Crossmodal matching capabilities of pre-school children

Nancy Ruth Pettus

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CROSSMODAL MATCHING CAPABILITIES
OF PRESCHOOL CHILDREN

A Thesis
Presented to the
Faculty of
California State College
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
in
Psychology

by
Nancy Ruth Pettus
April 1977
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ABSTRACT

Twenty preschool aged subjects were tested on crossmodal and intramodal matching of shapes in the visual and tactual modalities. Earlier studies had reported poor performance by young subjects and proposed a developmental trend in crossmodal abilities. Confusing task requirements and poor experimental controls were found in those studies. A puppet show format was utilized for trials under both simultaneous and successive matching procedures. Visual-visual, visual-tactual, tactual-visual, and tactual-tactual modality combinations were used. Subjects performed the tasks with familiar or unfamiliar objects. All subjects easily performed the matching tasks although more errors were made in successive matching trials. The tactual-tactual tasks produced the most errors and visual-visual tasks the least.
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ACKNOWLEDGEMENTS

I wish to express my thanks to my committee for their help and patience with my frustrations, especially Dr. Charles Hoffman.

To my family and friends for their moral support and time, I now express my appreciation.
INTRODUCTION

Studies on human perception and the development of perceptual skills have recently focused on the ability to combine and organize information which comes through different sensory modalities (e.g., visual, tactual). Various matching tasks have been given to different aged groups in an effort to discover when this ability is first present and factors which affect it.

Crossmodal matching tasks, which have included both abstract and familiar stimulus objects, have been successfully performed by children over five years of age (Balter and Fogarty, 1971; Milner and Bryant, 1968). Younger children have had considerable difficulty with the experimental task (Rudel and Teuber, 1964; Schneiderman, 1971), although the precise reasons for their failures have not been determined. There appears to be an increased ability to perform these matching tasks as children age; however, several alternative explanations might be offered.

Bryant's (1968) critique of the early sensory integration studies focused on their lack of necessary experimental controls. His concern was the failure on the part of Birch and Lefford (1963) in particular to show that the observed developmental trend was not due to improvement.
within a single modality by inclusion of similar matching trials involving only one modality at a time. This weakness was specifically addressed in later studies by Milner and Bryant (1968); Balter and Fogarty (1971); Rose, Blank and Bridger (1972); and Jackson (1973). Those studies included matching tasks within the single modalities (e.g., visual and/or tactual) similar to those tasks involving the two modalities and, therefore, provided performance level data on each sensory modality involved. Resultant data revealed that visual-visual tasks were performed most easily by all subjects, while in all conditions involving the tactual modality, performance declined.

Similar general findings are reported in other studies also, but a clear picture of crossmodal matching in children was not provided. Specific weaknesses in design were evident which preclude an understanding of perceptual integration. Despite inconsistencies in method of stimulus presentation (simultaneous and successive), the Rudel and Teuber (1964) study showed simultaneous trials to be easier, but many tasks were beyond the capabilities of the three and four year old subjects. Both the DeLeon, Raskin and Gruen (1970) and Cronin (1975) studies failed to include all four modality combinations in their trials, such as visual-visual (VV), visual-tactual (VT), tactual-visual (TV), and tactual-tactual (TT). Also, the order of trial items was not randomized; therefore, practice effects might
have affected results. Considerable difficulty was noticed with tactual tasks. Task requirements in the Schneiderman (1971) study were so complex and confusing that subjects performed the matching tasks in response to gross similarities (e.g., color) rather than to details as the trial demanded. Crossmodal matching results were not above chance levels.

Other studies on the development of crossmodal capabilities in children thus far have provided unclear and conflicting data. Birch and Lefford (1963) found no further improvement in crossmodal abilities after eight years of age, although Jackson (1973) noted a continuing improvement in crossmodal performance in ten year old subjects. Milner and Bryant (1968) found developmental crossmodal improvement in 5, 6, and 7 year old subjects, but this was not greater than gains noted within the single modalities involved. These apparent contradictions appear to reflect interpretation of data and methodological differences instead of gross inconsistencies in subject performance. Only Milner and Bryant (1968) included all modality conditions and compared between-modal performance to within-modal performance. Jackson (1973) related his trend to the inability of young subjects to process information in the tactual mode.

