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

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Gender differences on academic and intelligence tests have been the focus of a large body of literature that has often left basic questions unanswered. Recently, researchers have suggested that sex-related differences be examined from a theoretical view of ability related to neurological models of cognitive functioning. This study applied the planning, attention, simultaneous, successive (PASS) cognitive processing model, based on the neuropsychological work of A. R. Luria (1973), to the study of gender differences for 3 samples of boys and girls. Girls significantly outperformed boys on attention tasks at Grade 3 (n = 67) and on planning tests at Grade 6 (n = 66). These findings suggest that the PASS model offers a viable approach to the conceptualization of cognitive processes that may prove especially useful in understanding sex-related differences in cognitive and academic performance.

Gender differences in cognitive functioning and in the relationships between gender and achievement have been of interest to many researchers as well as the topic of a substantial body of research and debate (Burnett, 1986; Burnett & Lane, 1979; Deaux, 1984; Feingold, 1988; Fennema, 1985; Halpern, 1986, 1989; Linn & Petersen, 1985; Maccoby & Jacklin, 1974). Although cognitive differences have been reported in the areas of verbal, quantitative, and spatial abilities (Halpern, 1989; Linn & Petersen, 1985; Maccoby & Jacklin, 1974; Wittig & Petersen, 1979), the existing research has often provided inconclusive findings regarding the extent of gender differences and the reasons for them. In their review of the literature on gender differences, Maccoby and Jacklin (1974) concluded that girls typically outperform boys on measures of verbal ability. Although a variety of verbal tasks have been used, including tests of receptive and productive language, Wittig and Petersen (1979) suggested that these studies are limited by a failure to provide a clear definition of verbal ability. This is especially important given that gender differences in verbal ability (as well as nonverbal ability) have not been demonstrated on the Verbal and Performance portions of the Wechsler Intelligence Scale for Children—Revised (Sattler, 1988). More recently, in a meta-analysis of 165 studies investigating gender differences in verbal ability, Hyde and Linn (1988) reported a small weighted mean effect size (d = .11) for studies involving students aged 5 years or less (d = .13), aged 6–10 years (d = .06), and aged 11–18 years (d = .11), which indicated a slight superiority for girls. However, when examined by different types of verbal ability, the effect sizes favoring girls ranged from d = .02 for vocabulary to d = .33 for speech production.

Gender-related differences in quantitative ability, as measured by achievement in mathematics, have been widely researched. Most researchers agree that, generally, there appear to be no significant gender-related differences in quantitative ability among preschool and elementary school children (Armstrong, 1981; Cartledge, 1984; Fennema, 1977; Hilton & Berglund, 1974; Swafford, 1980); however, research with older students is less clear. Research studies involving students in Grades 6–9 have often reported no significant gender-related differences in mathematics achievement (Armstrong, 1981; Fennema & Carpenter, 1981; Fennema & Sherman, 1977; Hilton & Berglund, 1974; Swafford, 1980). When differences are reported within this age group, girls tend to perform better than boys in numeration and math computation, whereas boys tend to perform better than girls in math problem solving (Cartledge, 1984; Fennema & Carpenter, 1981; Fennema & Sherman, 1978; Marshall, 1984). However, by the end of high school, it appears that the average performance of boys consistently exceeds that of girls in all mathematical areas (Armstrong, 1981; Fennema & Carpenter, 1981; Fennema & Sherman, 1978). The results of a recent meta-analysis of 100 studies investigating gender differences in mathematics achievement (Hyde, Fennema, & Lamon, 1990) revealed that girls performed slightly better than boys in computation (d = .14) below age 15 years but not on tasks requiring understanding of mathematical concepts (d = .03). Boys aged 15–18 years out-performed girls in the area of problem solving (d = .29), but students aged 5–14 years earned very similar scores. In summary, these age trends revealed a slight superiority in computation for girls during the elementary and middle school years. However, gender differences favoring boys in problem solving were identified in high school (d = .29) and college (d = .32).

