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Configural errors on WISC–III block design

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Abstract

This study describes two experiments undertaken to explore the clinical significance and cognitive substrates of Block Design broken configurations in children. Broken configurations were defined as instances in which the child placed a block outside the 2×2 or 3×3 square matrix. In Experiment 1, 336 normal children between the ages of 6 and 14 were administered WISC–III Block Design. Broken configurations were fairly common, but almost always self-corrected. The tendency to break configurations was inversely related to overall Block Design performance and mother's level of education, and directly related to the perceptual cohesiveness of the design. In Experiment 2, children were administered WISC–III Block Design and a global–local similarity judgment task. The frequency of broken configurations was inversely related to global perceptual bias. Taken together, the results of these experiments indicate that while broken configurations are common, particularly on designs with high perceptual cohesiveness, a high number of broken configurations or final answers containing broken configuration are associated with weaker visuospatial skills. Broken configurations are also made more frequently by children whose perception is less influenced by the global properties of spatial stimuli. (*JINS*, 1999, *5*, 518–524.)

Keywords: Block Design, Broken configurations, Global–local, Visuospatial

INTRODUCTION

The Block Design subtest of the Wechsler scales is widely viewed as a clinically rich test assessing constructional, perceptual, and organizational abilities. Many authors have drawn attention to its suitability for qualitative analysis (Kaplan, 1983; Lezak, 1995). By noting where patients begin their constructions, the directions in which they work, where errors are made, and the frequency of certain error types, clinicians can infer a great deal about the nature of a patient's cognitive impairment and the location of focal brain lesions. For example, stimulus-bound errors, where patients focus excessively on the most perceptually salient features of the model, suggest poor executive skills and raise the possibility of anterior neuropathology (Milberg et al., 1996).

Kaplan and her colleagues (Kaplan, 1983; Milberg et al., 1996) have also suggested that block design performance can be analyzed with respect to both detail and configural levels. It has been suggested that left hemisphere-damaged patients have more difficulty with internal details while right hemisphere-damaged patients are more likely to distort the overall configuration (Akshoomoff et al., 1989; Ben-Yishay et al., 1971; Kaplan et al., 1991; Wilde et al., 1995). The tendency for right hemisphere damaged patients to distort the overall configuration is consistent with the well established finding that the right hemisphere is superior for analyzing global aspects of spatial information (Robertson & Delis, 1986; Robertson & Lamb, 1991).

The relationship between configural errors on block design and right hemisphere dysfunction has been well established in adults (Akshoomoff et al., 1989), as has the direct link between configural errors and diminished global processing (Kramer et al., 1991). Much less is known, however, about block design performance in children. For example, while broken configurations are relatively uncommon in normal adults (Paolo & Ryan, 1994; Troyer et al., 1994), it is not known how frequently these errors are made by children or what developmental trends might exist. Some data suggest that normal young children may be particularly prone to configural errors under certain circumstances. Using different types of block design patterns, Akshoomoff

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and Stiles (1996) systematically varied the degree of perceptual cohesiveness of the designs (Royer, 1977; Schorr et al., 1982). Perceptual cohesiveness refers to the number of internal block edges that are of the same color as the adjacent block. Studies with adults (Schorr et al., 1982) have shown that designs with more perceptual cohesiveness require more time to complete and are best solved with an analytic (*vs*. synthetic) strategy. Akshoomoff and Stiles (1996) reported that young children were more likely to break the configuration of nine-block designs when there was high perceptual cohesiveness (global patterns) than when there was low perceptual cohesiveness (local patterns). Their studies suggested that normal children might have difficulty considering the underlying configural grid when attempting to parse cohesive visual patterns into component parts.

Clearly, more information is needed about the clinical significance of configural errors on the widely used WISC–III Block Design subtest. Several groups of children, including those with nonverbal learning disabilities (Harnadek & Rourke, 1994), Turner's syndrome (Rovet, 1995; Rovet & Netley, 1982) and right-hemisphere dysfunction, have difficulty with visuospatial tasks like Block Design, and in some instances have been shown to have particular difficulty with global or configural processing (Bellugi et al., 1988; Bihrle et al., 1989). This paper describes two studies designed to address several issues related to the clinical relevance of block design in children. The first study looks at the incidence of configural errors in a large sample of normal children. It is only by establishing base rates for these types of errors that clinicians can determine at what point a particular pattern of errors is pathological. The second study was carried out to more clearly define relationships between Block Design configural errors and underlying cognitive processes.

