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Gender Differences in Planning, Attention, Simultaneous, and Successive (PASS) Cognitive Processes and Achievement

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Gender differences in ability and achievement have been studied for some time and have been conceptualized along verbal, quantitative, and visual–spatial dimensions. Researchers recently have called for a theory-based approach to studying these differences. This study examined 1,100 boys and 1,100 girls who matched the U.S. population using the Planning, Attention, Simultaneous, Successive (PASS) cognitive-processing theory, built on the neuropsychological work of A. R. Luria (1973). Girls outperformed boys on the Planning and Attention scales of the Cognitive Assessment System by about 5 points (d = .30 and .35, respectively). Gender differences were also found for a subsample of 1,266 children on the Woodcock–Johnson Revised Tests of Achievement Proofing (d = .33), Letter–Word Identification (d = .22), and Dictation (d = .22). The results illustrate that the PASS theory offers a useful way to examine gender differences in cognitive performance.

Gender differences in achievement and cognitive ability have been examined for some time, resulting in a substantial body of literature on the topic (e.g., Deaux, 1984; Fennema & Sherman, 1977; Geary, 1989, 1994, 1996; Halpern, 1986, 1989, 1997; Linn & Peterson, 1985; Maccoby & Jacklin, 1974; Voyer, Voyer, & Bryden, 1995). Some researchers have conceptualized the results of their findings within the context of verbal, quantitative, and visual–spatial abilities. For example, Maccoby and Jacklin (1974) concluded that girls usually do better than boys on verbal tasks. Hyde and Linn (1988) conducted a meta-analysis of 165 studies of gender differences in verbal ability and found a small mean effect size (favoring girls) of .11 for studies of students aged 5–18 years. Importantly, the differences between the genders were not uniform across tasks. For instance, the effect size for vocabulary was minimal (d = .02) but more substantial for speech production (d = .33). Gender differences in quantitative skills also have been found. Geary (1996), for example, stated that boys outperform girls on tests that involve spatial representation of mathematical relationships, presumably because "the male advantage in certain areas of mathematics (e.g., problem solving) is related to a male advantage in spatial abilities" (p. 236). Voyer et al. (1995) suggested that the difference in spatial abilities may be as large as 0.94 standard deviations and that the concept needs to be examined carefully using a variety of tests. Girls, on the other hand, have been found to have an advantage over boys on basic arithmetic tests, at least through junior high school (Hyde, Fennema, & Lamon, 1990).

Understanding the performance differences between the genders is at least partially based on the interpretations researchers give to the tests used in the various studies. This is made more difficult because many researchers do not provide clear definitions of their constructs, the tasks often are complex, and a variety of tests may be used to measure the same construct. For example, quantitative ability typically is measured on the basis of mathematics achievement. This means that items as diverse as basic math facts, long division, word problems, oral arithmetic problems, algebra, trigonometry, and so on may be included and that some topics (e.g., trigonometry) will not be included in tests for young children. Similarly, studies that compare girls and boys in verbal ability could include a variety of tasks such as vocabulary, verbal fluency, and verbal analogies that, although all verbal, may have different cognitive demands and lead to inconsistency when measuring the verbal ability construct. This led Halpern (1997) to propose a new taxonomy.

Halpern (1997) rejected the verbal, visual–spatial, and quantitative taxonomy domains. This conceptualization may have been used so often because it has been a superstructure for group and individual tests of ability since the early part of the 19th century (Kaufman & Lichtenberger, 1999). Although the schema has been popular in psychology and education for about 100 years, its weakness is apparent both in the study of gender-related differences and in intelligence testing (Naglieri, 1999). To replace this organizational system, Halpern (1997) suggested a taxonomy based "on underlying cognitive processes [which] offers a more fine-grained analysis of how information is retrieved from memory and what participants are doing when they are working on a cognitive task." (p. 1092). From this perspective, Halpern summarized some of the major findings as follows: Girls outperform boys on tests of verbal fluency, foreign language, fine-motor skills, speech articulation, reading and writing, and math calculation, and they typically earn higher grades in school in all or most subjects. Boys have been found to do better on tasks such as mental rotation, mechanical reasoning, math and science knowledge, and verbal analogies. These tasks were organized into eight areas that appear

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to reflect the underlying cognitive processes described by Halpern as areas in which girls and boys differ. Halpern's efforts to provide alternative descriptions of the underlying cognitive processes, which she used to organize a variety of tasks and her suggested taxonomy, is an important recognition of the need for a carefully articulated perspective, or theory, from which differences between girls and boys can be understood.