A number of studies have reported variation in the magnitude of sex-related differences in spatial ability depending on a variety of factors such as personality characteristics, involvement in spatial activities, ethnic background, parental attitudes, and the type of spatial task administered (Burnett

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& Lane, 1980; Connor, Serbin, & Schackman, 1977; Fennema & Sherman, 1977; Schratz, 1978). On the basis of their review of the research on sex-related differences in spatial ability, Caplan, MacPherson, and Tobin (1985) reported that the data supporting sex differences in spatial ability are weak, and when evidenced, the effect sizes are generally small. Thus, Caplan et al. concluded that it is not clear that sex differences in spatial ability actually exist. However, these conclusions have been sharply criticized by a number of researchers (Burnett, 1986; Halpern, 1986; Hiscock, 1986; Sander, Cohen, & Soares, 1986) who have found differential performance by gender. In fact, in a meta-analysis of 172 studies investigating gender differences in spatial ability, Linn and Petersen (1985) concluded that gender differences exist on some types of spatial ability. Specifically, large sex differences favoring boys were identified on tasks of mental rotation, and small differences favoring boys were identified on tasks of spatial perception. However, no sex differences were identified on tasks of spatial visualization.

McHugh, Koeske, and Frieze (1986) have stressed that gender-related differences cannot be adequately understood and researched unless boys and girls are compared according to a theoretical model of cognitive functioning. Geary (1989) has further emphasized that conceptual models of cognitive gender differences should provide an integration of the neurological and sociocultural components that influence the development of cognitive processes so as to recognize the complex interaction between neurological mechanisms and experience in cognitive development. The importance of a theoretical model of cognitive functioning has also been emphasized by researchers who have suggested ways to better define intelligence (in cognitive processing terms) and the way it is measured (Naglieri & Das, 1990; Sternberg, 1990). The planning, attention, simultaneous, successive (PASS) cognitive processing model (Das, Naglieri, & Kirby, 1994), which is based on the neuropsychological model of Luria (1966, 1970, 1973), fits the criteria set by Geary (1989) and McHugh et al. (1986) because it includes both neurological and sociocultural components and is a comprehensive theoretical model by which cognitive processes can be examined.

On the basis of his clinical investigations with brain-injured patients, Luria (1966, 1970, 1973) proposed that there are three functional units that provide three classes of cognitive processes responsible for all mental activity. The functional units work in concert to produce behavior and provide attentional (first unit), simultaneous–successive (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 and focused attention. According to Luria (1973), it is only under optimal conditions of arousal that higher levels of focused attention may be achieved. The second functional unit is responsible for "receiving, analyzing and storing information" (Luria, 1973, p. 67) through the use of simultaneous and successive processing.

Simultaneous processing is associated with the occipital–parietal areas of the brain (Das, Kirby, & Jarman, 1979) and involves the integration of stimuli into interrelated stimulus arrays (Naglieri & Das, 1988). The essential aspect of simultaneous processing is surveyability; that is, each element is related to every other element (Naglieri, 1989). For example, to produce a diagram correctly when given the instruction "draw a triangle above a square that is to the left of a circle under a cross," one must correctly comprehend the relationships among the shapes. Successive processing is associated with the frontal–temporal areas of the brain (Das et al., 1979) and involves the integration of stimuli into a specific serial order in which each component is related only to the next (Naglieri & Das, 1990). Examples of successive processing include recalling a series of digits or comprehension of syntax (Naglieri & Das, 1988). According to Das et al. (1979), information may be coded simultaneously, successively, or through both modes of processing. The form of coding implemented depends on the individual's competence with the particular processing mode, their habitual mode of processing, the demands of the task, and the existing knowledge base. Both simultaneous and successive processing operate on verbal and nonverbal information and receive information from all sensory receptors (Das, 1984; Naglieri, Das, & Jarman, 1990), and both forms of processing occur at the perceptual, memory, and conceptual levels of cognition (Naglieri & Das, 1988).

The third functional unit is located in the prefrontal divisions of the frontal lobes of the brain (Luria, 1973). This unit is responsible for planning—which includes the programming, regulation, and verification of behavior (Luria, 1973)—and is responsible for behavior such as asking questions, problem solving, and the capacity for self-monitoring (Naglieri & Das, 1988). Other responsibilities of the third functional unit include regulation of voluntary activity, impulse control, and various linguistic skills such as spontaneous conversation (Naglieri & Das, 1988). The third functional unit provides for the most complex aspects of human behavior (Das, 1984).

Although both the factorial validity of the PASS model (Naglieri, Braden, & Gottling, in press; Naglieri, Braden, & Warrick, 1991; Naglieri, Das, Stevens, & Ledbetter, 1990; Naglieri, Prewett, & Bardos, 1989) and the relationship between the processes and achievement (see Naglieri & Das, 1990, and Kirby & Das, 1990, for reviews) have been well documented, there has been relatively little research examining gender differences in PASS cognitive processing. Merritt and McCallum (1983) investigated gender-related differences in simultaneous and successive processing among college students and found very similar simultaneous and successive processing factor solutions for men and women. The authors concluded that men and women process information in a similar manner and with similar efficiency. However, this study did not include measures of planning or attention and did not examine developmental changes.