EXPERIMENT 1

The study by Akshoomoff and Stiles (1996) suggested that normal young children sometimes break the configuration of block designs, at least when perceptual cohesiveness is high. In fact, for children under age 8 years, broken configurations were the most common error made on global designs. Younger children in their study were also more likely than older children to break configurations. These data suggest that unlike adults, the tendency to break configurations may occur fairly often, and may correspond to developmental changes in spatial ability.

The primary goal of this first study was to establish base rates of configural errors for different age groups on the WISC–III Block Design subtest. As did Troyer et al. (1994), we made separate tabulations of configural breaks that appeared in the final product and those that were made *en route* but were self-corrected. A secondary goal was to explore the relationships between configural errors and overall performance, demographic variables, and block design pattern type. These secondary analyses can only be preliminary, however, since the Block Design subtest was not systematically designed to assess these issues. For example, the relationship between configural errors and age was not possible to assess with this sample because of the discontinuation rule. Because the subtest was discontinued after two successive errors, it was much less likely for the younger children to even attempt some of the more difficult block designs where configural errors occurred most often. Although tabulating the percentage of attempted designs on which configural errors were made would compensate for the fact that younger children attempted fewer designs, this would not overcome the limitation that younger children were less likely to have been administered the more difficult designs. In addition, the strength of studies by Akshoomoff and Stiles (1996) and Schorr et al. (1982) is that the types of design patterns used were systematically varied to address how pattern type related to performance variables. Similar analyses, however, are not possible with the WISC–III Block Design. Four of the six four-block designs and one of the three nine-block designs use two or more solid-color blocks, making it difficult to establish criteria for quantifying perceptual cohesiveness.

Methods

Research participants

The sample consisted of 336 normal children taking part in a piloting study for the WISC–III as a Process Instrument (WISC–III–PI; Kaplan et al., in press). There were 157 girls and 179 boys, ranging in age from 6 to 14. The demographic characteristics of the sample corresponded roughly to the 1990 United States Census. Of the children, 61.3% were White, 21.1% were African American, 16.7% were Hispanic, and the remaining 0.9% were of other ethnic origins. Eleven percent of the study sample had mothers who attended school for less than 12 years, 59.8% had 12 to 15 years of education, and 29.2% had 16 or more years. The educational levels of the fathers are not reported because of the high rate of missing data (15.8%).

The study sample was divided into four age groups. Sample size and demographic data are summarized in Table 1. There were no differences between the age groups in sex or mother's education.

Table 1. Mean age and Block Design raw score for each age group

Age group (years–months)		Age (years)		Block Design raw score	
	N	*M*	*SD*	*M*	*SD*
6–0 to 7–11	73	7.20	(0.58)	21.12	(10.59)
8–0 to 9–11	98	8.99	(0.61)	25.28	(11.36)
10–0 to 11–11	88	10.88	(0.57)	36.49	(11.98)
12–0 to 13–11	77	12.89	(0.56)	43.88	(12.67)

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Procedure

The block design subtest of the WISC–III was administered according to standardized procedures. As prescribed by the discontinuation rule, the subtest was discontinued after two consecutive designs for which no credit was given.

During standardized administration, examiners kept track of each instance in which the overall configuration of the design was broken. A break in configuration was defined as any instance in which the child placed a block outside the 2×2 (for Designs 4–9) or 3×3 (for Designs 10–12) square matrix. Any break in configuration, even if the child returned to the 2×2 or 3×3 matrix for his final production, was counted as a configural error. For each design on which a configural error occurred, examiners indicated whether the child's final block design solution included a broken configuration or whether the square 2×2 or 3×3 matrix was present. The presence of configural errors was binary; that is, for each design, examiners indicated only the presence or absence of such an error and not the total number of times such an error was made on any single design. We report only on Designs 4 to 12; the first three designs used concrete stimulus models, not all children were administered Designs 1 and 2, and the instructions for Design 3 varies as a function of age.

