *without* precues in Part 1 of the experimental analogies test).

Significant main effects for giftedness and precue novelty were found, as well as significant interactions of novelty by relevance and novelty by relevance by giftedness. There were no significant main effects or interactions involving grade level for either precued solution latency or for precued minus uncued solution latency.

As expected, both precued solution latencies and precued minus uncued solution latencies were significantly greater for items with novel precues than for items with familiar precues (for precued latency, $F(1,68)=69.69$ in School #1, $F(1,81)=31.65$ in School #2; for precued minus uncued latency, $F(1,68)=66.93$ in School #1, $F(1,81)=17.13$ in School #2; all $p<.01$). Gifted students were significantly faster than nongifted students for precued solution latency but not for precued minus uncued latency (for precued latency, $F(1,68)=7.52$ in School #1, $F(1,81)=6.50$ in School #2; both $p<.05$; for precued minus uncued latency,

Table 4. Mean Uncued Solution Latency, Precued Solution Latency, and Precued minus Uncued Solution Latency (Log)

		Novel				Familiar			
		Relevant		Irrelevant		Relevant		Irrelevant	
	n	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Uncued Solution Latencies									
School #1									
Nongifted	36	16.19	0.29	15.31	0.28	15.87	0.28	16.36	0.31
Gifted	38	14.91	0.36	14.87	0.36	14.66	0.33	15.15	0.41
School #2									
Nongifted	71	15.86	0.24	14.97	0.27	15.21	0.26	15.45	0.23
Gifted	16	15.02	0.52	14.46	0.52	14.60	0.42	15.01	0.59
Precued Solution Latencies									
School #1									
Nongifted	36	18.83	0.36	18.46	0.55	17.14	0.39	17.90	0.49
Gifted	38	18.16	0.43	16.74	0.55	15.15	0.44	16.11	0.41
School #2									
Nongifted	71	17.40	0.26	17.29	0.28	16.04	0.25	16.39	0.27
Gifted	16	17.46	0.74	15.14	0.53	14.67	0.57	15.41	0.70
Precued Minus Uncued Solution Latencies									
School #1									
Nongifted	36	2.64	0.35	3.15	0.49	1.27	0.39	1.55	0.44
Gifted	38	3.25	0.39	1.85	0.42	0.48	0.29	0.96	0.29
School #2									
Nongifted	71	1.54	0.27	2.32	0.31	0.83	0.25	0.94	0.31
Gifted	16	2.44	0.67	0.67	0.54	0.07	0.39	0.40	0.62

$F(1,68)=2.35$ in School #1, $F(1,81)=2.34$ in School #2; both $p>.10$). In both schools, novel relevant items produced substantially higher solution latencies than items in other conditions (for precued latency, $F(1,68)=17.88$ in School #1, $F(1,81)=15.04$ in School #2; both $p<.01$; for precued minus uncued latency, the effect was only marginally significant, $F(1,68)=3.25$ in School #1, $F(1,81)=3.02$ in School #2; both $p<.10$).

For precued solution latency, there was also a significant three-way interaction of novelty by relevance by giftedness in School #2, with gifted students allocating substantially more time to relevant novel information than to irrelevant novel information, and nongifted students allocating approximately equal time to relevant and irrelevant novel information, $F(1,81)=9.20$, $p<.01$. In School #1,

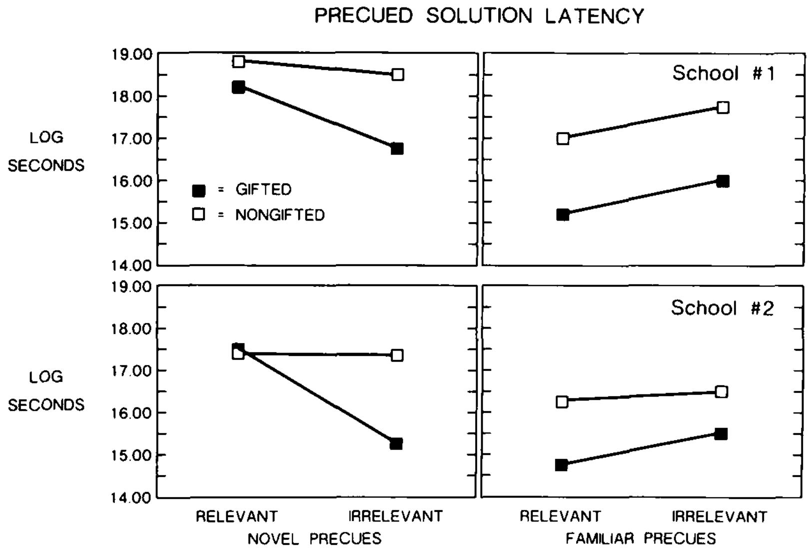

Figure 1. Precued solution latencies (Log seconds) for novel and familiar relevant and irrelevant precue information.

this interaction was only marginally significant, $F(1,68)=2.80$, $p<.10$. Plots of the mean precued solution latencies for gifted and nongifted students in the four novelty/relevance conditions are shown for both schools in Figure 1.