Bardos, Naglieri, and Prewett (1992) reported two experiments in which they examined gender differences in cognitive processing for subjects in Grades 2, 6, and 10 ($N = 434$), and Grades 4 and 5 ($N = 112$). In the first experiment they examined gender-related differences in simultaneous, successive, and planning processes. The results of the factor analysis revealed the emergence of three similar factor solutions for both boys and girls. The results further indicated that girls scored higher than boys in planning at all age levels, but the differences were significant only at Grade 6. In the second experiment they examined gender-related differences in simultaneous, successive, and planning processes and attention. The girls in Grades 4 and 5 performed significantly higher in planning than did the boys. However, both sexes performed equally well in attention, simultaneous, and successive processing.

The inclusion of planning measures in the Bardos et al. (1992) study provided evidence of the presence of gender-related differences in cognitive processing that may be developmental in nature and may be related to differences in academic achievement. However, because only one attention task was administered, the information on gender-related differences in PASS cognitive processing remains limited. Therefore, the purpose of the present study was to provide a comprehensive examination of developmental gender-related differences in PASS cognitive processes by using a complete battery of PASS tasks and samples of boys and girls at three age levels.

Method

Subjects

The sample consisted of 197 elementary (Grade 3, n = 67, mean age = 9.3 years, SD = 3.7 months; Grade 6, n = 66, mean age = 12.2 years, SD = 4.7 months) and high school students (Grade 9, n = 64, mean age = 15.2 years, SD = 5.3 months) from a public school district of approximately 12,000 students located in a predominantly middle-class, suburban Ohio community. The racial composition of the community from which the sample was selected was approximately 95% White, with the remaining percentages being African-American, Asian, and Hispanic. The racial composition of the sample was consistent with that of the community at large. There were approximately equal numbers of boys and girls at Grade 3 (boys, n = 29; girls, n = 38), Grade 6 (boys, n = 34; girls, n = 32), and Grade 9 (boys, n = 31; girls, n = 33). The results of t tests indicated that there were no significant differences in the ages of boys and girls at Grade 3 (t = 1.32, $p > .10$), at Grade 6 (t = .22, $p > .10$), or at Grade 9 (t = .87, $p > .10$). On the basis of the Matrix Analogies Test—Expanded Form (MAT-EF; Naglieri, 1985), the mean intelligence score for the total sample was 94.9 (SD = 12.0), which indicated that the sample was within the average range of intellectual ability.

Procedure

All subjects were individually administered the 12 experimental PASS cognitive processing tasks developed by Das and Naglieri (1989). The experimental tasks were administered by 1 of 9 trained examiners who were advanced graduate students in clinical, developmental, or school psychology. The PASS tasks were administered in the order that they are presented in the following section using standard directions developed by Das and Naglieri (1989) as part of a continuing intelligence test development activity. All protocols were checked for scoring accuracy by one of us.

Experimental Tasks

Planning Tasks

Planned connections. The planned connections task consisted of four items that were similar to the Trail Making test included in the Army Individual Test of General Ability, which has also been used by Reitan (1955). The first two items require the subject to draw a line to connect a series of numbers in their proper sequence (e.g., 1 to 2 to 3) when arranged on the page in a quasi-random fashion. The last two items require the subject to connect, in an alternative fashion, a series of numbers and letters in their proper sequence (e.g., 1 to A, 2 to B). The score is the time to completion for all four items. This task has consistently been demonstrated to load on a planning factor (Ashman & Das, 1980; Naglieri & Das, 1988; Naglieri et al., 1989).

Visual search. In this task, a target picture, consisting of a number, letter, or object in a box and surrounded by a field of similar items, was presented to the subject. The subject was instructed to search the surrounding field and to point to the item in the field that matched the target item. Two searches were presented on each 8½ in. × 11 in. (21.59 cm × 27.94 cm) page, with one search placed on the top half of the page and the other search on the bottom half of the page. The subjects were instructed to begin searching as soon as the stimulus page was exposed, and the items were timed from the point of exposure until both targets were found. The score is the total time recorded for all 16 targets. This task has been demonstrated to load on a planning factor in a number of previous research investigations (Ashman & Das, 1980; Naglieri & Das, 1988; Naglieri, Das, Stevens, & Ledbetter, 1990; Naglieri et al., 1989).