Results

As indicated in Table 1, there is a clear developmental trend toward improved performance on Block Design, as measured by total raw score [$F(3,332) = 62.7$, $p < .0001$].

Table 2 reports the number of children in each age group who attempted each design, the percentage of those children who made a configural error on each design, and the number of children whose final product contained a configural error. The data indicate that configural errors are quite common on almost all of the block design problems. Designs 10 and 11 seem to be those in which the most configural errors were made, ranging from 26.9% to 38.4% of all participants. Even the simpler four-block problems elicit broken configurations; approximately 1 of every 6 older children made configural errors on Designs 4 to 7.

Table 3 reports frequency distributions for the total number of configural errors made in each age group. Although the highest percentage of participants in each age group did not break any configurations, over half the participants in each age group broke the configuration on at least one design. Broken configurations were rarely offered as the child's final solution to the problem, however. Only 12.3% of the sample did this once, and only 2.8% of the sample did this two or more times.

As previously noted, the discontinuation rule precluded examination of possible developmental trends in making configural errors. Preliminary analyses, however, were carried out to explore the relationship between broken configurations and other variables. The percentage of attempted designs on which configural errors was made was inversely related to maternal level of education ($r = -.22$, $p < .001$). Configural errors were also inversely related to overall achievement on the Block Design subtest; after parsing out the role of age on Block Design raw score, the correlation between the percentage of attempted designs on which con-

Table 2. Number of children in each age group attempting each design, the percentage of those children making configural errors, and the number of children whose final production contained a configural error

Age group (years)	Design number								
	4	5	6	7	8	9	10	11	12
6–7									
N	73	71	63	51	46	39	24	14	10
Percent	19.2	21.1	22.2	25.5	28.3	25.6	29.2	50.0	10.0
Final	0	1	1	1	0	1	4	3	0
8–9									
N	98	98	93	89	80	71	45	32	26
Percent	13.3	16.3	31.2	21.3	20.0	23.9	33.3	37.5	15.4
Final	0	1	4	2	1	1	3	4	1
10–11									
N	88	87	87	81	81	81	72	59	53
Percent	19.3	21.8	24.1	22.6	28.4	24.7	38.9	37.3	24.5
Final	0	0	0	0	1	0	7	12	4
12–13									
N	77	77	77	75	74	73	68	61	52
Percent	13.0	16.9	16.9	17.3	21.6	27.4	32.4	45.9	25.0
Final	0	0	0	0	0	1	5	6	1

Table 3. Total number of configural errors made by children in each age group

	Age group (years)			
	6–7	8–9	10–11	12–13
No. Errors	No. cases	No. cases	No. cases	No. cases
0	41 (49.4)	41 (40.6)	40 (43.5)	38 (46.9)
1	17 (20.5)	26 (25.7)	18 (19.6)	13 (16.0)
2	14 (16.9)	13 (12.9)	7 (7.6)	11 (13.6)
3	3 (3.6)	8 (7.9)	3 (3.3)	2 (2.5)
4	3 (3.6)	5 (5.0)	7 (7.6)	5 (6.2)
5	2 (2.4)	4 (4.0)	4 (4.3)	1 (1.2)
6	2 (2.4)	1 (1.0)	3 (3.3)	3 (3.7)
7	0 (0)	2 (2.0)	5 (5.4)	3 (3.7)
8	1 (1.2)	1 (1.0)	3 (3.3)	2 (2.5)
9	0 (0)	0 (0)	2 (2.2)	3 (3.7)

Note. Percentage of the total number of children making errors is in parentheses.

figural errors were made and Block Design raw score was significant ($r = -.20$, $p < .001$). There was no relationship between configural errors and sex. A one-way ANOVA indicated ethnic differences, however [$F(2,330) = 6.61$, $p < .01$], with African American participants breaking configurations more often than Whites or Hispanics. Group differences remained statistically significant even after repeating the ANOVA covarying for maternal level of education.