McHough, Koeske, and Frieze (1986) argued that gender differences cannot be understood adequately unless girls and boys are compared according to a theoretical model of cognitive functioning. Geary (1989) further emphasized that conceptual models of cognitive differences between the genders should provide an integration of the neurological and sociocultural components that influence the development of cognitive processes. Similarly, Sternberg (1990) and Naglieri (1999) stressed the importance of using a theoretical approach to define and measure intelligence, especially when group differences are examined, such as when genders are compared. Naglieri and Das (1997a) contended that a theory of cognitive abilities should be based on a neuropsychologically derived view of processing operationalized with a well-developed test. The Planning, Attention, Simultaneous, Successive (PASS) theory described by Das, Naglieri, and Kirby (1994) is such a theory.

The PASS theory is derived from research in neuropsychology and cognitive psychology with particular emphasis on the work of Luria (1966, 1973, 1980). Luria proposed that there are three types of cognitive processes responsible for mental activity associated with three functional units of the brain. These processes work in concert to produce behavior and provide attention (first unit), simultaneous and successive processing (second unit), and planning (third unit) cognitive processes. The first functional unit, located in the brain stem and reticular activating system (Luria, 1973), provides the brain with the appropriate level of arousal or cortical tone for focused attention and resistance to distraction. The second functional unit (occipital–parietal and frontal–temporal areas of the brain) is responsible for "receiving, analyzing and storing information" (Luria, 1973, p. 67) using simultaneous and successive processing. The third functional unit is located in the frontal lobes of the brain (Luria, 1973) and is responsible for planning, including the programming, regulation, and verification of behavior (Luria, 1973). This provides the capability for behavior such as asking questions and problem solving and the capacity for self-monitoring (Das et al., 1994). These processes provide a different perspective that redefines intelligence within the context of cognitive processes (Naglieri, 1999), which has been used to study gender-related differences.

Bardos, Naglieri, and Prewett (1992) were the first to compare the performance of girls and boys using the PASS theory. They studied samples of children in Grades 2, 6, and 10 (N = 434) and Grades 4 and 5 (N = 112). In their first study, they used measures of planning, simultaneous, and successive cognitive processes and found that girls outperformed boys in planning in Grade 6. In their second investigation, they found that girls did better than boys in planning in Grades 4 and 5. This study, however, involved small samples and inconsistent measures and did not adequately assess the attention component of the PASS theory. Warrick and Naglieri (1993) examined all four PASS processes using a sample of boys and girls in Grades 3, 6, and 9 (N = 197) and found that girls earned significantly higher scores on measures of attention in Grade 3. Differences between the genders were found at each grade for Planning (d = .43, .52, and .35 for Grades 3, 6, and 9, respectively), but these findings were not significant. Relatively small sample sizes and restriction in range limited the generalization of the results of this study.

Initial research on gender differences using the PASS theory suggested cognitive differences between the genders (Bardos et al., 1992; Warrick & Naglieri, 1993). These studies were limited because they included relatively small samples of children who were not representative of the U.S. population and who were given versions of PASS tasks that required further development. They did, however, suggest that the PASS theory could provide an important taxonomy for understanding gender differences in basic cognitive processes. The goal of the study discussed in this article was to examine girls and boys on PASS cognitive processes using a large, nationally representative sample of children aged 5–17 years to determine if differences exist and if this theory therefore might provide a potentially viable means of examining gender differences.

Method

Participants

Participants were 2,200 girls and boys aged 5–17 years. The group's composition closely reflected the U.S. population according to age, gender, race, Hispanic origin, parental education, community setting, and geographic region (see Table 1). The sample was organized into three age groups (5–7, 8–10, and 11–17) to examine developmental changes in PASS standard scores. The sample contained approximately equal numbers of girls and boys who matched each other and the U.S. population. All participants were individually administered PASS tests by trained examiners during the standardization phase of the Cognitive Assessment System (CAS; Naglieri & Das, 1997b). A portion of the sample was also admin-

Table 1
Percentages of Sample Demographic Characteristics by Gender and for Total Sample Compared With 1992 U.S. Census Data

Characteristic	Boys (N = 1,100)	Girls (N = 1,100)	Total (N = 2,200)	U.S. Census
Race				
White	74.5	77.3	75.9	76.9
Black	13.7	13.0	13.4	13.5
Other	11.8	9.7	10.7	9.6
Ethnicity				
Hispanic	11.3	10.9	11.1	11.4
Non-Hispanic	88.7	89.1	88.9	88.6
Parental education				
< high school	19.5	20.1	19.8	20.3
High school	29.3	28.7	29.0	28.6
Some college	29.4	27.8	28.6	28.7
4 or more years of college	21.9	23.4	22.6	22.5
Community setting				
Rural	24.7	25.7	25.2	24.8
Urban/suburban	75.3	74.3	74.3	75.2
Geographic region				
Midwest	25.4	24.8	25.1	25.2
Northeast	18.5	18.9	18.7	18.7
South	33.9	33.6	33.8	34.2
West	22.3	22.6	22.5	21.9

istered the Woodcock–Johnson Tests of Achievement—Revised (WJ–R; Woodcock & Johnson, 1989). This subsample of 1,266 children was also representative of the larger sample and the U.S. population (see Table 2).