Planned codes. This task consisted of two items in which the subject was presented with a page containing double boxes. The top parts of the boxes contained the letters A, B, C, and D, whereas the bottom portions of the boxes were divided in half and remained empty. The subject was instructed to fill in the bottom portion of the box with a sequence of Xs and Os that corresponded to the particular letter. For example, the child wrote XOX under the letter A, OXX under the letter B, and so forth. On the first task the empty boxes were arranged in a vertical fashion such that the first column consisted of all As; the second consisted of all Bs, and so forth. In the second item, the empty boxes were arranged in diagonal rather than vertical columns on the page. Therefore, recognition of the pattern in which the letters were arranged should have facilitated completion time. The correct sequence of Xs and Os for the particular item was located at the top of the item page so that the subject could refer to it as needed. A time limit of 1 min was imposed for each stimulus page, and the score was the total number of correct responses. The subjects were instructed to develop and implement an effective strategy to help them successfully complete this task. This task was previously demonstrated to load on a planning factor by Naglieri et al. (1989).

Simultaneous Tasks

Simultaneous verbal. In this task the subject was presented with an 8½ in. × 11 in. (21.59 cm × 27.94 cm) template containing six different picture options. The subject was then requested to choose the option that correctly answered the question that was printed at the bottom of the page and was also read aloud by the examiner. The questions involved logical-grammatical relationships represented by various types of pictures (e.g., people, objects, and shapes). For example, the subject might be presented with a set of pictures and be asked to identify the one that "shows a girl behind a boy." The 23 items in this task were scored either one or zero, and the subject's score on the task was the total number correct.

Figure memory. In this task the subject was shown a geometric shape and was instructed to observe the shape for 5 s. The stimulus item was then removed, and the subject was asked to trace the original design, which was presented embedded within a more complex geometric design. The 24 items in this task were scored either one or zero, and the subject's score on the task consisted of the total number correct. This task has been consistently demonstrated to load on the simultaneous factor (Naglieri & Das, 1988; Naglieri, Das, Stevens, & Ledbetter, 1990; Naglieri et al., 1989).

MAT–EF. The MAT–EF (Naglieri, 1985) is a standardized individually administered nonverbal test of ability. The test consists of 64 standard progressive matrix-type items. For each item, the subject is required to select the one of six options that best completes the abstract figural analogy. The score is the total number correct. Similar matrix-type tasks have been consistently demonstrated to load on a simultaneous factor (Das et al., 1979; Naglieri & Das, 1987, 1988; Naglieri, Das, Stevens, & Ledbetter, 1990; Naglieri et al., 1989).

Successive Tasks

Sentence repetition. In this task, the subject was required to repeat nonmeaningful sentences, which contained no content words. The sentences contained no nouns or verbs but were composed of color words such as "The yellow greened the blue." The subject was required to repeat the sentence precisely as stated by the examiner. The task consisted of 12 sentences, which were scored either one (for a completely accurate response) or zero. The subject's score on the task consisted of the total number correct.

Sentence questions. In this task, the sentences presented in the sentence repetition task were repeated, and the subject was asked a question regarding the sentence. For example, the sentence "The yellow greened the blue" was repeated and was followed by the question "Who greened the blue?" The correct response was "the yellow." All items were scored either one or zero, and the subject's score on the task consisted of the total number correct. The sentence repetition and sentence questions tasks have been previously demonstrated as a measure of successive processing (Naglieri et al., 1989).

Word repetition. This task consisted of 9 single syllable words, with a high degree of familiarity (e.g., shoe, bird, and car). The words were presented orally by the examiner, and the subject was required to repeat the series of words in the same order in which they were presented. The task consisted of 26 items ranging in length from 2 to 9 words. All items were scored either one or zero, and the subject's score on the task consisted of the total number correct. This task has been used as a marker task for successive processing and has been repeatedly demonstrated to load on a successive factor (Das et al., 1979; Naglieri & Das, 1987, 1988; Naglieri et al., 1989).

Attention Tasks

Number finding. This task consisted of two pages of items on which the subject was required to underline specific numbers within rows of numbers that contained both targets and distractors. On the first page, the targets were the numbers 1, 2, and 3 when they were printed in boldface type. On the second page, the targets were the numbers 1, 2, and 3 when printed in boldface type and the numbers 4, 5, and 6 when printed in open-face type. Each page contained 180 numbers and 45 targets. The score for each subject was obtained by summing the total number correct on each page. A total of 90 s was permitted for each page.

