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Stimulus Variables in the Block Design Task

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Block-design construction tasks reliably assess cognitive deficits due to brain injury. We examined the important aspects of this task with four experiments using normal subjects. Two problem-solving strategies are identified: an analytic strategy in which subjects mentally segment each block in the design to be constructed and a synthetic strategy, which involves wholistic pattern matching. Three experiments found a predominate analytic strategy. The time to place a single test block in a display decreased the greater the number of interior edges for that block in the design. Also, two-colored blocks requiring an orientation judgment were placed slower than solid blocks. The fourth experiment predicted overall construction times for a design from the number of solid blocks and interior edges of its blocks. These studies suggest refinements in the block-design test for investigating constructional disability in brain-damaged patients. We recommend such analyses of other neuropsychological tests.

Block-design construction tasks (see Figure 1) are frequently used as measures of intelligence and in the diagnosis of organic brain damage (Goldstein & Scheerer, 1941; Kohs, 1923; Wechsler, 1958). In a review of 38 behavioral tests used in the diagnosis of brain damage, Spreen and Benton (1965) found that the block-design test distinguished between brain-damaged and normal individuals with 80% accuracy, one of the highest rates for a behavioral test; this rate compares favorably with electroencephalographic and radiologic techniques. Diller et al. (1974) found that the block-design test reliably predicted outcome in a brain-injury rehabilitation program.

In light of the clinical value of block-design tests, a psychological analysis of this task is important. Theorists have proposed that subjects use two distinct strategies in solving block designs (Behrens & Miles, 1957; Goldstein & Scheerer, 1941; Rapaport, 1945; Wechsler, 1958). In the analytic strategy, the displayed design is mentally segmented into units corresponding to block faces, then the blocks are directly placed, one by one, to match each unit. In the synthetic strategy, the design is viewed as a whole and is not differentiated into units corresponding to block faces; instead, the blocks are manipulated until they match the pattern or seem to "click" with adjoining blocks to reproduce the design. Thus, the synthetic approach focuses on the gestalt of the stimulus pattern and matches this overall design.

Goldstein and Scheerer (1941), Wechsler (1958), and Rapaport (1945) agree that the analytic strategy is more efficient than is the synthetic in solving block-design tasks. Behrens and Miles (1957) asked subjects to verbalize the strategy they used during block-design performance. Those who verbalized an analytic strategy solved the task more quickly.

Goldstein and Scheerer (1941) suggested that brain-damaged individuals do not perform well on block designs because of an inability to adopt an analytic approach. Attempts to elucidate the hypothesized contribution of the analytic versus synthetic strategies to block-design performance on the Wechsler Adult Intelligence Scale (WAIS; Ben-Yishay, Diller, Mandleberg, Gordon, & Gerstman, 1971; Kaplan, Note 1) have been largely unsuccessful. However, it is not surprising that error analyses of familiar psychological tests are unrevealing, since the tests themselves were not designed to vary the crucial test dimensions systematically. One study (Royer & Weitzel, 1977) did vary

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systematically the amount of "mental slicing" needed to solve a series of block-design problems. The data supported the hypothesis that efficient block-design performers use an analytic approach to block construction.

Royer (1977) elaborated an information-processing model of the block-design task based on the idea of the "uncertainty" (in color or orientation) associated with the placement of each block in a display. Royer did not address the cognitive strategies an individual might use to solve the task. The "mental slicing" operation was only viewed as increasing the number of response alternatives rather than representing a performance strategy.

Let us characterize the alternative problem-solving strategies more fully. Subjects using the "synthetic strategy" would attend to the gestalt appearance of the display section under consideration; they would take a block and rotate it in the construction design until it formed the desired pattern. Subjects following the "analytic strategy" would segment the focused area into its crucial sides, noticing the orientation of the colored edges (e.g., red corner northwest, white corner southeast), choose a two-colored block rotated into a matching orientation, and then place it into the target cell. This part of the task—segmentation and orientation determination—is crucial and depends upon the number of perceptual cues indicating "edges" of the block to be placed. We will discuss these "edge cues" later. We propose that the subject selects one of these strategies. We hypothesize that this selection varies with several factors: (a) individual subjects may be biased toward a predominately analytic or synthetic strategy; (b) designs with strong gestalt figures suggest a synthetic strategy more than do less good figures; and (c) later pieces in the construction space are more likely to be placed using a synthetic strategy because large, partially-constructed designs exert greater "gestalt forces" upon construction.