No trend was found at all by Schneiderman (1971), who proposed that transfer across modalities does not occur
until the child has developed representative schemas. Rudel and Teuber (1964), who also failed to get crossmodal transfer with three and four year old subjects, cited inability to understand task requirements as the major factor determining outcome. Both the Schneiderman (1971) and Rudel and Teuber (1964) matching tasks were so confusing to subjects that they did not comply with trial requirements. Responses were often not related to the task at hand. Only in the Rudel and Teuber (1964) study was task difficulty related to the poor performance.

Similar performance on crossmodal and tactual intra-modal tasks led Balter and Fogarty (1971) to speculate whether processing of tactual information rather than inter-modal integration is the source of the trend. Fewer errors were obtained on crossmodal tasks than on tactual intra-sensory matching with five to eleven year olds in several studies (Birch and Lefford, 1963; DeLeon, Raskin and Gruen, 1970) which tends to support this interpretation.

The nature of the developmental trend in crossmodal matching is not yet resolved or understood. Criticisms of earlier research have focused on methodological problems and different interpretations. It can be argued that preschoolers did not understand the task instructions even though they were clear to older children, which resulted in an apparent, but false, trend in perceptual abilities. Additionally, it seems possible that a trend might be
apparent within a particular modality or for crossmodal tasks involving that modality, but not for other modalities. The present research was designed to explore crossmodal behavior in preschool subjects. An attempt was made to address the methodological issues and question of a modality specific effect. A simple testing situation was designed to avoid lack of understanding by the young subjects. The format was structured to attract the subjects' attention and to encourage their active interest and participation. All within and between modality conditions (VV, VT, TV, TT) were incorporated into the study to provide a comparison between recognition across and within modalities. The present study was designed to determine crossmodal capabilities of preschool children, the effects of simultaneous and successive presentation methods and the differences in performance between modalities.

With an experimental procedure designed for easy understanding by subjects, it was felt that preschool children could perform matching tasks both within and between the visual and tactual modalities. Two presentation procedures were used to address the issue of acquisition and storage of information, particularly for the tactual modality (Rose, Blank and Bridger, 1972). If information storage, required in successive presentation, rather than acquisition is the problem, there should be fewer errors in simultaneous than in successive matching. If performance inequalities are
inherent within a particular modality or the comparison process, then both conditions should produce equal errors; within-modal data will provide information for this comparison. Whether familiarity of stimulus objects benefits matching (both within and between) will be determined by comparison of data from the two stimulus sets (groups of subjects) and also within the two presentation methods.
METHOD

Subjects

Children who participated in the study attended preschools in San Bernardino, California. One of the schools was located in an older section of town and children attending were from lower middle and lower class white and Mexican-American families. The other school was located in a newer, middle class neighborhood and was attended primarily by white children.

Permission slips and information sheets were sent home with each child in both preschools requesting name, sex, birthdate, general health and birth order information. Although few forms were completed and returned, teachers at both schools did secure permission and supplied birthdates for approximately seventeen children at each preschool. From those, ten children were randomly selected at each location, for a total of twenty subjects (ten boys and ten girls) ranging in age from 2-2 to 5-5 ($M = 4.3$).

Design

Subjects were randomly assigned to two groups, with an equal number of boys and girls in each group. Group One was presented with three familiar geometric forms and Group Two performed the tasks with three unfamiliar forms. Both
sets of stimulus forms are presented in Figure 1. Availability of a verbal label was felt to add a memory demand (Milner and Bryant, 1968), therefore, two sets of stimuli were used. Within subjects variables were manner of presentation (i.e., simultaneous and successive), to maintain consistency of presentation (Rudel and Teuber, 1964), and the four modality combinations (VV, VT, TV, TT). Each of the three stimulus objects was presented under both tactile and visual modality conditions and under both simultaneous and successive presentation methods for a total of twenty-four trials. Presentation method was counterbalanced across groups while order of modality combination and target stimulus were randomized to control for serial and practice effects.

**Apparatus**

The procedure involved a puppet show presentation using a simple puppet stage approximately 61 by 68 by 20 centimeters. The background stage scenery consisted of three doors. The solid lower section of the stage apparatus had a centered hole large enough for the subjects' hands. This hole was curtained to prevent visual inspection of the forms inside for tactual presentation.