Expressive attention. This task was similar to the Stroop test (Golden, 1978) and consisted of three cards but was different in that the letters were larger, the colors were more saturated, and the number of stimuli per page were reduced by about 50%. The first card consisted of rows containing the words *red, blue, green,* and *yellow*, arranged in varying order. When presented with the first card, the subject was required to read all the words in order across the page as quickly as possible. The second card contained blocks of the colors red, blue, green, and yellow arranged in rows in varying order. When presented with the second card, the subject was required to name the colors on the card as quickly as possible and in the order in which they were presented. The third card consisted of the words *red, blue, green,* and *yellow* that were printed in color. However, the words were printed in colors that did not correspond to the written word. For example, the word *red* may have been printed in green, and the word *green* may have been printed in yellow. When presented with the card, the subject was required to name the color the word was printed in as quickly as possible. The time needed to complete the third card was used as the score for this task. This task was previously demonstrated as a measure of attention (Hurt & Naglieri, 1992; Naglieri et al., 1989).

Receptive attention. This task contained two stimulus pages consisting of 20 rows of 10 letter pairs. The subject was instructed to underline, row by row, all pairs of letters that were physically identical (e.g., *NN* but not *Nn*). The second stimulus page was similar to the first, except that the subject was instructed to underline all pairs of letters with the same name (e.g., *BB* or *Bb*, but not *Ba*). The time allotted for each task was 120 s. The score for each subject was obtained by adding the total number correct on each page. This task was based on the work of Posner and Boies (1971) and has been previously demonstrated as a measure of attention by Naglieri et al. (1989).

Data Analysis

Because of the different criteria for obtaining raw scores among the various PASS tasks, raw scores were normalized across the total sample to yield standard scores with a mean of 100 and a standard deviation of 15. These standard scores were used in all analyses. Composite scores for each of the four PASS areas were developed by averaging each subject's scores within each processing area as follows: planning = planned connections, visual search, and planned codes; attention = number finding, expressive attention, and receptive attention; simultaneous = simultaneous verbal, figure memory, and MAT–EF; successive = sentence repetition, sentence questions, and word repetition. Grade and gender differences in PASS cognitive processes were examined using multivariate analysis of variance (MANOVA) procedures. Significant multivariate effects were followed by univariate analyses.

Results

Developmental Trends

Differences in PASS performance were analyzed using a 2 (sex) × 3 (grade) MANOVA. The results of the MANOVA indicated a significant main effect for grade, $F(8, 374) = 65.86, p < .001$. Univariate follow-up analyses indicated that the grade effects were significant across all four PASS processes: planning, $F(2, 191) = 240.20, p < .001$; attention, $F(2, 191) = 125.78, p < .001$; simultaneous, $F(2, 191) = 14.88, p < .001$; and successive, $F(2, 191) = 29.27, p < .001$. Inspection of the mean PASS processing scores at each of the three grade levels (presented in Table 1) reveals evidence of a strong developmental trend as the PASS processing scores increase throughout the grades.

Further univariate follow-up analyses were conducted to examine the developmental trends between grade levels. The results of these analyses indicated that the increase in PASS scores from Grade 3 to Grade 6 was significant at $p < .01$ for all four PASS processes: planning, $F(1, 131) = 104.63$; attention, $F(1, 131) = 43.36$; simultaneous, $F(1, 131) = 8.31$; and successive, $F(1, 131) = 9.54$. The increase in PASS scores from Grade 6 to Grade 9 was significant for planning, $F(1, 128) = 21.37$, $p < .01$; attention, $F(1, 128) = 14.30$, $p < .01$; and successive, $F(1, 128) = 4.84$, $p < .01$; but not for simultaneous ($F < 1$). This failure to demonstrate a significant increase in the simultaneous composite score may be best explained through examination of the mean scores for boys and girls (presented in Table 2). Examination of Table 2 reveals that for girls there was actually a decrease in the simultaneous processing composite from the sixth to the ninth grades.