We propose that the difficulty of an overall construction problem can be represented as the sum of the difficulties of selecting and placing the individual pieces in the construction. We exploit this intuition in our first three experiments: They drastically simplify the overall task down to a fractional part, namely, the time the subject requires to identify the kind of block face that fits into a specified cell of the display. This experimental restriction is analytically convenient and powerful, enabling us to manipulate display variables precisely. Moreover, the "place one block" test seemed still to capture the essential flavor of the larger construction task, since in our Experiment 4 we predict the difficulty ordering of complete constructions using hypotheses suggested by the results of the "place one block" tests.

Different subjects may follow predominately either an analytic or a synthetic strategy. Edge cues for a block will have a powerful impact on its placement time for subjects following the analytic strategy but not for subjects following the synthetic strategy. While one normally has no independent evidence of which strategy a subject is following (the processes involved here are so fast that introspections about them are untrustworthy), we can use a person's sensitivity to edge cues in placement time as an indicator of his or her use of an analytic strategy.

As noted, the process of perceptually segmenting a block within a display (mentally extracting it from its surround) and identifying its orientation should depend heavily on cues signaling its interior edges. Royer (1977) referred to these edge cues as the number of "adjacencies" of opposite-colored edges for the block. To appreciate the power of these edge cues, note Figure 1, which shows three displays using two-colored blocks in a 2 × 2 matrix. Every block around the edge of the overall 2 × 2 figure has two "external edges," so we will ignore external edges and count only "interior edges" of blocks that break up the interior of the figure. (Imagine that a grid or plus sign is projected onto the 2 × 2 matrix.) The three designs in Figure 1 illustrate 4, 2, and 0 interior edge cues, respectively. Four is the maximum number for a 2 × 2 matrix; 12 is the maximum number of interior edges for a 3 × 3 matrix.

Why are edge cues so crucial to segmentation? Two complementary descriptions come to mind. One description is that the subject follows the interior edges in aligning a local, one-block, mental grid with block

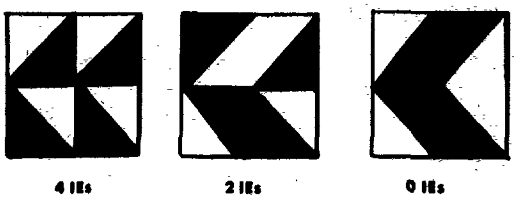

Figure 1. Illustration of 0, 2, or 4 interior edges (IEs) in 2 × 2 designs.

edges, and he or she then "projects" that one-block grid onto the display area, identifying one block at a time. The time to align and project a one-block grid is shorter at outer borders (i.e., center blocks are usually hardest) and for blocks with more interior edge cues. It is as though mental effort is required to project an edge where none exists in the gestalt visual organization of the design. An alternative description is that interior edge cues facilitate the "extraction" of single blocks from a gestalt display by indicating the edges where one would, so to speak, pick up that block.

Whether we use the projection or extraction metaphor, construction time should be clearly shorter for designs that have more interior edge cues. Thus, in Figure 1, for subjects following an analytic strategy, construction time should be shortest for the design with four interior edge cues and longest for the design with no interior edges. Conversely, for subjects following a synthetic strategy, the right-hand design in Figure 1 would be easier, since it forms a simple gestalt that is easily recognized when reproduced.

Just as a design can be scored according to its number of interior edges, so also can a single block. For example, the upper right-hand block in the three designs of Figure 1 has 2, 1, and 0 interior edges, respectively. Our hypothesis suggests that when the person's task is to identify a specified block embedded in a display, his or her time to identify that block will decrease with its number of interior edges in that display.