Measures

Cognitive Assessment System

The PASS processes were assessed using the CAS (Naglieri & Das, 1997b), an individually administered test for children aged 5–17 years. The CAS is organized into four scales (Planning, Attention, Simultaneous, and Successive) according to the PASS theory and a Full Scale standard score, each with a mean of 100 and standard deviation of 15. The average internal reliabilities for the PASS scales are as follows: Planning = .88; Simultaneous = .93; Attention = .88; Successive = .93; and Full Scale = .96. The CAS was standardized on 2,200 persons aged 5 years 0 months to 17 years 11 months who closely matched the U.S. population on the basis of gender, race, ethnicity, parental education, community setting, geographic region, classroom placement, and educational classification. Extensive reliability and validity research was presented in the CAS *Interpretive Handbook* (Naglieri & Das, 1997a). Naglieri (1999) summarized much of this research and concluded that tests based on the PASS theory (a) are sensitive to the problems shown by children with attention deficit disorder and reading recoding disabilities: (b) relate to academic achievement; and (c) have relevance to intervention and instruction. Perhaps most important, however, the PASS scales' overall correlation with achievement in several academic areas (.70, N = 1,600) was higher than the correlation between the Wechsler Intelligence Scale for Children—Third Edition (Wechsler, 1991) and achievement (.59, N = 1,284).

Each PASS scale has regularly administered subtests. These are described below according to the PASS scale to which they belong.

Planning Scale. Matching Numbers consists of four pages, each containing eight rows of six numbers per row. The child is instructed to underline the two numbers in each row that are the same. Numbers increase in length from one digit to seven digits across the four pages, with four rows for each digit length. Each item has a time limit. The subtest score is based on the combination of time and number correct for each page.

Planned Codes contains two pages, each with a distinct set of codes and arrangement of rows and columns. A legend at the top of each page shows how letters correspond to simple codes (e.g., A, B, C, and D correspond to OX, XX, OO, and XO, respectively). Each page contains seven rows and eight columns of letters without codes. The child is instructed to fill in the appropriate code in the empty box beneath each letter. On the first page, all the As appear in the first column, all the Bs in the second column, all the Cs in the third column, and so on. On the second page, letters are configured in a diagonal pattern. The child is permitted to complete each page in whatever fashion he or she wishes. The subtest score is based on the combination of time and number correct for each page.

Planned Connections contains 8 items. The first 6 items require the child to connect numbers appearing in a quasi-random order on a page in sequential order. The last 2 items require the child to connect both numbers and letters in sequential order, alternating between numbers and letters (e.g., 1-A-2-B-3-C). Items are constructed so that the child never complete a sequence by crossing one line over the other. The subtest score is based on the total amount of time in seconds used to complete the items.

Attention Scale. Expressive Attention uses two different sets of items depending on the age of the child. Children 8 years and older are presented with three pages. On the first page, the child reads color words (i.e., BLUE, YELLOW, GREEN, and RED) presented in quasi-random order. Next, the child names the colors of a series of rectangles (printed in blue, yellow, green, and red). Finally, the words BLUE, YELLOW, GREEN, and RED are printed in a different color than the colors the words name. The child is instructed to name the color ink the word is printed in rather than to read the word. Performance on the last page is used as the measure of attention. The subtest score is based on the combination of time and number correct.

Number Detection consists of pages of numbers that are printed in different formats. On each page, the child is required to find a particular stimulus (e.g., the numbers 1, 2, and 3 printed in an open font) on a page containing many distractors (e.g., the same numbers printed in a different font). There are 180 stimuli with 45 targets (25% targets) on the pages. The subtest score reflects the ratio of accuracy (total number correct minus the number of false detections) to total time for each item summed across the items.

Receptive Attention is a two-page paper-and-pencil subtest. On the first page, letters that are physically the same (e.g., TT but not Tt) are targets. On the second page, letters that have the same name (e.g., Aa but not Ba) are targets. Each page contains 200 pairs of letters with 50 targets (25% targets) and the same set of distractors. The subtest score reflects the ratio of accuracy (total number correct minus the number of false detections) to total time for each page summed across the pages.

Simultaneous Scale. Nonverbal Matrices is a 33-item subtest that uses shapes and geometric designs that are interrelated through spatial or logical organization. The child is required to decode the relationships among the parts of the item and choose the best of six options to occupy a missing space in the grid. Each matrix item is scored as correct or incorrect. The subtest score is based on the total number of items correctly answered.

