On the relative difficulty of auditory and visual, temporal and spatial, integrative and nonintegrative sequential pattern comparisons*

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Nine tests requiring visual or auditory pattern comparison, visual-auditory intersensory integration, temporal-spatial integration, or both types of integration simultaneously were administered to 414 first-grade children. Error scores indicate that neither auditory-visual nor temporal-spatial integration is more difficult than similar comparisons not involving integration. Spatial patterns were much easier to compare by contrast to temporal patterns.

This research has to do with the relative difficulty of "integrative" vs comparable "nonintegrative" sequential pattern comparisons for young children, as measured by tasks related to one introduced by Birch & Belmont (1964). In the original Birch-Belmont task, children observed a series of pencil taps and were required to choose the equivalent one of three printed dot patterns. For example, they observed tap, tap, pause, tap, tap. They were then shown three patterns (. . . , . . . , . . .) and were asked to choose the one which was like the taps. Birch & Belmont (1964, 1965) devised this as a measure of "auditory-visual integration" (AVI) and suggested that the ability to make such comparisons is of a higher order by contrast to nonintegrative perceptual abilities. Blank & Bridger (1966, 1967) and Blank, Weider, & Bridger (1968) rejected perceptual in favor of conceptual mediation of sequential pattern comparison, but did not clearly reject the view that comparisons involving temporal-spatial integration (TSI) were more difficult.

In a research report (1971a) and in a general review paper, Goodnow (1971b) noted a variety of factors, primarily at the level of complex processes such as scanning and memory, which might explain the

assumed generally greater difficulty of integrative tasks.

Several workers have contributed contrary evidence. Muehl & Kremenak (1966) showed that for first graders, a task involving simultaneous AVI and TSI (comparing beeps to printed dots, and vice versa) was *not* more difficult, but intermediate in difficulty between auditory-temporal pattern comparison involving neither AVI nor TSI, which was hardest, and visual-spatial pattern comparison involving neither kind of integration, which was easiest. Zigmond (1966) independently reported the same result.

Research on this topic (e.g., Birch & Belmont, 1964, 1965; Kahn & Birch, 1968; Beery, 1967; and the two studies cited in the preceding paragraph) confounded auditory with temporal, and visual with spatial qualities, making it difficult to assess the separate roles of audition, vision, temporality, spatiality, AVI, and TSI. Sterritt & Rudnick (1966) and Rudnick, Sterritt, & Flax (1967) added a comparable test involving comparisons of visual-temporal stimuli (a flashing light) with visual-spatial patterns (printed dots). In the latter studies, the task requiring simultaneous AVI and TSI (comparing beeps to printed dots) proved no more difficult than the task involving only TSI (comparing flashes to printed dots).

Sterritt, Martin, & Rudnick (1971) provided a much larger range of measures, permitting unconfounded tests of the hypotheses that tasks requiring AVI alone, TSI alone, and simultaneous AVI and TSI are harder than comparable nonintegrative sequential pattern comparisons. Their results provided evidence that neither kind of integration, alone or in combination, was more difficult than comparable nonintegrative pattern comparison. Two problems in that research, however, were that the number of Ss was small, which might have biased the results in the direction

of finding no differences, even if they exist, between integrative and nonintegrative tasks and in the age of the Ss, prefirst graders, which might mean simply that integrative abilities had not yet developed.

SUBJECTS

The Ss were black and chicano first-grade children drawn from nine elementary schools in a predominantly impoverished urban neighborhood. The 270 black children ranged in age from 75 to 101 months, with a mean age of 85.02 months. The 144 chicano children had a mean age of 85.52 months, with a range of 76 to 100 months. The mean age of the total group of 414 Ss was 85.20 months. Sensory functioning of all Ss was found to be grossly intact (several potential Ss were dropped from the study because of questionable sensory functioning). Ss were tested from mid-January to early May.