Because the experimental arrangement used was novel, we shall describe it. Subjects looked at a display design, then at a construction matrix with a specially marked cell (the asterisk in Figure 2). Their task was to select one of six block faces that matched the display block in the specified location. Figure 2 shows the format of a trial, with the two types of construction matrices tested. On different trials the construction matrix could be either empty (top in Figure 2) or filled (bottom in Figure 2) except for the missing cell to be supplied by the subject. We hypothesized that subjects would be more likely to use a synthetic strategy with a filled construction matrix, since gestalt properties of the overall design are then available to attract them. If so, then the effect on decision time of the number of interior edges of the to-be-identified cell should be less for filled construction matrices. The edge effect should be greater for empty matrices, because they force the subject to segment the overall design and to extract the specified piece.

The experiments were conducted with normal young adults (Stanford undergraduates) of above-average intelligence. These subjects should comprise more efficient problem-solvers than those seen in the typical clinical setting.

Experiment 1

Method

Subjects. Ten undergraduates at Stanford University, both male and female, participated for introductory psychology credit. They were tested individually.

Design. This study had a 3 × 2 × 2 design. The three factors manipulated were the number of interior edge cues, the type of piece to be identified, and the presence or absence of blocks previously placed in the construction. The piece to be identified had 2, 1, or 0 interior edge cues; the piece was two-colored or solid; and the piece was the first or last block face to be fitted into the construction.

Stimuli. As shown in Figure 2, each stimulus card contained two figures, a display pattern on the right composed of some 2 × 2 arrangement of the blocks used in the WAIS block-design subtest and to its left a 2 × 2 construction matrix with an asterisk in one of its quadrants. The other three quadrants were either empty or filled with the blocks appropriate to the adjacent design.

Below each stimulus card appeared six choices labeled "a" through "f" corresponding to the two solid block faces and the four possible orientations of the two-colored block face.

Procedure. The subject was instructed to identify which block face from the set "a" through "f" corresponded to the area of the display pattern designated by the asterisk. The cards were presented in a two-field tachistoscope. When the experimenter said "Ready," the subject pressed a button to start a trial. A fixation

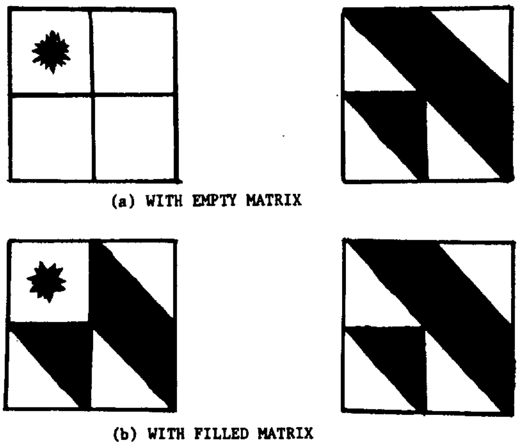

Figure 2. Illustration of a test display (right) with a construction matrix (left), which is empty (top) or nearly filled (bottom). (The one cell to be extracted from the display pattern and identified is marked by an asterisk. The six alternative "block responses" are not shown here.)

point appeared in the center of the field for 1 sec, then the trial stimuli came on and a clock started. The subject decided which one of the six block faces fitted into the asterisk cell of the construction matrix. The subject responded by pressing a single "stop" button and simultaneously saying aloud the correct answer, "a" though "f", a code indicating the six block faces. The reaction time was recorded in millisec. The subject was first given 45 practice trials. Then the set of 66 test items was given to the subject four times, for a total of 264 trials.

Results

The overall error rate within subjects ranged from 0 to 4%, with a mean of 2.2%. The variation in error rates was too small

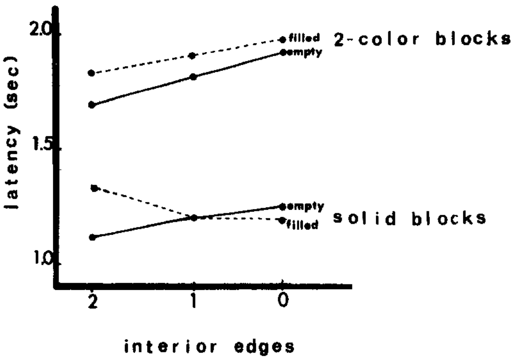

Figure 3. Average time to identify a specified block when it was solid or two-colored, occurred in an empty or filled matrix, and had 0, 1, or 2 interior edges.

to relate to experimental conditions. The low error rates indicate that our instructions stressing accuracy were effective.