Preliminary analyses were also carried out to explore whether designs with more perceptual cohesiveness elicit more broken configurations (Akshoomoff & Stiles, 1996). The patterns used in the WISC–III varied unsystematically along two dimensions that could potentially influence whether configural errors were made: The number of internal block edges that were of the same color as the adjacent block (perceptual cohesiveness), and the number of solid-colored blocks. These two dimensions are particularly confounded for the four-block designs, so no attempt was made to analyze those designs. For the nine-block designs, we used Schorr et al.'s (1982) criteria to establish that Designs 10 and 11 have the greatest perceptual cohesiveness, with 12 and 11 internal block edges, respectively, having adjacent blocks of the same color. Design 12 was more intermediate, with eight internal block edges. Design 10, although technically possessing high perceptual cohesiveness, uses three solid-red blocks running vertically down the middle and two solid-white blocks on the sides. The use of five solid-colored blocks makes it difficult to make predictions about this particular design. We therefore made only one hypothesis, predicting that Design 11, with high perceptual cohesiveness and no solid-color blocks, would elicit more broken configurations than Design 12, with moderate perceptual cohesiveness and one solid-colored block. This hypothesis was supported [$\chi^2(1) = 40.87$, $p < .0001$]. Although no hypotheses were generated about Design 10, the chi-square analyses indicated that Design 10 elicited fewer broken configurations than Design 11 [$\chi^2(1) = 20.18$, $p < .0001$] but more broken configurations that Design 12 [$\chi^2(1) = 17.44$, $p < .0001$].

Discussion

Experiment 1 indicated that broken configurations occurring at some point in the examinee's problem solving attempt are fairly common, particularly on Designs 10 and 11. These errors are typically self-corrected and broken configurations occurring on the examinee's final product are rare. Consequently, the presence of three or fewer broken configuration during a child's problem-solving efforts on Block Design should not be interpreted as anything outside the range of normal. The presence of a broken configuration as the child's final product, or the occurrence of six or more broken configurations, is much less common, and raises the possibility of some impairment in visuospatial ability.

Although occurring fairly often in a normal population of children, the tendency to break configurations was inversely related to overall block design performance. This suggests that broken configurations are more likely to be made by children with weaker overall visuospatial problem solving ability. Broken configurations were also inversely related to mother's level of education and were made more frequently by African American children. Finally, although the design patterns included in the WISC–III were not designed for studies of perceptual cohesiveness, the results of our preliminary analyses are consistent with Akshoomoff & Stiles's (1996) finding that broken configurations are more often made on designs with greater perceptual cohesiveness.

Because of the discontinuation rule, it was not possible to determine what the relationship might be between configural errors and age. Even using the percentage of designs on which errors were made is not sufficient, since the types of design administered to the older children were much more likely to be those that elicited broken configurations. This accounts for the apparent tendency for older children to be more prone toward configural errors.

EXPERIMENT 2

The second study was designed to yield more information about underlying mechanisms contributing to configural errors by going beyond the more traditional discontinuation rules. Performance on block design was also associated with a cognitive task that assessed the children's perceptual bias. In the perceptual bias task, children were presented with visual hierarchical stimuli that could be matched to a standard figure at either the local or global level. We hypothesized that children who were more strongly biased toward global matches would make fewer configural errors on Block Design.

Methods

Research participants

Participants were 37 children, ages 6 through 12 years, who were recruited as volunteers from two San Francisco Bay Area public school districts. There were 18 boys and 19 girls with a mean age of 9.66 years ($SD = 2.1$). Age distribution did not differ significantly by sex. All subjects were in mainstream classrooms and screened for any history of learning problems and neurologic, psychiatric, or medical conditions.

Stimuli and procedures

Two tasks were administered: a perceptual bias test, and the Block Design subtest of the WISC–III. The perceptual bias test (Kimchi & Palmer, 1982; Kramer et al., 1991) consisted of 32 stimulus cards. Each card contained a standard figure at the top and two comparison figures at the bottom (see Figure 1). The standard figure consisted of a global form (square or triangle) constructed from smaller, local forms (squares or triangles). One comparison figure was similar to the standard figure at the global level and the other comparison figure was similar to the standard figure at the local level. The number of elements used to construct the standard figures varied: Global triangles consisted of either 3, 10, 15, or 36 local elements, and global squares consisted of either 4, 9, 16, or 36 local elements. Each type of comparison figure appeared equally often in the left and right positions.