Other materials consisted of a hand puppet, a cloth bag and the stimulus forms as shown in Figure 1. The forms were made of masonite and were approximately two inches in
Figure 1. Stimulus forms.
size to permit maximum tactual exploration and manipulation as suggested by Milner and Bryant (1968). Size was suggested to affect completeness of tactual exploration, particularly with very young subjects.

Procedure

The apparatus was set up on a low table in a side room in each preschool. Subjects were seated on a rug placed in front of the stage. Teachers at both schools had told the children that some of them would be helping with a puppet show, so they were expecting to be involved. Each subject was brought into the room, introduced to the puppet and instructed to sit on the rug. Two experimenters were present: one seated beside the stage to manipulate the puppet and tell the story, the other seated behind the stage to record errors and to arrange matching stimulus forms above the doors and in the compartment below the stage.

Several minutes were spent with each child prior to testing during which time interaction with the puppet was encouraged. Experimental tasks were demonstrated and the subject given several trial matching tasks using figures not used in the actual experiment or puppet show with that subject. The story involved the puppet's search for his father's fortune and jewels which had been stolen by a sly old fox. The stimulus objects were clues which guided the puppet into the fox's home to find the treasure.
During the VV matching portion of the study, the puppet showed the subject a shape, the curtain on the puppet stage was raised, and the subject was directed to select a matching shape from those located over the three doors. VT matching also involved the puppet showing the subject the shape. For the matching selection, however, the subject then was directed to put his hand into the hole under the puppet stage, feel all three shapes and select the matching shape.

For those tasks requiring initial tactual contact, the subject was required to put his hand into a cloth bag held by the puppet which contained the target shape. TV matching then required the subject to select a matching shape from those displayed above the doors on the stage. In TT tasks, subjects matched the shape in the cloth bag with a shape selected by feel from the compartment below the stage. The puppet directed the subject's actions during each trial as part of the treasure hunt search. Periodically throughout the testing, a prize (e.g., ring, marble, bracelet) was found when the puppet opened the stage doors during a visual matching task as the visual portions of the matching task allowed the matching stimulus objects to be directly related to the doors on the stage behind which the prizes were hidden.

Simultaneous presentation involved continuous exposure of the initial stimulus shape during the matching. In the
tactual-tactual portion of the experiment, the subject was required to use both hands. Successive presentation required subjects to look at or feel the target shape, which was then removed before presentation of the matching shapes from which he must choose the appropriate match. Under both methods the initial stimulus was presented for five seconds before presentation of the matching shapes. In keeping with the literature (Millar, 1971; Baltar and Fogarty, 1970), subjects were given a maximum of twenty seconds to select a matching shape. The second experimenter noted errors and prepared for the next trial.

Three different shapes were utilized in the tests and each shape was the target shape under each of the two presentation methods and in each of the four modality conditions. At the end of the session the puppet had "successfully completed his treasure hunt" with the help of the subject and the subject had several pieces of "treasure" for himself. The puppet then carried on a short dialogue with the child during which time he was thanked for his help in bringing about a successful treasure hunt and was sent off with his part of the treasure.
RESULTS

The results of the study were analyzed in a three way analysis of variance. As shown in Table 1, the two significant findings in this experiment concerned presentation method and modality combination. Simultaneous presentation of stimuli produced significantly fewer errors than did successive presentation, $F(1, 18) = 5.793, p < .05$. The differences in errors scored in the various modalities were also significant, $F(11, 198) = 6.276, p < .001$. No other effects were significant in this analysis.

Table 2 presents the errors scored in each condition in the study. The fewest number of errors was made on VV tasks; the 13 total errors accounted for only 11 percent of the total errors. Each of the intermodal (VT, TV) conditions had 25 percent of the errors scored on the experimental tasks. Tactual-tactual trials produced 44 (39 percent) errors. These results were further analyzed by Duncan's Multiple Range Test. Comparisons of the VV errors to those of the TT, VT, and TV errors were significant in each of the modality combinations. The TV findings differed significantly from those of the TT condition, but were not significant when compared to the VT results. The final comparison between VT and TT findings revealed a significant difference. As can be seen in Table 2, the
Table 1