The primary results on average placement times are shown in Figure 3. A first main effect is that solid blocks are identified 649 msec faster on average than are two-colored blocks. This effect is understandable in that two-colored blocks require the subject to determine the correct orientation of the specified block (out of four possibilities). A second main effect is that a piece was identified more quickly the greater the number of interior edges it had in its display, with $F(2, 18) = 10.07$, $p < .005$. Figure 3 shows that this quickening due to interior edges occurred in three of the four conditions, the exception being identification of solid blocks and their placement in a filled matrix. Although blocks were placed 69 msec quicker in empty matrices, this difference was not statistically significant.

By averaging across relevant conditions in Figure 3, the reader can note how the several variables interacted in determining identification times. First, the number of interior edges had a marked effect on placement of two-colored pieces but not of solid-colored pieces. This interaction is statistically significant, $F(2, 18) = 7.42$, $p < .005$. A second interaction is that placement time increased more markedly with the number of interior edges when the construction matrix was empty than when it was filled, with $F(1, 18) = 6.45$, $p < .01$. This result would occur if subjects were more likely to follow a synthetic strategy when the construction matrix contained a gestalt-inducing pattern.

Perhaps the more interesting interaction is that between the number of edges and the construction space when a solid block is being placed (lower lines in Figure 3). Placement time of a solid piece in a filled matrix *increases* 160 msec from 0 to 2 interior edges ($p < .025$), but in an empty matrix *decreases* 132 msec from 0 to 2 interior edges ($p < .005$). The interaction here is significant, $F(2, 18) = 10.88$, $p < .001$. While the composite data show no overall effect, that arises because two underlying trends (for filled vs. empty matrices) cancel one another. We will return to this finding in the Discussion Section.

Discussion

Our results permit several conclusions. First, practically all of these college students used a predominately analytic rather than a synthetic strategy. This conclusion was evidenced by their sensitivity to the interior-edges cues in identifying blocks. Second, two-colored blocks are identified more slowly than are solid blocks because the orientation of the two colors must also be identified in the former case. Third, the number of interior edges reliably affects the identification of two-colored blocks but has no overall influence for solid blocks. Fourth, a filled construction matrix is more likely than is an empty matrix to evoke a synthetic strategy, since the attraction of an overall gestalt arises with the filled matrix.

The most unexpected result of this study was that the time to identify a solid block varied with its number of interior edges in a manner depending on the construction space. It is as though an analytic strategy was evoked by an empty construction space (as with the two-colored blocks), but a synthetic strategy was evoked by a filled space. The results also suggest that subjects are using interior edges at the very beginning of the process, as early as the "rough segmentation" of the display, before deciding upon the kind of block they are examining. The next study isolated and examined this specific decision (solid vs. two-colored block) in greater detail. In this next study, subjects simply decided whether a specified block in the display was solid or two-colored, with no orientation decision required in the latter case. The issue is whether this decision would be similarly affected by the number of interior edges of the tested block.

Experiment 2

Method

Subjects. Ten undergraduates at Stanford University, 5 male and 5 female, participated for introductory psychology credit.

Design. This study had a 3 × 2 design. The two factors manipulated were the number of interior edges and the type of piece. The piece to be identified had either 2, 1, or 0 interior edges, and it was either solid or two-colored.

Stimuli. The stimuli were similar to those used in Experiment 1 (see top of Figure 2), except that all had empty construction spaces and no block-face choices appeared below the actual stimuli. The 48 test patterns were divided among the six cells of the experimental design.

Procedure. The procedure was the same as that in Experiment 1, except that the subject had to indicate simply whether the specified piece should be solid or two-colored by pressing one of two response keys. Thirty practice trials were followed by the set of 48 test items repeated five times for a total of 240 trials.

Results

The results were similar in pattern to those in Experiment 1. Overall, identification times were shorter the greater the number of interior edges of the target piece, with $F(2, 18) = 8.09$, $p < .005$. Identification times averaged about the same for solid and two-color blocks. Recall that two-color decisions were slower than solid decisions in Experiment 1; that was expected because those two-colored judgments also required orientation to be identified, whereas the judgments of Experiment 2 did not require an orientation decision.