Verbal–Spatial Relations consists of 27 items that require the comprehension of logical and grammatical descriptions of spatial relationships. The child is shown items containing six drawings and a printed question at the bottom of each page. The items involve both objects and shapes that are arranged in a specific spatial manner. For example, the item, "Which picture shows a circle to the left of a cross under a triangle above a square?" includes six drawings with various arrangements of geometric figures, only one of which matches the description. The examiner reads the question aloud, and the child is required to select the option that matches the verbal description. The child must indicate his or her answer within a 30-s time limit. The subtest score reflects the total number of items correctly answered within the time limit.

Table 2
Percentages of Subsample Demographic Characteristics by Gender and for Total Sample Compared With 1992 U.S. Census Data

	Boys (n = 619)	Girls (n = 647)	Total (n = 1,266)	U.S. Census
Race				
White	78.4	78.5	78.4	76.9
Black	12.8	11.4	12.1	13.5
Other	8.9	10.1	9.5	9.6
Ethnicity				
Hispanic	12.1	13.1	12.6	11.4
Non-Hispanic	87.9	86.9	87.4	88.6
Parental education				
< high school	20.2	19.2	19.7	20.3
High school graduate	28.6	29.5	29.1	28.6
Some college	31.5	31.2	31.4	28.7
4 or more years of college	19.7	20.1	19.9	22.5
Community setting				
Rural	29.9	28.1	29.0	24.8
Urban/suburban	70.1	71.9	71.0	75.2
Geographic region				
Midwest	26.7	26.3	26.5	25.2
Northeast	18.1	18.1	18.1	18.7
South	36.3	36.3	36.3	34.2
West	18.9	19.3	19.1	21.9

Figure Memory is a 27-item subtest. The child is shown a two- or three-dimensional geometric figure for 5 s. The figure is then removed. The child is presented with a response page that contains the original design embedded in a larger, more complex geometric pattern. The child is asked to identify the original design embedded within the more complex figure. To be scored correct, all lines of the design must be indicated without any additions or omissions. The subtest score reflects the total number of correct items.

Successive Scale. Word Series requires the child to repeat words in the same order as stated by the examiner. The test consists of the following 9 single-syllable, high-frequency words: *Book, Car, Cow, Dog, Girl, Key, Man, Shoe, Wall.* The examiner reads 27 items to the child. Each series ranges in length from 2 to 9 words. Words are presented at the rate of 1 word per second. Items are scored as correct if the child reproduces the entire word series. The subtest score is based on the total number of items correctly repeated.

Sentence Repetition requires the child to repeat 20 sentences that are read aloud. Each sentence is composed of color words (e.g., "The blue is yellowing"). The child is required to repeat each sentence exactly as presented. To help reduce the influence of simultaneous processing and accent the demands of the syntax of the sentence color words are used so that the sentences contain little semantic meaning. An item is scored as correct if the sentence is repeated exactly as presented. The subtest score reflects the total number of sentences repeated correctly.

Sentence Questions is a 21-item subtest that uses the same type of sentences as those in Sentence Repetition. Children aged 8–17 are read a sentence and then asked a question about the sentence. For example, the examiner says, "The blue is yellowing" and asks the following question: "Who is yellowing?" The correct answer is "The blue." Responses are scored as correct if the child successfully answers the question regarding the sentence. The subtest score reflects the total number of questions answered correctly.

Woodcock–Johnson Tests of Achievement—Revised

Nine of the WJ–R subtests included in this study are summarized below.

Letter–Word Identification. This subtest requires the child to identify letters and words. The words are presented from high frequency to low frequency. Comprehension of the word is not required. Median reliability for the standardization sample is .94.

Passage Comprehension. This task begins with identification of pictures followed by items that include a picture and sentence with a word omitted. More difficult items involve a printed sentence with a word omitted. This is a modified cloze procedure, which requires that the child use syntactic and semantic clues to decide which word best answers the question. Median reliability for the standardization sample is .90.

Calculation. This subtest requires the child to solve a variety of math calculations. Items include simple addition to advanced geometry, trigonometry, and calculus. Median reliability for the standardization sample is .93.

Applied Problems. Initial items in this subtest involve basic counting. The difficulty of items increases as the word problems become longer and purely verbal (i.e., no pictorial stimuli are involved). Median reliability for the standardization sample is .92.

Dictation. This subtest measures basic writing skills, punctuation, capitalization, spelling, and usage. The child responds in writing to the various items. Median reliability for the standardization sample is .91.

Word Attack. This subtest requires the child to apply phonic and structural analysis skills to pronounce nonsense words that are phonically regular. All of the words follow patterns of regular English pronunciation and spelling but are novel to the child. Median reliability for the standardization sample is .91.