PROCEDURE

Nine perceptual tests and the types and numbers of integrations involved in each test are summarized in Table 1. In each item of Test 1, the child compared a beep pattern with a printed dot pattern. First the beeps and then the printed dot pattern was presented to the child, and he responded "same" or "different." In Test 2, the dot pattern came first and the beep pattern second. Both tests required two kinds of integrations simultaneously, i.e., visual (V) to auditory (A) and temporal (T) to spatial (S), or the reverse. Tests 3 and 4 required the child to compare beep with flash visual patterns, all of which were temporal (AT to VT and VT to AT), while Tests 5 and 6 required comparison of temporally with spatially arranged patterns (flash to dot and dot to flash), all of which were visual (VT to VS and VS to VT). Tests 7-9 did not require integration, but only intrasensory comparisons (beep to beep, flash to flash, or dot to dot).

AT patterns were presented via headphones, using tones approximately 1,000 Hz at 60 dB (re audiometric zero) for the first pattern and 1,200 Hz at 60 dB for the second pattern. VT patterns were flashed by two NE 34 lamps, one lamp for the first and the other for the second pattern. Separate frequencies and separate lamps were used for the first and second patterns to make it easier for the children to know when the first pattern ended and the second began. The tone or light was on for 0.2 sec and off for 0.4 sec (short pause) or 1.0 sec (long pause). The first and second patterns were separated by a 2.8-sec pause. VS dot patterns were presented in the form of a printed line of dots, one pattern per

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Table 1
Means and Standard Deviations of Error Scores for Perceptual Tests

Test Number		1	2	3	4	5	6	7	8	9
Perceptual Comparisons		AT-VS*	VS-AT	AT-VT†	VT-AT	VT-VS	VS-VT	AT-AT	VT-VT	VS-VS
Number of Integrations		2	2	1	1	1	1	0	0	0
Kinds of Integrations		A to V & T to S	V to A & S to T	A to V	V to A	T to S	S to T			
Black N = 30	Mean	8.07	7.07	8.23	7.90	7.83	6.73	8.37	8.40	4.10
	SD	2.88	2.63	2.67	2.67	2.39	2.50	3.49	2.53	2.62
Chicano N = 16	Mean	7.56	6.44	6.75	8.62	7.50	8.44	8.56	8.75	3.19
	SD	2.30	2.78	2.00	3.22	1.64	3.09	2.53	2.30	2.69
Total N = 46	Mean	7.89	6.85	7.72	8.15	7.72	7.33	8.44	8.52	3.78
	SD	2.70	2.70	2.56	2.90	2.17	2.84	3.19	2.46	2.68

*AT = auditory-temporal (beeps); VS = visual-spatial (printed dots); †VT = visual-temporal (light flashes)

page. The dots were 2 mm in diam with 2 mm (short space) or 8 mm (long space) between dots. For Test 9 (VS to VS), the two patterns of the pair were on separate pages, with a blank page exposed for approximately ½ sec between presentations of the patterns of one pair. When a VS pattern was the first of a pair, the S generally glanced at the page and then looked up in anticipation of the second pattern. The examiner used this cue to initiate the exposure of the second pattern. When the VS pattern was second, the page was exposed after the end of the first pattern and left exposed until S responded (usually a very short time).

Every S received only one type of perceptual test. Each test was administered to 30 black and 16 chicano children. Fifteen black and 8 chicano children received one form and the other half a second form. Each form consisted of Parts A, B, C, and D.

Part A was composed of two sets of six items. Each item included 1-12 "bits" (beeps, flashes, or dots) to be counted by the child. The first set of six items was administered in the first modality (e.g., beep, beep), and the second set in the second modality (e.g., a printed pair of dots). A standard set of instructions asked the children to count and report the number of bits.

Parts A and C were intended to orient the children to the fact that they were expected to attend to the detailed characteristics of each stimulus presentation. Pilot data had indicated that young children from the neighborhood under study could not perform these kinds of tasks in the absence of the appreciably easier portions of the tests. Blank & Bridger (1967) had demonstrated that accurate counting and the concept of pauses were associated with higher scores on this type of test.

Part B included 12 items. Bits were administered first in one modality (the

same modality as in the first set of Part A) and then in the second modality (like the second set of Part A). The children were directed to compare the number of bits in the first with the second and to report "same" or "different." The number of bits to be compared ranged from one and one to six and six.