An interesting finding is that the decrease in identification time with more interior edges was very marked for two-colored blocks but was practically absent for solid blocks. For two-colored pieces, the decreasing response time with number of interior edges yielded $F(2, 18) = 15.07$, $p < .001$; for solid-colored pieces, the comparable value is $F(2, 18) = 1.43$, $p > .10$. Combining the two, the overall interaction between type of block and number of interior edges yields $F(2, 18) = 16.35$, $p < .001$. This replicates findings from Experiment 1.

Discussion

Identification of two-colored but not solid blocks varies with their number of interior edges. The insensitivity of solid-block decisions to the edge cues may arise from subjects deciding on the basis of a homogeneous area of one color (in the 0 cues case) without requiring any segmentation of blocks. Thus, a solid block surrounded by 0 interior edges means that at least an entire half region of the 2 × 2 design is of that one color; only a fast, imprecise area match would be required to locate (or project) the asterisk cell within that large area. This area-covering strategy

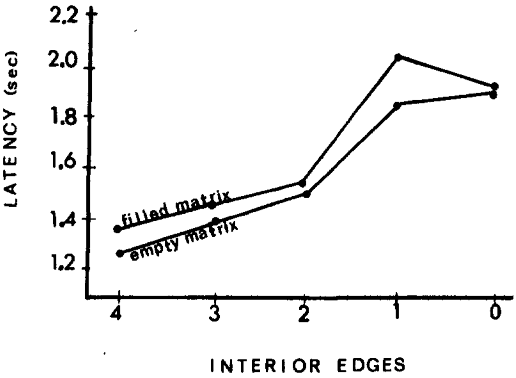

Figure 4. Average time to identify the center block in a 3 × 3 display, depending on its interior edges and filled versus empty construction space.

opposes the effect otherwise expected if the solid block had to be segmented exactly within its background.

The fact that two-colored blocks are identified as such faster when they have more interior cues implies that the preliminary, rough segmentation of the design is influenced by these cues. As before, solid pieces lend themselves more to synthesis because the presence of a large area of one color allows a fast decision by global matching rather than by segmentation.

Experiment 3

With 2 × 2 displays the number of interior edges for a piece can be either 0, 1, or 2. We wanted to examine the influence on identification times of a greater range of variation in interior edges of the displayed part. Consequently, Experiment 3 utilized the center block in 3 × 3 displays. This center block can have from 0 to 4 interior edges with its surrounding cells. The displays varied in the number of interior edges, and the construction matrix was either empty or filled (except for the cell to be filled in).

Method

Subjects. Ten undergraduates at Stanford University, 5 male and 5 female, participated in this study for introductory psychology credit.

Design. This study had a 5 × 2 design. The two factors were the number of interior edge cues (0 to 4) and the construction space (empty vs. filled). The piece to be identified had either 4, 3, 2, 1, or 0 interior edges, and the construction space contained either 0 or 8 filled cells. All pieces in the display were two-colored.

Stimuli. The stimuli were similar to those used in Experiment 1, except that only designs that could be composed of some 3 × 3 arrangement of two-colored blocks were used. Four response choices labeled "a" through "d", corresponding to the four possible orientations of a two-colored piece, appeared below each stimulus card.

Procedure. The procedure was the same as that in Experiment 1, except in the manner in which a response was made. The subject was seated at the tachistoscope before a 5-key response panel. The center key was the "start" button with which the subject began a trial. The other four keys corresponded to choices "a" through "d" (different orientations of the two-colored block). Thirty-two practice trials were followed by the set of 30 test items and two filler items, repeated five times for a total for 160 trials.

Results

The main result is depicted in Figure 4. Identification time is a monotone decreasing function of the number of interior edges of the center piece to be identified. The overall analysis for the interior-edge effect yields $F(4, 36) = 7.77$, $p < .001$. Each point on Figure 4 differs significantly from its neighbors except for those at 1 versus 0 interior cues. As a second main effect, subjects were 75 msec faster to place a cell in an empty construction matrix than in a full matrix, with $F(1, 9) = 10.33$, $p < .025$. This factor did not interact with the number of interior edges, with $F(4, 36) = .80$, $p > .10$.