Overall Gender Differences

The results of the MANOVA further demonstrated a significant main effect for gender, $F(4, 188) = 4.61$, $p < .001$. Univariate follow-up analyses demonstrated significant gender differences in planning, $F(1, 191) = 8.65$, $p < .01$, and attention, $F(1, 191) = 11.79$, $p < .001$, but not for simultaneous ($F < 1$) or successive ($F < 1$). Examination of the mean scores by gender presented in Table 2 indicates that girls scored higher than boys on both the planning and attention composites at all three grade levels. The MANOVA results also indicated a significant Gender × Grade interaction effect, $F(8, 374) = 2.08$, $p < .05$. The univariate follow-up analyses demonstrated a significant interaction between grade and attention, $F(2, 191) = 4.67$, $p < .01$, but not between grade and planning ($F < 1$), between grade and simultaneous, $F(2, 191) = 1.88$, $p > .10$, or between grade and successive, $F(2, 191) = 1.35$, $p > .20$.

Gender Differences at Each Grade

To more specifically isolate gender differences in PASS cognitive functioning, we conducted MANOVA and univariate F tests for each PASS-dependent variable by gender at each grade level. The MANOVA results were significant for Grade 3, $F(4, 61) = 3.61$, $p = .01$, and for the univariate value for attention, $F(4, 61) = 13.4$, $p < .01$. The gender differences on the other PASS components at Grade 3 were not significant, nor were the MANOVA results at Grades 6 and 9. The differences between the means reported in Table 2 can generally be described as small, with the exception of planning at Grade 6, which is moderate, and attention at Grade 3, which would be considered large after Cohen's (1988) suggested interpretations of the size of d (presented in the last column of Table 2).

Finally, discriminant analyses were conducted for the entire sample and for each grade separately to provide further information regarding the relationship between gender and the PASS cognitive processes. The standardized discriminant coefficients presented in Table 3 indicate that for Grade 3 and the total sample the discriminant function is primarily defined by attention. At Grade 6, planning, and at Grade 9, planning, simultaneous, and successive tasks, provide the greatest discrimination between the sexes with regard to PASS cognitive processing. Thus, it appears that in general, girls perform better on this function than boys. There was also a strong negative value of simultaneous processing on this function, which indicates that simultaneous processing may be the process that best defines cognitive functioning for boys, on the basis of the PASS model. Examination of the structure coefficients presented in Table 3 supports this interpretation in that planning and attention, the two processes in which girls scored significantly higher than boys, demonstrated high structure coefficients. However, simultaneous processing demonstrated the highest negative correlation to the function that most likely indicates a relationship to male cognitive functioning.

Table 1
PASS Composite Standard Score Means and Standard Deviations for Grades 3, 6, and 9

Subjects	Planning	Attention	Simultaneous	Successive
Grade 3 (N = 67)				
M	85.47	88.07	94.85	92.86
SD	9.08	10.70	8.16	10.72
Grade 6 (N = 66)				
M	103.44	102.13	102.28	100.85
SD	6.67	8.51	12.21	11.03
Grade 9 (N = 64)				
M	111.66	110.30	103.04	106.60
SD	5.08	6.23	10.76	9.82

Note. PASS = planning, attention, simultaneous, and successive model.

Table 2
PASS Composite Standard Score Means and Standard Deviations for Boys and Girls at Grades 3, 6, and 9

	Girls		Boys		
Subjects	*M*	*SD*	*M*	*SD*	*d*
Grade 3	$N = 38$		$N = 29$		
Planning	87.13	9.07	83.29	8.79	−0.43
Attention	92.09	7.93	82.79	11.68	−0.96
Simultaneous	94.31	7.80	95.55	8.70	0.15
Successive	94.56	10.57	90.62	10.69	−0.37
Grade 6	$N = 32$		$N = 34$		
Planning	105.17	5.37	101.82	7.41	−0.52
Attention	102.98	9.77	101.33	7.18	−0.19
Simultaneous	103.58	12.06	101.05	12.41	−0.21
Successive	100.81	11.01	100.88	11.22	0.01
Grade 9	$N = 33$		$N = 31$		
Planning	112.52	4.99	110.75	5.09	−0.35
Attention	110.97	6.35	109.58	6.11	−0.22
Simultaneous	100.91	11.84	105.31	9.14	0.41
Successive	105.61	8.10	107.66	11.41	0.21

Note. d = Female–male mean scores divided by the average standard deviations for a particular grade level = $[(n_m * s^2_m + n_{fm} * s^2_{fm})/n_m + n_{fm}]^{1/2}$. PASS = planning, attention, simultaneous, and successive model.