Reading Vocabulary. This subtest consists of items that test the child's knowledge of synonyms and antonyms. For the synonym items, the child is asked to provide a word with a similar meaning. Antonyms require the child to produce a word with the opposite meaning. The child is required to read the printed word then provide the answer. Median reliability for the standardization sample is .93.

Quantitative Concepts. This subtest measures the child's knowledge of basic math terms, signs, shapes, and facts. Although many of the items include basic math knowledge, some involve computation. Median reliability for the standardization sample is .87.

Proofing. This subtest requires the child to find and correct written statements that include punctuation, spelling, capitalization, and usage errors. Median reliability for the standardization sample is .91.

Procedures

Participants from throughout the United States were included in this study if they participated in the standardization of the CAS (see Naglieri & Das, 1997b, for more information on the standardization procedures). After parental permission was obtained, trained examiners administered the CAS and WJ–R, and specially trained personnel checked all test protocols for accuracy. Standard scores (M = 100, SD = 15) were obtained from the test manuals and used in all data analyses. Means and standard deviations were computed by gender and for the total sample. The differences between the mean standard scores earned by girls and boys were first examined by computing d ratios, which describe the differences between the genders in standard deviation units (Cohen, 1988), using the following formula:

$$(X_1 - X_2)/\text{SQRT}\ [(n_1 * SD_1^2 + n^2 * SD_2^2)/(n_1 + n_2)].$$

The significance of the differences between the genders was examined with a 3 (age group) × 2 (gender) factorial multivariate analysis of variance with the CAS standard scores as multiple dependent variables. Identical analyses were conducted for the WJ–R standard scores.

Results

PASS standard score means and standard deviations are provided by gender and age group and for the total sample in Table 3. Gender differences also are presented, using d ratios for the four PASS scales and the Full Scale score. Girls and boys were similar on the PASS Simultaneous and Successive Scales (d ratios for all age groups $<$ .12). In contrast, differences between girls and boys were apparent on the Planning and Attention Scales. Girls outperformed boys on the Planning Scale (median d = .34, range = .25–.39) and the Attention Scale (median d = .36, range = .28–.43). These d ratios are considered small (Cohen, 1988).

The d ratios for girls and boys by age are presented in Table 3. There were minimal linear developmental trends for the Planning, Simultaneous, and Successive Scales. In contrast, the Attention Scale boy/girl d ratios increased from −.28 (ages 5–7) to −.36 (ages 8–10), to −.43 (ages 11–17). Girls outperformed boys on the CAS Full Scale differences, earning d ratios of .31 at ages 5–7, −.19 at ages 8–10, and −.30 at ages 11–17. Overall, girls earned Full Scale CAS standard scores that were about one-quarter of a standard deviation above those of boys.

There was a significant gender effect across the four Full Scale CAS standard scores, with a multivariate $F(4, 2016) = 24.9$, $p <$ .001. There was no significant age effect and no Age × Sex interaction effect. The genders differed significantly in Planning, $F(1, 2019) = 58.1$, $p < .001$, Attention, multivariate $F(1, 2019) = 68.2$, $p < .001$, and less strongly on Successive processes, multivariate $F(1, 2019) = 4.3$, $p < .05$. No significant differences

Table 3
Sample Sizes, Means, Standard Deviations and d ratios for PASS and Full Scale Standard Scores by Age Group and for the Total Sample

Scale	Age group (years)	Boys			Girls			Boys/Girls	Total sample		
		n	*M*	*SD*	*n*	*M*	*SD*	*d*	*N*	*M*	*SD*
Planning	5–7	425	97.60	15.20	430	102.68	14.65	−.34	855	100.16	15.13
	8–10	295	97.91	14.66	287	101.56	14.86	−.25	582	99.70	14.90
	11–17	335	97.00	15.00	339	102.86	15.15	−.39	674	99.95	15.35
	5–17	1,055	97.50	14.98	1,056	102.44	14.87	−.33	2,111	99.97	15.12
Attention	5–7	429	98.35	14.69	426	102.36	13.94	−.28	855	100.35	14.45
	9–10	293	97.52	14.19	287	102.68	14.45	−.36	580	100.07	14.54
	11–17	344	96.34	16.03	342	103.14	15.43	−.43	686	99.73	16.09
	5–17	1,066	97.47	15.01	1,055	102.70	14.56	−.35	2,121	100.07	15.02
Simultaneous	5–7	447	99.33	15.03	448	100.86	13.41	−.11	895	100.10	14.25
	8–10	299	101.13	15.03	299	99.76	14.67	.09	598	100.44	14.85
	11–17	350	99.67	16.67	350	99.26	15.44	.03	700	99.46	16.06
	5–17	1,096	99.93	15.58	1,097	100.05	14.43	−.01	2,193	99.99	15.01
Successive	5–7	431	99.87	14.68	426	101.41	13.70	−.11	857	100.64	14.21
	8–10	300	99.37	15.82	298	100.14	15.47	−.05	598	99.76	15.64
	11–17	349	98.76	15.33	348	100.13	15.44	−.09	697	99.45	15.39
	5–17	1,080	99.37	15.21	1,072	100.64	14.78	−.08	2,152	100.01	15.01
Full	5–7	403	98.85	14.91	398	103.10	12.66	−.31	801	100.96	13.99
	8–10	288	98.14	14.83	276	101.06	15.20	−.19	564	99.57	15.07
	11–17	329	96.86	16.59	331	101.67	15.50	−.30	660	99.27	16.22
	5–17	1,020	98.01	15.46	1,005	102.07	14.36	−.27	2,025	100.02	15.06