The overall error rate per subject varied from 0 to 12%, with a mean of 2.4%.

Discussion

Again, we have a powerful demonstration of the influence of the number of interior edges on placement latencies. The greater range of variation of interior edges available in the 3 × 3 matrices enhanced the effects of this cue. Recall that the size-of-the-edges effect is a rough index of how much subjects are using the analytic strategy. We conclude that all of our subjects mainly used the analytic strategy. Consistent with this conclusion, the edges effect appeared almost as strongly with filled construction matrices as with empty ones. Recall that in Experiment 1 filled matrices had given rise to some evidence for synthetic, wholistic processing. But that tendency is overridden by pressures toward analytic processing with the center block of a 3 × 3 matrix.

One of the factors promoting analytic processing here was surely the selection of displays to be constructed, all comprised solely of two-colored blocks. This restriction tends to produce "choppy" figures, generally without much overall organization, with "good figures" comprising at best only local subparts of the total display. Such displays tend to discourage a global gestalt approach characteristic of the synthetic strategy.

In contrast to the displays used, certain displays would strongly suggest a wholistic approach, namely, matrices that have large solid areas of one color. For these, it is as though the perceptual apparatus generates a simple, global internal description (e.g., "all red") that guides the construction. But for the more difficult matrices such as we have studied, a more complex segmentation and description of the display must be generated. For such displays the processes guided by interior edge cues become prominent.

Whereas the first three studies investigated identification of a single block with tachistoscopic presentations, the next study applied the major hypotheses of this article to predict the time to construct entire designs as required in the WAIS block-design subtest.

Experiment 4

Method

Subjects. Sixteen students at Stanford University, both male and female, participated in this study for pay.

Design. This study had a 7 × 3 design. The two factors manipulated were the number of interior edges and the number of one-colored blocks in a design. The design had either 12 (the maximum possible), 10, 8, 6, 4, 2, or 0 interior edges, and the design had either 0, 2, or 4 solid pieces; however, with 4 solid pieces no designs exist with 12 or 0 interior edges, so those conditions cannot be tested. The designs also permitted us to contrast solution time for overall symmetrical (about the diagonal axis) versus asymmetrical designs.

Stimuli. The designs were presented in the same format as the WAIS designs; the nine blocks from the WAIS were used in this study. All stimuli could be constructed by some 3 × 3 arrangement of the blocks. The test set consisted of 73 different designs.

Procedure. Subjects were run individually. They were shown the six block faces of the cubes and were told that the designs could be formed from some 3 × 3 arrangement of these block faces. Subjects were instructed to construct the designs out of nine blocks as rapidly and accurately as possible. The session began with eight practice items followed by the 73 test patterns. The time from the moment a subject was shown the design until he or she placed the last block was recorded.

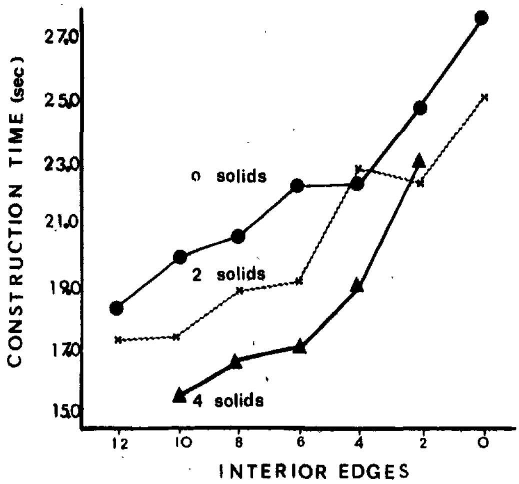

Figure 5. Average time to construct Wechsler Adult Intelligence Scale block designs depending on the number of interior edges and solid blocks in the design.