This three-way interaction becomes much sharper when the results for precued minus uncued solution latencies are examined. For precued minus uncued data, the interaction is significant in both schools ($F(1,68)=4.44$ $p<.05$ in School #1; $F(1,81)=8.13$, $p<.01$ in School #2). Mean precued minus uncued solution latencies for gifted and nongifted students in both schools are shown in Figure 2.

With only one degree of freedom for this interaction, the possibilities for additional statistical analyses are somewhat limited. Winer (1962, pp. 440–443) has suggested the use of post-hoc comparisons (e.g., Newman–Keuls tests) within levels of the variables. To make the appropriate comparisons in the present case, the four novelty/relevance conditions were treated as levels of a single condition, and Newman–Keuls tests were performed separately for gifted and nongifted subjects. In both schools, Newman-Keuls tests indicated that gifted subjects allocated significantly more time to relevant novel information than to irrelevant novel information ($p<.01$); for nongifted subjects, however, the time allocated to relevant novel information did not differ significantly from the time allocated to irrelevant novel information ($p>.10$ in both schools). Alternatively, when gifted and nongifted students are compared within levels, the only significant difference between the two groups is in the novel irrelevant

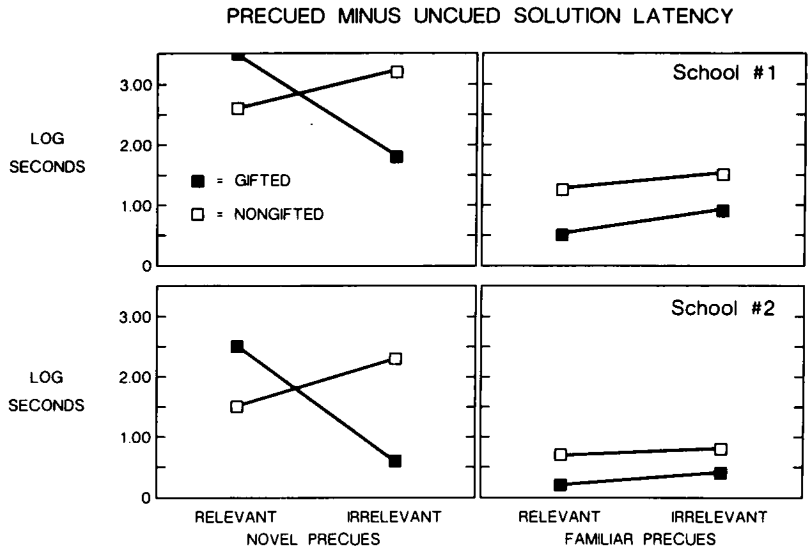

Figure 2. Precued solution latencies minus uncued solution latencies (Log Seconds) for novel and familiar relevant and irrelevant precue information.

condition, with gifted students allocating significantly less time than nongifted students to novel irrelevant precues ($p<.05$ in both schools).

The effects of novelty and relevance on precued solution accuracy and on uncued minus precued solution accuracy were analyzed using weighted four-way mixed analyses of variance (grade × giftedness × novelty × relevance). Uncued solution accuracy, precued solution accuracy, and uncued minus precued solution accuracy are shown in Table 5.

For both precued solution accuracy and uncued minus precued accuracy, significant main effects were found for giftedness, precue novelty and precue relevance, as well as a significant interaction of precue novelty by giftedness. There were no significant main effects or interactions involving grade level.

Both precued solution accuracy and uncued minus precued accuracy were significantly higher for gifted students than for nongifted students (for precued solution accuracy, $F(1,68)=5.93$ in School #1, $F(1,81)=5.67$ in School #2; for uncued minus precued accuracy, $F(1,68)=6.33$ in School #1, $F(1,81)=4.74$ in School #2; all $p<.05$). Precued accuracy and uncued minus precued accuracy were significantly higher for familiar than for novel precue conditions (for precued accuracy, $F(1,68)=84.81$ in School #1, $F(1,81)=98.30$ in School #2; for uncued minus precued accuracy, $F(1,68)=75.18$ in School #1, $F(1,81)=58.52$ in School #2; all $p<.01$). Both precued accuracy and uncued minus precued accuracy also were significantly higher for irrelevant than for relevant precue conditions (for precued accuracy, $F(1,68)=103.33$ for School #1,

Table 5. Uncued Solution Accuracy, Precued Solution Accuracy, and Uncued Minus Precued Solution Accuracy