Note. Negative *d* values indicate that boys earned lower mean scores than girls. PASS = Planning, Attention, Simultaneous, Successive.

were found in Simultaneous processes, multivariate $F(1, 2019) = 0.12$, $p > .05$.

WJ–R test means, standard deviations, and *d* ratios are provided according to age and gender and for the total sample (see Table 4). Girls and boys performed similarly on many of the achievement variables, with some exceptions. Girls aged 11–17 years outperformed boys on the Proofing ($d = .33$), Letter–Word Identification ($d = .22$), and Dictation ($d = .22$) subtests. The total sample of girls aged 5–17 years also outperformed boys on the Proofing subtest ($d = .20$). These are the same ages at which the Planning and Attention Scale differences between the genders were most pronounced.

Significant main effects for gender, multivariate $F(9, 1196) = 6.0$, $p < .001$, and age, multivariate $F(18, 2392) = 26.1$, $p < .001$, were shown on the WJ–R achievement scores, but there was no Gender × Age interaction effect. Girls outperformed boys on the Letter–Word Identification, $F(1, 1204) = 4.1$, $p < .001$, Passage Comprehension, $F(1, 1204) = 4.6$, $p < .001$, Dictation, $F(1, 1204) = 6.9$, $p < .001$, and Proofing, $F(1, 1204) = 12.6$, $p < .001$, subtests.

Discussion

Girls outperformed boys between the ages of 5 and 17 years on measures of Planning, which is consistent with initial suggestions reported by Bardos et al. (1992) and Warrick and Naglieri (1993), and on measures of Attention, as suggested by Warrick and Naglieri (1993). A significant, formerly undetected, yet much smaller difference to the advantage of girls was also found in Successive processing. The findings from this study that girls and boys differed in basic PASS cognitive processes are especially important because these data were obtained using a national representative sample of school-aged children, and, therefore, the probability of sampling error is considerably reduced. Moreover, because the sample was representative of the U.S. population, generalization to the wider population is more appropriate than has been possible from previous research that involved smaller, nonrepresentative samples. Important, however, is that gender differences were also found on the Proofing, Dictation, Passage Comprehension, and Letter–Word Identification achievement subtests (especially for the 11–17 year age group), the same age group for which differences in Planning and Attention were uncovered. These academic tasks involve not only academic skills but also Planning and Attention processes (Naglieri & Das, 1997a).

The higher Planning and Attention scores for girls and similarly higher scores on the Proofing, Letter–Word Identification, Passage Comprehension, and Dictation subtests is logical given the cognitive processing demands of these tasks. The Proofing items, for example, require the child to find errors in a written sentence. This demands careful examination of the stimuli and detection of errors in spelling, punctuation, and syntactic and grammatical structures. These tasks involve good attention and planning. Similarly, the Letter–Word Identification and Dictation and subtests require decisions, for example, about (a) what rules are relevant to the task; (b) if the rule can be applied; (c) if the rule is effective; and (d) if not, other ways the task can be solved, which involve planning. Finally, it has been well documented that success in reading comprehension requires, for example, the use of strategies such as (a) looking back at the information given, (b) distinguishing relevant from irrelevant information, (c) resisting the distraction caused by irrelevant information, and (d) using good methods to analyze the passage and answer the specific questions asked (Pressley, 1998; Pressley & Woloshyn, 1995). In addition to the

Table 4
Sample Sizes, Means, Standard Deviations, and d ratios for Woodcock–Johnson Tests of Achievement—Revised Standard Scores by Age Group and for Total Sample