Table 3
Results of Discriminant Analysis Using the Four PASS Composites and Gender

PASS composite	Standardized discriminant function coefficients	Structure coefficients
Entire sample		
Planning	−0.29	0.34
Attention	1.32	0.64
Simultaneous	−0.76	−0.34
Successive	−0.21	0.02
Grade 3		
Planning	−0.13	0.39
Attention	0.98	0.94
Simultaneous	−0.26	−0.17
Successive	0.25	0.33
Grade 6		
Planning	0.84	0.95
Attention	0.36	0.62
Simultaneous	−0.04	0.42
Successive	−0.03	0.22
Grade 9		
Planning	−0.72	−0.46
Attention	−0.19	−0.26
Simultaneous	0.67	0.50
Successive	0.63	0.45

Note. PASS = planning, attention, simultaneous, and successive model.

Discussion

The primary purpose of this study was to investigate the presence of gender-related differences in PASS cognitive processing across and within three grade levels. A significant main effect for gender was evidenced for planning and attentional processes, and a significant Gender × Grade interaction effect was evidenced for attentional processing. Differences between the sexes were found at Grade 3 (in attention) and Grade 6 (in planning), although only the Grade 3 results were significant. The importance and implications of these findings are now discussed.

When analyzed separately at each grade level, a significant gender difference in attentional processes favoring girls was evidenced for the third-grade sample, but the differences at Grades 6 and 9 were nonsignificant. Although girls scored higher than boys at all three grade levels, these results indicate that the gender differences in processing tasks involving attention may be more pronounced at younger ages and may be indicative of developmental differences between boys and girls. This conclusion was supported through examination of the differences (for Grade 3, $d = -.96$; for Grade 6, $d = -.19$; and for Grade 9, $d = -.22$), which indicated that the gender difference on attention tasks in favor of girls was more than four times greater at Grade 3 than at Grades 6 and 9. Although further research is needed, these findings may offer important clinical and educational insights into a variety of issues. For example, if developmental gender differences in attentional processes do exist, this could provide greater insight into the disproportionally higher incidence of young boys diagnosed with attention deficit hyperactivity disorder and with other behavioral problems that have serious educational, social, and emotional ramifications (American Psychiatric Association, 1987; Barkley, 1981, 1991).

A moderately sized gender difference in favor of girls was evidenced in planning processes for the sixth-grade sample. Although not significant, examination of the mean scores indicated that girls scored higher on planning tasks at all three grade levels, and examination of the ds indicated fairly consistent effect sizes across all three grades (Grade 3, $d = -.43$; Grade 6, $d = -.52$; and Grade 9, $d = -.35$). These gender differences in planning processes are consistent with previous research in which Bardos et al. (1992) reported that although girls scored higher than boys in planning at all grade levels, the differences were significant at Grades 4, 5, and 6 but not at Grades 2 and 10. The results of that study in conjunction with the present findings suggest that girls may be more advanced in the development of planning processes from around Grades 3 through 6 but that by Grade 9, the difference is no longer significant. Further research is needed to more fully investigate this hypothesis.

If future studies continue to support the hypothesis that girls use planning processes more efficiently in solving cognitive tasks, then the gender-related difference evidenced in planning may help explain the results of studies that evidence female superiority in reading achievement. Furthermore, if gender-related differences in planning processes do exist, they may underlie the gender-related differences favoring girls on verbal tests, which have frequently been reported in the literature (Maccoby & Jacklin, 1974). Because certain language functions are regulated by the third functional unit (Naglieri & Das, 1988), it is possible that the superior performance of girls in planning may account for their superior performance on verbal tasks. In her meta-analysis of studies of gender-related differences on cognitive tests, Hyde (1981) reported that although gender-related differences on verbal tasks have been consistently reported, the effect sizes are small (mean effect size of approximately .24). Furthermore, in the meta-analysis reported by Hyde and Linn (1988) the effect sizes for gender differences on various types of verbal abilities ranged from .02 to .33, in favor of girls, with an overall mean effect size of .11. The effect sizes for the planning differences reported in the present study, although small to moderate at each of the three grade levels, are even larger than those reported by Hyde. Therefore, it may be that the small but consistent gender-related differences on verbal tests may be accounted for by the consistent gender-related differences evidenced in planning. However, further research in this area is also needed.