Part C included two sets of six items. As in Part A, the first set was administered in one modality, the second set in the second modality. The task in Part C, however, was to count the number of *groups* of bits. The number of groups ranged from two to four. The child was instructed to count the number of "bunches" of beeps, flashes, or dots. In Part C, as in Part A, the child counted and reported the numbers. He did not compare counts.

Part D was the most complex task and most resembled tests employed in prior investigations in this line of research. Part D included 12 items requiring *pattern* comparison. The children were instructed, in the following manner, to respond "same" or "different" to the patterns: "Now I am going to give you one bunch and then another, and I want you to tell me if the second bunch is *exactly* the same as the first. They must have the *same* number of stops and the stops must come in exactly the same places. If there is any difference in the number of stops or where the stops come, say 'different.' If there are no differences, say 'same.'" If the child appeared confused or hesitated, the instructions were elaborated. The difficulty level of the 12 items ranged from comparing three bits (e.g., . . . vs . . .) to comparing seven bits in as many as three groups (e.g., vs).

In all four parts of the test, the children were told "right" when they were correct and told "no" and "let's try the next one" when incorrect. Each child was encouraged as

necessary. The child's attention was drawn to the stimulus emitter before each item. Short rests were sometimes necessary between parts of the test.

RESULTS

Integration was required only in Parts B and D of those tests which involved auditory-visual and/or temporal-spatial integration. For this reason, all statistics reported here reflect the sum of scores earned on Parts B and D. The same type of analysis of variance was performed on B alone and on D alone, as well as the sum B + D, with essentially identical results.

The black prefirst-grade pupils studied previously (Sterritt, Martin, & Rudnick, 1971) made a mean of 9.07 errors per form, SD = 3.70. By contrast, each of the ethnic groups in the present study of first graders made fewer errors (black first-grade mean = 7.41 errors, SD = 3.02, $t = 3.88$, $df = 16$, $p < .01$; chicano first-grade mean = 7.31 errors, SD = 3.04, $t = 9.21$, $df = 16$, $p < .001$). The rank order of mean error scores on the nine tests remained essentially the same (black pre- vs black first graders, $r = +.81$, $p < .005$; black pre- vs chicano first graders, $r = +.96$, $p < .001$).

The design was a two-factor fixed-effects model analysis of variance with disproportionate cell frequencies. A general least-squares solution was performed to handle the disproportionality problem. Analysis was accomplished with the BMD 05V computer program of the UCLA Biomedical Laboratory.

In the analysis of variance, a significant main effect was found, associated with tests ($F = 13.67$, $df = 8,378$, $p < .001$). The Ethnic Group by Form interaction was significant ($F = 5.60$, $df = 1,378$, $p < .05$). That is, chicano pupils performed better on Form 1 than on Form 2, while black pupils performed better on Form 2 than on Form 1, no explanation of this is apparent, and it is doubted that

this finding would survive replication. No other main effects or interactions were significant. The 5% confidence limits were obtained for the mean error scores for each of the nine tests. In every case, the errors were significantly fewer than would have occurred if the Ss had responded randomly. Planned comparisons following analysis of variance (Hays, 1963) were made in order to test the following hypotheses.

Hypothesis 1

AVI is more difficult than auditory or visual intrasensory comparison.

In the four tests involving only temporal patterns (3, 4, 7, and 8) which provide a factorially counterbalanced test of this hypothesis, the number of errors on intersensory tests (3 and 4, $M = 7.94$ errors) did not differ ($t = 0.99$, $df = 378$, n.s.) from errors on intrasensory tests (7 and 8, $M = 8.48$ errors).

Hypothesis 2

Pattern comparison requiring TSI is more difficult than pattern comparison not involving TSI.

In the four visual stimulus tests (5, 6, 8, and 9) which provide a factorially counterbalanced test of this hypothesis, significantly more errors did occur ($t = 2.50$, $df = 378$, $p < .01$) when TSI was required (Tests 5 and 6, $M = 7.52$ errors) than when TSI was not involved (Tests 8 and 9, $M = 6.15$). Most errors, however, were made on Test 8 ($M = 8.52$ errors), a test which did not involve TSI. Thus, it is obviously the extreme ease of Test 9 ($M = 3.78$ errors) rather than the factor of TSI which explains this result.