Subtest	Age group (years)	Boys			Girls			Boys/Girls	Total group		
		n	*M*	*SD*	*n*	*M*	*SD*	*d*	*n*	*M*	*SD*
Applied Problems	5–7	252	103.4	19.3	262	103.9	18.1	−.03	514	103.7	18.7
	8–10	167	110.9	18.5	177	106.5	15.8	.26	344	108.6	17.3
	11–17	200	101.6	15.0	207	101.6	13.6	.00	407	101.6	14.3
	5–17	619	104.8	18.2	646	103.9	16.2	.05	1,265	104.4	17.2
Calculation	5–7	251	101.1	17.6	261	100.6	15.4	.03	512	100.9	16.5
	8–10	167	107.2	21.4	176	104.6	19.3	.13	343	105.9	20.4
	11–17	199	100.1	17.4	208	102.8	15.0	−.17	407	101.5	16.3
	5–17	617	102.4	18.8	645	102.4	16.5	.00	1,262	102.4	17.7
Dictation	5–7	252	96.9	14.5	261	99.2	13.7	−.16	513	98.1	14.1
	8–10	167	94.2	13.6	177	95.4	12.0	−.09	344	94.8	12.8
	11–17	198	88.3	16.6	208	91.5	12.9	−.22	406	89.9	14.9
	5–17	617	93.4	15.4	646	95.7	13.4	−.16	1,263	94.6	14.5
Letter–Word Identification	5–7	252	98.3	17.1	262	101.4	16.4	−.19	514	99.9	16.8
	8–10	167	103.1	17.3	177	103.5	15.8	−.02	344	103.3	16.5
	11–17	200	101.6	17.6	208	105.3	16.2	−.22	408	103.5	17.0
	5–17	619	100.7	17.4	647	103.2	16.2	−.15	1,266	102.0	16.8
Passage Comprehension	5–7	249	102.0	16.1	258	104.6	16.6	−.16	507	103.3	16.4
	8–10	167	104.7	17.2	177	106.5	14.9	−.11	344	105.6	16.0
	11–17	200	104.1	17.5	208	106.5	15.6	−.14	408	105.3	16.6
	5–17	616	103.4	16.8	643	105.7	15.8	−.14	1,259	104.6	16.4
Proofing	5–7	236	99.7	13.5	247	100.7	12.5	−.08	483	100.2	13.0
	8–10	165	97.6	18.2	175	101.2	17.6	−.20	340	99.4	18.0
	11–17	199	95.9	18.0	208	101.4	14.9	−.33	407	98.7	16.7
	5–17	600	97.9	16.5	630	101.1	14.9	−.20	1,230	99.5	15.8
Quantitative Concepts	5–7	252	103.2	18.0	262	103.0	16.3	.01	514	103.1	17.1
	8–10	167	101.7	16.8	175	99.2	15.4	.16	342	100.4	16.1
	11–17	199	99.8	19.0	208	99.9	15.8	−.01	407	99.8	17.4
	5–17	618	101.7	18.0	645	101.0	15.9	.04	1,263	101.3	17.0
Reading Vocabulary	5–7	244	100.7	15.1	251	103.3	14.9	−.17	495	102.0	15.0
	8–10	167	104.2	18.0	176	104.6	16.1	−.02	343	104.4	17.0
	11–17	200	103.1	18.3	208	104.7	15.6	−.09	408	103.9	17.0
	5–17	611	102.4	17.1	635	104.1	15.5	−.10	1,246	103.3	16.3
Word Attack	5–7	247	98.9	14.8	256	99.3	13.6	−.03	503	99.1	14.2
	8–10	165	99.2	18.6	175	99.1	17.1	.01	340	99.1	17.8
	11–17	200	102.3	21.2	208	105.4	19.6	−.15	408	103.9	20.4
	5–17	612	100.1	18.2	639	101.2	16.9	−.06	1,251	100.7	17.5

academic skills and knowledge required, these activities also especially involve Planning and Attention skills, on which girls outperformed boys.

As suggested by McHough et al. (1986), a theoretical model of cognitive functioning can augment understanding of gender-related differences. In particular, Geary's (1989, 1994) recognition of the relevance of neurological (e.g., brain–behavior) structures and their corresponding cognitive functions (e.g., the PASS conceptualization) could be used to better understand gender differences. For example, Geary (1994) stated, "girls often show an advantage over boys on basic arithmetic tests, at least through junior high school . . . related to the tendency of boys to commit procedural errors when solving complex arithmetic problems" (p. 195). He continued, writing that boys tend to "use procedures that are correct for some problems but are inappropriately applied to solve other problems" (p. 195). Procedural errors and misapplication of methods can be understood from the PASS theory. Planning processing is involved in making decisions about how to do things, selection of the best method to complete a problem, monitoring the accuracy of the solution (e.g., remembering to check one's work), and determination of when the task is accurately completed. The lower Planning scores earned by the boys in this study provide a cognitive explanation for these procedural arithmetic errors and suggest that girls may perform this activity better because of better Planning processing.