Analysis of Variance for Total Errors

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>ms</th>
<th>F</th>
<th>p</th>
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<tbody>
<tr>
<td>Total</td>
<td>186.925</td>
<td>479</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stimuli</td>
<td>0.3</td>
<td>1</td>
<td>0.3</td>
<td>0.392</td>
<td>ns</td>
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<tr>
<td>Error(_b)</td>
<td>13.792</td>
<td>18</td>
<td>0.766</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Within subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td>1.008</td>
<td>1</td>
<td>1.008</td>
<td>5.793</td>
<td>.05</td>
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<td>Modality</td>
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<td>0.364</td>
<td>6.276</td>
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<td>0.034</td>
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<tr>
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<td>Stimuli (x)</td>
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<td></td>
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<tr>
<td>Method (x)</td>
<td>1.005</td>
<td>11</td>
<td>0.091</td>
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<td>Error(_1)</td>
<td>3.124</td>
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<td>0.174</td>
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<td>Error(_2)</td>
<td>11.542</td>
<td>198</td>
<td>0.058</td>
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<tr>
<td>Error(_3)</td>
<td>104.895</td>
<td>198</td>
<td>0.530</td>
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Table 2
Total Errors Scored by Experimental Groups

<table>
<thead>
<tr>
<th>Familiar Stimuli</th>
<th>Unfamiliar Stimuli</th>
<th>Total</th>
<th>Percent Of Total</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Modality</td>
<td>Simultaneous</td>
<td>Successive</td>
</tr>
<tr>
<td>VV</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>VT</td>
<td>5</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>TV</td>
<td>9</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>TT</td>
<td>10</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>36</td>
<td>63</td>
</tr>
</tbody>
</table>

Total Simultaneous: 46  Total Successive: 68

Note. Maximum total errors = 480
largest difference in error rate was between the YY task and the TT task. Intermodal experimental tasks appeared to be of almost equal difficulty. Both intermodal tasks were more difficult than YY tasks and less difficult than TT tasks for the subjects.
DISCUSSION

In this study, preschool subjects easily performed matching tasks within and between the visual and tactual modalities, unlike earlier studies (Rudel and Teuber, 1964; Schneiderman, 1971), which failed to get performance above chance levels. It follows from these results that the experimental situation and task requirements are particularly important factors for young children. Developmental trends based upon situations beyond the cognitive abilities of subjects are trends only of cognitive understanding rather than perceptual abilities. Experiments, therefore, need to be designed to measure what they purport to measure and conclusions drawn accordingly.

Data in the present study was similar to that of earlier studies utilizing older subjects. Matching tasks involving only the visual modality resulted in the fewest errors while tactual trials produced the most errors (DeLeon, Raskin and Gruen, 1970; Jackson, 1973); crossmodal performance was superior to tactual performance. This data extends demonstration of crossmodal perceptual abilities downward to include preschool subjects. It also suggests inequalities between visual and tactual modalities affect, but does not preclude integration of perceptual information from different sensory organs.
Inclusion of controls for the various methodological procedures more clearly established the results as reliable evidence of crossmodal capabilities and differences in performance between the visual and tactual modalities. Familiarity of stimulus objects did not affect results although imposition of a memory demand did as found by Rose, Blank and Bridger (1972). The results of this study showed that performance on matching tasks declines when the inherent delay is imposed under successive presentation conditions. It appears that storage requirements rather than the actual acquisition of information is the more critical factor affecting performance. Both the Birch and Lefford (1963) and Rudel and Teuber (1964) studies used simultaneous and successive matching procedures, but neither controlled for nor investigated the effects upon task performance. In each of the modality combinations (VV, VT, TV, TT), more errors were made in trials with successive matching. Inaccurate interpretations of data were, therefore, made in those earlier studies which did not use consistent methodology or discriminate between presentation methodologies when analyzing data.

While this study does not preclude the existence of a developmental trend in crossmodal perception, it does demonstrate that performance by preschool subjects produces results similar to those involving older subjects. Methodological problems were inherent in earlier studies (Birch
and Lefford, 1963; Rudel and Teuber, 1964; Schneiderman, 1971; Cronin, 1973), which led to unclear data and erroneous conclusions. Inequalities in the tactual modality, which remained constant regardless of presentation method or stimulus object suggest that much of the early work merely failed to identify the actual factors involved.

Further experimental investigations are necessary to explore crossmodal capabilities in even younger children to see if there is a developmental progression in integration skills. Techniques and task demands, however, must be in accordance with both cognitive and performance capabilities of the subjects.
References


Bryant, P. E. Comments on the design of developmental studies of cross-modal matching and cross-modal transfer. *Cortex*, 1968, 4, 127-137.