Stimulus cards were presented to the children one at a time at a distance of approximately 60 cm. Participants were asked to give their first, most immediate impression of which of the two comparison figures looked most like the standard figure and they were advised that there were no right or wrong answers. The dependent measure from this task was the total number of comparison figures selected that had the same global shape as the standard figure.

The WISC–III block design subtest was administered according to standardized procedures, with the exception that two additional designs were administered beyond the discontinuation rule. The examiner recorded each block placement the participant made *en route* to his or her final product. Configural errors were defined as in Experiment 1. A total configuration error score was tabulated by counting the number of designs on which the child made a configural error.

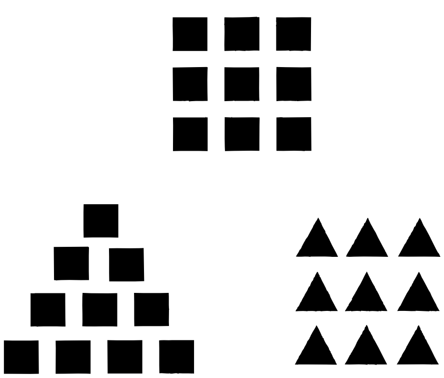

Fig. 1. Example of the perceptual bias task stimuli, with the standard figure (top), global comparison figure (lower right), and local comparison figure (lower left).

Results

As a group, the children in our sample did well on Block Design, achieving a mean scaled score of 12.78 ($SD = 4.1$). The mean number of designs on which a configural error was made was 0.95 ($SD = 1.0$), and the median was 1.0. Configural errors were uncommon on Designs 3 to 8. On Designs 9, 10, 11, and 12, broken configurations were made by 16.2, 29.7, 29.7, and 16.2% of participants, respectively. These error rates are comparable to those obtained in Experiment 1.

A hierarchical regression analysis was utilized to determine what predicted the number of designs on which a configural error was made. Age, Block Design scaled score, and number of global responses were entered in a stepwise fashion. Results are summarized in Table 4. Block Design scaled score entered first, explaining 45.4% of the variance. Lower Block Design scaled scores were associated with a greater number of configural errors. Global perceptual bias entered into the equation next, explaining an additional 10.5% of the variance [$F_{\text{change}} = 7.67$, $df = 2{,}34$, $p < .01$]; children who selected the global comparison figure least often were most likely to make configural errors on Block Design. Age did not explain a significant proportion of the variance in configural errors beyond that explained by Block Design scaled score and global perceptual bias.

Because 2 of the children were not administered Design 12, the multiple regression analysis was repeated using the proportion of designs on which a configural error was made as the dependent variable. The results were unchanged.

Discussion

Experiment 2 demonstrated that the tendency to break the configuration on Block Design is related to overall competence on Block Design and global response bias on a simi-

Table 4. Results of the hierarchical regression analysis identifying variables predicting configural errors on Block Design

Variable	Beta	R^2	R^2 Change	F	df	p
Block Design scaled score	−.672	0.45	.45	29.14	1,35	<.0001
Global perceptual bias	−.317	0.55	.10	21.19	2,34	<.0001

Note. Block Design scaled score: $df = 1{,}35$; Global perceptual bias: $df = 2{,}34$.

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larities judgment task. The relationship between broken configurations and Block Design scaled score is consistent with Experiment 1, which indicated that raw scores and configural errors were inversely related once the effect of age was partialled out. In Experiment 2, using scaled scores essentially partials out the role of age. As was previously demonstrated with adults (Kramer et al., 1991), the children who made configural errors on block design selected the global comparison figures on the perceptual bias task less often than did children who did not make configural errors. This supports the hypothesis that these errors reflect differences in the perceptual coding of global–local features of the stimulus.