Hypothesis 3

Perceptual comparisons requiring simultaneous AVI and TSI are more difficult than comparisons involving only one or none of these integrations.

The two tests requiring two simultaneous integrations (1 and 2, $M = 7.37$ errors) were not harder than the four tests (3, 4, 5, and 6, $M = 7.73$ errors) requiring only one integration ($t = 0.76$, $df = 378$, n.s.). The two tests requiring two simultaneous integrations (1 and 2, $M = 7.37$ errors) did not differ from the three tests involving no integrations (7, 8, and 9, $M = 6.91$ errors, $t = 0.91$, $df = 378$, n.s.). Single-integration tests (3, 4, 5, and 6, $M = 7.73$) were harder ($t = 1.95$, $df = 378$, $p < .05$) than no-integration tests (7, 8, and 9, $M = 6.91$). But this result is clearly due to the purely spatial test (9, $M = 3.78$ errors), which was significantly easier ($t = 7.00$, $df = 378$, $p < .001$) than the other no-integration tests (7 and 8, $M = 8.48$ errors). When Test 9 was omitted, the other no-integration tests did not differ from the single-integration tests ($t = 1.58$, $df = 378$, n.s.).

Hypothesis 4

Perceptual comparisons of purely spatial patterns are easier than comparisons of visual-spatial with temporal patterns, which are in turn easier than comparisons among purely temporal patterns.

Test 9, the only purely spatial test ($M = 3.78$ errors) proved much easier ($t = 5.99$, $df = 378$, $p < .001$) than the four tests which required comparison of temporal with spatial patterns (1, 2, 5, and 6, $M = 7.70$), which are in turn significantly easier ($t = 1.97$, $df = 378$, $p < .025$) by comparison to the four tests involving only temporal patterns (3, 4, 7, and 8, $M = 8.21$).

DISCUSSION

The results of this study indicate that the much emphasized factors of auditory-visual and temporal-spatial "integration" appear to be of little or no significance in determining the relative difficulty for young children of the types of tests studied here. Rather, there appears to be a simple order of difficulty, depending on whether the test is temporal, spatial, or both. Purely spatial tests are simplest, tests which involve both spatial and temporal patterns are intermediate in difficulty, and the most difficult are the purely temporal tests.

The results of the present study provide striking confirmation of the results of tests of the same hypotheses by Sterritt, Martin, & Rudnick (1971). Moreover, the present study demonstrates the generality of conclusions across two ages (prefirst grade and first grade) and two ethnic groups (black and chicano).

The present results amply confirm the suggestion made earlier by Blank & Bridger (1967) and Goodnow (1971a) that temporal pattern comparison is much more difficult than comparison of spatial patterns. Goodnow (1971b) and Blank & Bridger (1967) implied, however, that the conceptual task would often be harder when temporal-spatial integration was involved. In contrast to that view, the present results demonstrate that in the type of task studied here, temporal-spatial integration is significantly easier than pure temporal pattern comparison.

The training portions were employed in the present study because prior data indicated that most Ss probably could not cope with the D task at all unless the kinds of orientation provided by Parts A, B, and C were given first. Thus, at least for the types of tasks considered here, some facilitation of mediational activities may be necessary if performance above chance levels is to occur. The abilities under consideration, whether integrational or nonintegrational, may appear earlier

and more reliably when "conceptual" supports are available for "perceptual" judgments. This obviously is the case with regard to reading, the socially significant achievement to which all of this work is oriented.

Thus, in the only studies in which any conclusions are possible about the relative difficulty of auditory-visual and temporal-spatial integration vs similar nonintegrative judgments (Muehl & Kremenak, 1966; Sterritt, Martin, & Rudnick, 1971; Zigmond, 1966; and this report), all of the evidence suggests that auditory-visual and temporal-spatial integrations are not higher-order abilities. Rather, it appears that if the child can make such pattern comparisons at all, he can make them just as successfully when integrations are definitely required as when they are clearly not involved.

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