		Novel Precues				Familiar Precues			
		Relevant		Irrelevant		Relevant		Irrelevant	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Uncued Solution Accuracy (Number of Items Correct)									
School #1									
Nongifted	(36)	8.53	0.13	8.64	0.11	8.69	0.10	8.58	0.12
Gifted	(38)	8.39	0.12	8.84	0.06	8.68	0.08	8.45	0.13
School #2									
Nongifted	(71)	7.69	0.14	8.21	0.11	8.35	0.09	8.15	0.09
Gifted	(16)	8.00	0.32	8.13	0.27	8.25	0.17	8.19	0.21
Precued Solution Accuracy (Number of Items Correct)									
School #1									
Nongifted	(36)	4.33	0.39	8.03	0.25	7.83	0.31	7.97	0.24
Gifted	(38)	5.55	0.30	8.37	0.15	8.26	0.13	8.18	0.15
School #2									
Nongifted	(71)	3.69	0.27	7.28	0.21	7.85	0.14	7.59	0.18
Gifted	(16)	4.13	0.60	8.38	0.18	8.31	0.28	8.25	0.21
Uncued Minus Precued Solution Accuracy									
School #1									
Nongifted	(36)	4.19	0.41	0.61	0.27	0.86	0.32	0.61	0.27
Gifted	(38)	2.84	0.31	0.47	0.14	0.42	0.15	0.26	0.12
School #2									
Nongifted	(71)	4.00	0.31	0.92	0.24	0.51	0.15	0.56	0.19
Gifted	(16)	3.88	0.50	−0.25	0.37	−0.06	0.27	−0.06	0.27

$F(1,81)=56.33$ for School #2; for uncued minus precued accuracy, $F(1,68)=110.39$ in School #1, $F(1,81)=33.91$ in School #2; all $p<.01$). There was also a significant interaction between novelty and relevance, with significantly lower accuracy for novel relevant items than for items in any of the other conditions (for precued accuracy, $F(1,68)=97.16$ in School #1, $F(1,81)=69.43$ in School #2; for uncued minus precued accuracy, $F(1,68=50.94$ in School #1, $F(1,81)=37.77$ in School #2; all $p<.01$).

Relationship Between Precued Analogies and Other Measures

Correlations between scores on the precued verbal analogies test (total number of items correct), the mathematical insights test, and the Thorndike–Hagen (CAT) verbal analogies are shown in Table 6. The magnitudes of the correlation coefficients suggest that there is some overlap among the abilities assessed by the different measures, and performance on the experimental verbal analogies task is relevant to more traditional measures of intellectual ability.

For School #1, the only school in which teacher ratings were available, test scores were correlated with teachers' ratings of general intelligence, verbal ability, and quantitative ability. Correlations for the total sample and for the gifted and nongifted subsamples are shown in Table 7.

For the total sample, the correlation between scores on the experimental analogies and ratings of general intelligence was .40 ($p<.001$). Despite considerable restriction of range, this correlation jumped to .56 ($p<.001$) for the gifted subsample, and dropped to nonsignificance ($r=.15$) for the nongifted subsample. The difference between these two correlation coefficients is statistically significant ($z=1.99$, $p<.05$). The Thorndike–Hagen (CAT) verbal analogies showed a similar pattern of high correlation for gifted subjects and low correlation for nongifted subjects, but the subgroup differences did not reach statistical significance and correlations for gifted students were not substantially higher than for the total sample.

Table 6. Intercorrelations of Test Instruments, Schools 1 and 2

	1	2	3	4
Total Sample (*n* = 161)				
1. Precued Verbal Analogies	—	.40***	.39***	.31***
2. Mathematical Insights		—	.44***	.42***
3. CAT Verbal Analogies			—	.40***
4. CAT Number Series				—
Gifted Sample (*n* = 54)				
1. Precued Verbal Analogies	—	.05	.28	.14
2. Mathematical Insights		—	.25	.32*
3. CAT Verbal Analogies			—	.12
4. CAT Number Series				—
Nongifted Sample (*n* = 107)				
1. Precued Verbal Analogies	—	.36**	.29*	.28*
2. Mathematical Insights		—	.27*	.37**
3. CAT Verbal Analogies			—	.27*
4. CAT Number Series				—