Results

The average construction times are displayed in Figure 5. The data show very orderly relations: Construction time decreases monotonically with the number of interior edge cues and with more solid cells in the design. The decrease in construction time with fewer interior edges was significant overall and for each of the three functions of Figure 5 considered separately (all $ps < .001$). Designs with four solid-color blocks were constructed on average 2 sec faster than were designs with two solid blocks, which in turn were constructed 1.8 sec faster than were designs with zero solid blocks. Pairs of these means differ reliably at $p < .001$. Confining attention to the functions between 10 and 2 interior edges (recall, 12 and 0 interior edges were unrealizable with four solid blocks), there is a reliable interaction in construction time between the number of interior edges and the number of solid blocks, with $F(8, 120) = 2.80, p < .01$. The nature of this interaction is apparent in Figure 5: The 4-solids function rises more steeply than do the 2-solids and 0-solids function. However, this conclusion relies heavily upon two points, namely, the 4-solid point at 2 interior edges, and the 2-solid point at 4 interior edges. Removal of these aberrant points would create near parallelism in the three functions, removing the aforementioned interaction.

Recall that the designs were varied in symmetry. Designs symmetrical about a diagonal axis were solved 1.7 sec faster than were asymmetrical designs; this difference was significant, $F(1, 15) = 8.45$, $p < .025$. This distinction of symmetrical versus asymmetrical designs was not confounded with differences in average numbers of solid blocks or numbers of interior edges.

Discussion

This study demonstrates that the results of the first three studies are relevant to predicting performance with the actual WAIS block-design procedure. When the dimensions of the designs are held constant, the number of interior edge cues and number of solid pieces are the two major determinants of difficulty in block-design constructions. Symmetry has a smaller influence in comparison. The major effect of interior edges on processing time suggests that the test with these subjects primarily depends on analytic abilities. Designs with fewer interior edges take more time to construct because of the additional time required to mentally segment the edges of cells in the design. In addition, designs with more solid pieces take less construction time because no decision about the orientation of solid pieces is required.

The results that number of solid blocks and symmetry significantly influence difficulty confirm other studies of block-design solving. However, given the importance of interior edges as a predictor of difficulty, it is surprising that this factor has received only two scattered citations in the literature (i.e., in Rapaport, 1945, and in Royer & Weitzel, 1977). Although Royer (1977) investigated interior edges as a determinant of "perceptual cohesiveness," he did not highlight this factor in his model, which emphasizes perceptual factors.

The curves in Figure 5 are positively accelerated, increasing at a faster rate over the smaller numbers of interior edges (IEs); the effect upon difficulty is greatest between 0 and 6 IEs. In this study, when the first 6 interior edges were introduced, five pieces changed from having 0 or one interior edges to having 2; when the pattern has 6 IEs, all of its pieces have at least 2 IEs. With 2 IEs, the orientation of a two-colored block is completely specified, so additional IEs should have a less powerful influence. In Experiment 3 (see Figure 4) the increase in response time between 1 and 2 interior edges was four times greater than for any other step up in interior edges; since five pieces moved through this important step between 0 and 6 IE patterns, one could have predicted that the slope of this half of the function would be steeper.

General Discussion

All four studies indicate that individuals who efficiently solve block designs predominantly use an analytic approach, since overall processing time varies inversely with the number of interior edges. When an interior edge is present, the color of the edge can be encoded immediately; however, when the block has no interior edge, it must be mentally segmented before its color can be encoded, and each segmentation requires extra processing time.

The three studies that investigated both two-colored and solid pieces found that solid pieces, like two-colored pieces, are extracted and identified using edge cues and are processed by the same analytic and synthetic processes as two-colored pieces. Solid pieces, however, are easier to identify and construct because one need not identify their orientation. The studies indicate that solid pieces are more often placed using the synthetic strategy than are two-colored pieces. Also, pieces with no interior edges are more likely to be placed with the synthetic strategy. For two-colored pieces, a filled construction space induced a synthetic approach to a lesser degree than anticipated; however, a filled construction space induced subjects to place solid pieces almost exclusively by synthesis.

Our results confirm the claims of Goldstein and Scheerer (1941), Wechsler (1958), Rapaport (1945), and Behren and Miles (1957) that there are two strategies in solving block designs and that those who efficiently solve the task follow predominantly the analytic strategy. They also confirm the findings of Royer (1977) regarding perceptual cohesiveness. Our four studies dissect the important aspects of the block-design task with a clarity not heretofore achieved. They particularly demonstrate the importance of interior-edge cues for block-design performance. They also illustrate how the analytic strategy can be used systematically to complete the mental segmenting when interior-edge cues are absent. The results provide a basis for investigating block-design performances in other clinical populations, with special attention to the use of the analytic strategy.