The girls' higher scores on the Planning and Attention subtests could be interpreted as reflecting different rates of maturation of the prefrontal cortex, as discussed, for example, by Welsh and Pennington (1988) and Welsh, Pennington, and Groisser (1991). These authors defined *executive function* as "the ability to maintain an appropriate problem-solving set for attainment of a future goal (Luria, 1966) . . . [including] (a) an intention to inhibit a response or to defer it to a later more appropriate time, (b) a strategic plan of action sequences, and (c) a mental representation of the task" (Welsh & Pennington, 1988, pp. 201–202). These cognitive activities are consistent with definitions and descriptions of Planning and Attention (Naglieri, 1999) and the Luria view on which the PASS theory is based. Research is needed to closely examine rates of development of executive (Planning) processes and attention and to determine if different rates are related to different levels of performance in academic tasks such as mathematics and written composition, as anticipated by Das et al. (1994).

The findings from this study and the PASS theoretical perspective they are based on also can be integrated with results summarized by Halpern (1997). Halpern concluded that girls performed better than boys in verbal fluency, mathematical calculation, and written language—all of which have been described as requiring Planning processing from the PASS theory (Das et al., 1994; Garofalo, 1986; Naglieri, 1999; Warrick, 1989). Academic activities like these require generation of methods for successful task completion (i.e., plans or strategies), self-monitoring of the activity, self-correction, and verification of completion, all of which are included in the conceptualization of Planning as described by Naglieri (1999) following from Luria (1966). Halpern also concluded that girls perform better than boys in fine motor skills and speech articulation, both of which are associated with the motor organization and patterning of speech associated with the frontal lobes (i.e., the Planning component of the PASS theory). Speech articulation involves "organizing the muscles of the speech apparatus to form sounds or in patterning groups of sounds into words" (Lezak, 1995, p. 88). The neuropsychological structures involved in speech articulation also are closely "involved in the initiation and programming of fine hand movements" (Lezak, 1995, p. 88). The finding that girls are better than boys in fine motor skills and speech articulation described by Halpern (1997) is also consistent with the findings of girls' Planning advantages because Planning is related to frontal lobe functioning (Das et al., 1994).

These results have important implications for classroom instruction, especially for boys. Planning and Attention are important processes that affect many areas of daily life, especially academic performance. The lower scores earned by boys on the Planning and Attention Scales suggest that these children need to be taught to plan more thoughtfully and be more strategic in the things they do and the extent to which they focus their attention. Planning is a vital process for decision making, self-control, and self-monitoring, but it also plays a key role in the ability to make shifts in attention (Lezak, 1995). There is growing literature on instructional methods that focus on cognitive processes such as planning; this work has been summarized by Ashman and Conway (1993, 1997). Related texts by Pressley and Woloshyn (1995), Mastropieri and Scruggs (1991), and Scheid (1993) all offer cognitively based instructional methods that focus on teaching children to improve their strategic (i.e., planning) skills. In addition, there has been research that has specifically focused on teaching children to be more planful when completing mathematics calculation problems (Naglieri and Gottling, 1995, 1997; Naglieri and Johnson, 2000).

Naglieri and Gottling (1995, 1997) and Naglieri and Johnson (2000) provided a Planning-based instruction to children with low scores in Planning and who performed poorly in mathematics calculation. The Planning-based intervention was designed to teach children to (a) be more reflective and self-evaluative about how they completed the mathematics computation, (b) monitor their performance, and (c) focus on the relevant aspects of the work. All three of these studies demonstrated that the intervention, which facilitated Planning processes, led to improved performance on classroom multiplication problems. Naglieri and Johnson (2000) showed that children with a specific weakness in Planning (without deficits in Attention, Simultaneous, or Successive processes) improved considerably ($d = 1.4$) over baseline rates in mathematics computation. That is, helping children better use Planning processes can have important implications for classroom work. Given that boys perform more poorly than girls in Planning, and girls outperform boys in mathematics calculation, interventions that focus on strategy use for boys seems warranted. Additionally, methods that teach strategy use (e.g., Ashman & Conway, 1997; Pressley, 1988; Pressley and Woloshyn, 1995) should be used with girls to help them perform better in areas such as mental rotation, mechanical reasoning, and verbal analogies.

Differences in basic psychological processes of Planning and Attention were found, and although not large, they were important because differences in some areas of achievement were also found. Future research should be conducted to determine if the differences in academic achievement could be attributed to these differences in cognitive processing. It also will be important to also determine if the gender differences are consistent across demographic variables and if these differences can be influenced by interventions designed to improve performance in cognitive processing. Finally, researchers should consider if the Planning and Attention advantages girls evidenced can be used to augment their performance in academic areas in which they traditionally have had difficulty.

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