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

Table 7. Correlation of Tests with Teachers' Ratings of Ability, School #1

	Teachers' Ratings		
	General Intelligence	**Verbal Ability**	**Math Ability**
Total Sample (n = 74)			
Precued Verbal Analogies	.40***	.39***	.32**
Mathematical Insights	.34**	.20	.36**
CAT Verbal Analogies	.40***	.38***	.41***
CAT Number Series	.28*	.14	.28*
Gifted Sample (n = 38)			
Precued Verbal Analogies	.56***	.52***	.38*
Mathematical Insights	.16	.02	.21
CAT Verbal Analogies	.46**	.46**	.39*
CAT Number Series	.33*	.12	.29
Nongifted Sample (n = 36)			
Precued Verbal Analogies	.15	.21	.09
Mathematical Insights	.11	.10	.12
CAT Verbal Analogies	.17	.27	.10
CAT Number Series	.09	.05	.17

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

DISCUSSION

The results of this study provide evidence that intellectually gifted students (in grades 6, 7, and 8) are more sensitive to the relevance of novel information than are nongifted students. The results also suggest that the greater sensitivity of gifted students to stimulus relevance may account for much of the difference between gifted and nongifted students' attention to novel stimuli. The gifted and nongifted students in this study differed substantially in their attention to *irrelevant* novel information, but not in their attention to *relevant* novel information. Gifted students allocated approximately the same amount of time to relevant novel information as did nongifted students, but quickly dismissed irrelevant novel information. Nongifted students, however, allocated as much time to irrelevant novel information as they did to relevant novel information.

When the experimental conditions made it impossible for subjects to evaluate the relevance of novel information (i.e., during the initial precue presentation), there were no significant differences between gifted and nongifted students in the amount of time allocated to either novel or familiar information. We do not wish to suggest that the absence of differences necessarily results from the absence of information about precue relevance. However, the results are at least consistent with the view that the relationship between intelligence and response to novelty depends upon the superior ability of more intelligent individuals to evaluate the relevance of novel stimuli.

Both gifted and nongifted students made more errors in dealing with novel relevant information than with novel irrelevant or familiar information, and nongifted students made more errors than gifted students. However, whereas the differences between gifted and nongifted students in solution *latency* depended upon the novelty/relevance conditions (with significant differences only in the novel irrelevant condition), differences in solution *accuracy* of gifted and nongifted students were approximately the same across experimental conditions. In all four precued verbal analogy conditions, the correct response depended upon the accurate determination of precue relevance. Thus, the higher overall accuracy of gifted students is consistent with previous findings (Davidson & Sternberg, 1984) that intellectually gifted individuals are better able to distinguish between relevant and irrelevant information than are nongifted individuals. The solution accuracy data indicate that gifted students are consistently superior to nongifted students in distinguishing between relevant and irrelevant information, regardless of the acutal relevance or novelty of the information.

If differences between solution accuracy of gifted and nongifted students do not vary across novelty/relevance conditions, why are solution latency differences so much greater for novel irrelevant information than for any of the other conditions? Although this study did not explicitly address processing mechanisms, one possibility is that gifted students evaluate novel information for its relevance *before* engaging in any further processing, whereas nongifted students do not evaluate the relevance until *after* exhaustive processing has been completed.

The results of this study support the view that the ability to deal effectively with novel information is a useful indicator of academic intelligence. Scores on the precued verbal analogies were significantly correlated with teachers' ratings of intelligence and with standardized measures of academic ability. The correlations between teachers' ratings and scores on the experimental test were significantly higher for gifted students than for nongifted students, despite the more restricted range of scores and ratings for gifted students. A similar pattern of higher gifted than nongifted correlations between the Thorndike-Hagen subtests and teachers' ratings suggests that rating criteria or accuracy may have differed for gifted and nongifted students. More specifically, the higher correlations for the gifted sample may reflect a tendency for teachers to be more attentive to gifted than to nongifted students (thus providing more accurate ratings of the intellectual abilities of gifted students), or to give relatively more weight to intellectual factors in ratings of gifted students, and relatively more weight to nonintellectual factors in ratings of nongifted students.

Overall, the findings of this study indicate that the relationship between intelligence and attention to novelty may depend upon the relevance of novel information to the individual's effective functioning and adaptation within a given environment. This qualification, however, does not diminish the importance of the relationship between intelligence and response to novelty. On the contrary, it suggests that a careful examination of the relevance (or irrelevance) of novel stimuli may offer an explanation for the apparent instability of many measures of response to novelty. It may be said with some confidence that if the novel relevant and novel irrelevant items used here had been administered separately to assess the relationship between intelligence and response to novelty, without considering the relevance of the stimuli, the results of these separate administrations would have shown the kind of instability previously noted by McCall (1979).

Although the ability to transform novel information into something more familiar may be, as Raaheim (1974) suggested, the core of intelligent behavior, adequate assessment of the ability may require an understanding of the relevance of the information that will be transformed. This is consistent with contextual views of intelligence, which stress the importance of considering the extent to which behavioral indicators of "intelligence" actually are adaptive within (and relevant to) a given contextual situation or cultural setting (e.g., Sternberg, 1985).

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