The relatively lower performance of boys on measures of planning processes is important for two reasons. First, it suggests that the PASS theoretical view of intelligence may be more sensitive to important differences between the sexes that are not apparent when traditional IQ tests have been used. The lack of IQ sex differences is likely to be due to the fact that tests like the Wechsler scales do not measure planning or attentional processes (Naglieri & Das, 1990). Second, the poorer performance of boys on planning processes may have important implications for instruction, especially because researchers have found beneficial effects of training in planning and goal setting, problem-solving strategies, and hypothesis generation (Peterson, 1988). For example, Cormier, Carlson, and Das (1990) found that when subjects who performed poorly on measures of planning (the same planned connections and visual search tasks used in the present investigation) were randomly assigned to one of two treatments, those who were given instruction that encouraged planful solutions of problems performed significantly better than did a control group. This instruction facilitated a planful and organized analysis of the relevant information and examination of the component parts of the task. Similarly, Kar, Dash, Das, and Carlson (1993) conducted two experiments in which they examined the extent to which good and poor planners differentially benefited from instruction designed to facilitate the use of strategies. The results of both their experiments showed that strategy verbalization training was more effective for those with low planning scores (on the Das & Naglieri, 1989, tests) than those with good scores on planning. Kar et al. concluded that because planning controls and regulates cognitive processing, improving planning skills can optimize performance. Additionally, because verbalization is one method used to formulate and generate plans of action, it helps the subject recognize the important parts of a problem, direct and control cognitive activity, and increase recognition of the important aspects of the problem. These findings suggest that poor planners will benefit from a different kind of instruction than will those with good planning processes (see Das, Naglieri, & Kirby, 1994, for a complete discussion of remediation that is based on PASS).

Finally, developmental trends were identified in this study that are worthy of discussion. With only one exception, the subjects' performance on the PASS processing tasks increased significantly throughout each subsequent grade level. This finding supports Luria's (1973) theory that these underlying cognitive processes involve a developmental process that is biologically based. The single exception to the consistent developmental progression evidenced in this study was in the area of simultaneous processing, in which the increase in scores from the sixth to the ninth grade was not significant. Examination of the mean scores by gender indicated that the performance of girls on the simultaneous processing tasks actually decreased from the sixth to the ninth grade. This finding may offer an important direction for future research aimed at clarification of gender differences in spatial and quantitative ability. Luria (1966) and Das et al. (1979) predicted that mathematics achievement may be closely related to simultaneous processing because of the highly spatial nature of mathematics. This predication has been substantiated through several research investigations (Garofalo, 1986; Naglieri & Das, 1987; Wachs & Harris, 1986). As previously discussed, the research on gender differences in mathematics achievement indicates that there appear to be no gender-related differences through elementary school, but by the end of high school boys generally outperform girls in all areas of mathematics (Armstrong, 1981; Cartledge, 1984; Fennema, 1977; Fennema & Carpenter, 1981; Fennema & Sherman, 1978; Swafford, 1980). Thus, it will be important for future research to investigate gender-related differences in PASS cognitive processing with high school–age subjects to determine whether gender-related differences in simultaneous processing may help explain the decreasing performance of girls in mathematics through the high school years.

The results of this study have suggested important cognitive gender differences that have not been previously detected by existing models of intelligence (e.g., Wechsler or Binet scales), because current IQ tests do not measure planning or attentional processes (Naglieri & Das, 1990). Therefore, it appears that the PASS model of cognitive processing offers a more comprehensive view of intellectual functioning (Naglieri, Das, & Jarman, 1990), which may help explain gender-related differences in academic test performance (Naglieri, 1989; Naglieri & Das, 1990). Additionally, knowledge of an individual's cognitive processing competencies may have implications for instruction and remediation.

According to Kirby and Williams (1991) and Das, Naglieri, and Kirby (1994), information about PASS processes can guide instruction for students without learning difficulties as well as for those with learning difficulties. For example, they suggest that the planning processes could be improved through instruction that encourages the student to be more aware of his or her cognitive activities, to step back from the problem to consider it in a broader context, and to develop problem-solving strategies. The importance of improving the processing competence of poor planners was recently shown by Cormier et al. (1990). They found that poor planners did better when instructed to solve progressive matrices while verbalizing the problem, to justify why they believed the answer they chose was correct, and to explain why each of the other options was not correct. These results suggested that poor planners benefited from an instructional technique that did not help good planners and, like other findings (e.g., Brailsford, Snart, & Das, 1984), suggested that the PASS model may have relevance to instruction and remediation. At this point, research is needed into the specific circumstances within which intervention can be most helpful and how to best link PASS processing information to particular instructional technologies.

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