Pilot data (Kiernan & Schorr, Note 2) from patients with diffuse degenerative cerebral disease suggests that such patients are unable to apply the analytic strategy systematically. Studies have recently been completed (Kiernan and Schneider, Note 3) with patients having lateralized cerebral infarctions to investigate proposed qualitative differences between left-brain-damaged and right-brain-damaged groups (Warrington, 1969). Another study has been completed (Kiernan, Note 4) investigating the development of the analytic strategy in first- and second-grade children.

Finally, our results can be used to develop new test sets of block-design stimuli that are graded in difficulty in a empirically informed manner to replace currently used block-design tests that are not so derived. The number of interior edges and solid pieces would be the primary variables in composing these test stimuli, although symmetry and the type of gestalt pattern also could be taken into account. By controlling such factors and the dimensions of the designs (2 × 2 vs. 3 × 3), several sets of equivalent test items could be constructed. One such set of block-design patterns has been constructed by Kiernan, and standardization data are presently being collected with it.

We believe that the methods we have used in analyzing the block-design task can be applied to other standard tests commonly used in neuropsychological diagnosis. While analyses of the errors patients commit on these tasks can provide some useful hypotheses, only a more thorough restructuring of the tasks, together with empirical analyses, will permit the assessment of the most salient component abilities and task variables for further neuropsychological investigation. Indeed, cognitive studies with normal populations can provide the empirical basis for understanding the nature of neurologically based behavioral disability.

Reference Notes

1. Kaplan, E. Personal communication, February 1980.
2. Kiernan, R. J., & Schorr, D. *An analysis of the cognitive processes in the block design task.* Paper presented at the sixth annual meeting of the International Neuropsychology Society, Minneapolis, February 1978.
3. Kiernan, R. J., & Schneider, J. A. *The effect of lateralized brain lesions on cognitive strategies in the block design task.* Manuscript in preparation, 1982.
4. Kiernan, R. J. *The development of block design ability in first and second grade children.* Paper presented at the seventh annual meeting of the International Neuropsychology Society, New York, February 1979.

References

Behrens, B., & Miles, C. H. A test of "tendency to analyze" for use with college men. *Proceedings of the Iowa Academy of Sciences*, 1957, *64*, 108–513.

Ben-Yishay, Y., Diller, L., Mandleberg, I., Gordon, W., & Gerstman, L. J. Similarities and differences in block design performance between older normal and brain-injured persons: A task analysis. *Journal of Abnormal Psychology*, 1971, *78*, 17–25.

Diller, L., et al. Studies in cognition and rehabilitation in hemiphlegia. *Rehabilitation Monograph #50 of the Institute of Rehabilitation Medicine.* New York: New York University Medical Center, 1974.

Goldstein, K., & Scheerer, M. Abstract and concrete behavior: An experimental study with special tests. *Psychological Monographs*, 1941, *53* (2, Whole No. 239).

Kohs, S. C. *Intelligence measurement: A psychological and statistical study based upon the Block-Design Test.* New York: Macmillan, 1923.

Rapaport, D. *Diagnostic psychological testing* (Vol. 1.). Chicago: Year Book Publishers, 1945.

Royer, F. L. Information processing in the block design task. *Intelligence*, 1977, *1*, 32–50.

Royer, F. L., & Weitzel, K. E. Effect of perceptual cohesiveness on pattern recoding in the block design test. *Perception & Psychophysics*, 1977, *21*, 39–46.

Spreen, O., & Benton, A. L. Comparative studies of some psychological tests for cerebral damage. *Journal of Nervous and Mental Disease*, 1965, *110*, 323–333.

Warrington, E. K. Constructional apraxia. In P. J. Vinken & G. W. Brugn (Eds.), *Handbook of clinical neurology* (Vol. 4.). Amsterdam: North Holland Publishing Co., 1969.

Wechsler, D. *The measurement and appraisal of adult intelligence.* Baltimore, Md.: Williams & Wilkins, 1958.

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