Once the variance associated with scaled score and global bias are accounted for, the child's age is unrelated to the tendency to make configural errors. These data may initially seem to run counter to those obtained by Akshoomoff and Stiles (1996), who reported that younger children broke the configuration on nine-block global designs more often than older children. The sample studied by Akshoomoff and Stiles (1996), however, was younger than the children in the present study. The children in their study were 6-, 7-, and 8-year-olds, and it was the 6-year-olds who appeared to be most prone toward configural errors. The present study's sample was comprised primarily of older children. Thus it remains possible that normal children age 6 and younger do break the configuration more often than older children. Consistent with this possibility are the findings of two studies that examined similarity judgments in children. Dukette and Stiles (1996) presented children with stimuli that could be matched on the basis of either global or local features. Under some experimental conditions, 4-year-olds were more likely to base their similarity judgments on the basis of local level information, whereas children 6-years and older continued to make global level matches. Dukette and Stiles concluded that there were significant developmental trends in spatial integrative functioning between the preschool and early school age period. Similarly, Kramer et al. (1996), using the same similarity judgment task used in the present study, reported that children younger than age 7 exhibited a weaker global bias than older children when assessed (Kramer et al., 1996). All age groups, however, were more likely to make global level matches when the local stimuli were smaller and more numerous.

GENERAL DISCUSSION

These two studies demonstrate that violations of the 2×2 and 3×3 square matrices on WISC–III Block Design occur fairly often in normal children of all ages. Although the modal number of broken configurations was zero, a high percentage of children made several configural errors. For the 6- and 7-year-old group, who attempted an average of 5.4 of the studied designs, over 13% broke the configuration on three or more designs. In the 12- and 13-year-old group, who attempted an average of 8.2 of the studied designs, over 13% broke the configuration on five or more designs. Almost all of these broken configurations, however, are self-corrected. Less than 3% of the 336 children in Experiment 1 offered broken configurations as their final product on two or more designs. Accordingly, the presence of a few self-corrected configural errors are of doubtful clinical significance, particularly when they occur on the nine-block designs. More than one final answer containing a broken configuration, however, should alert the clinician to the possibility of underlying spatial difficulties.

Although not designed specifically to assess this dimension, configural errors on WISC–III Block Design appear to be related to specific parameters of the stimuli. Consistent with the work of Akshoomoff and Stiles (1996), we found that designs with the greatest degree of perceptual cohesiveness were the ones on which the most broken configurations were made. Both Experiment 1 and Experiment 2 indicated that configural errors were also related to overall level of achievement on Block Design. In fact, Experiment 2 demonstrated that Block Design scaled score explained 45% of the variance in configural errors. This implies that the tendency to violate the square matrix of the stimulus pattern is associated with weaker visuospatial ability.

Experiment 2 also demonstrated a relationship between how global children are in their perceptual bias and the number of configural errors they make on Block Design. Children who tended to make configural errors were less likely to select the global comparison figures on the similarity judgment task. Similar findings have been reported previously in adults (Kramer et al., 1991). These results suggest that there is a specific underlying information processing component to configural errors that involves the tendency to be influenced by the global properties of a visuospatial stimulus. Importantly, these findings are based on a sample of normal children, indicating that these observed relationships, already documented in right-hemisphere patients (Akshoomoff et al., 1989; Robertson & Lamb, 1991) are present in neurologically intact individuals. Accordingly, when a child breaks the configuration on several designs, inferences can be made about how the child processes information without necessarily implying that there is a cognitive deficit or structural lesion.

Despite its many strengths, WISC–III Block Design has some limitations for studying visuospatial ability. The designs do not appear to be systematically varied along any particular dimension. In addition, the discontinuation rule introduces variability in the numbers and types of designs administered. Studies like those of Akshoomoff and Stiles (1996) and Schorr et al. (1982) offer important contributions to our understanding of what individual performances on block design tasks might mean. Emphasis on error analysis also plays an important role in interpreting WISC–III Block Design performance. Similarly, the clinician's ability to more comprehensively understand the implications of a child's cognitive test performance will be enhanced by procedures implemented by Kaplan and colleagues in their process-oriented adaptation of the WISC–III (Kaplan et al., in press). These procedures include quantification of nu-

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merous aspects of a child's test performance (e.g., types of errors, location of errors, strategies implemented) and variations on standardized administration such as multiple choice and cued conditions, untimed trials, and addition of stimuli with systematically varied parameters.

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