ASYMMETRIC EFFECTS IN CROSS-MODAL TRANSFER

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Transfer from visual to tactual presentation and in the reverse order was investigated in two experiments designed as paired associate learning. Two sets of three-dimensional nonsense objects differing in form were used as stimuli. The two experiments give conclusive evidence for higher transfer from tactual to visual presentation than from visual to tactual, thus indicating asymmetry between the two modalities. In the discussion of this effect a verbal mediation hypothesis is suggested.

In a previous paper cross-modal transfer was investigated as a function of distinctiveness and preparatory set (Björkman, Garvill & Molander, 1965). Seven solid ceramic "nonsense" objects were used as stimuli. They varied in weight, form, surface structure and colour. (Another set of stimuli but similar in form can be seen in Fig. 1.) The stimuli can be described as consisting of specific tactual aspects (weight), specific visual aspects (colour) and aspects common to the visual and tactual modalities (form and surface structure). Distinctiveness was manipulated by varying the colour of the objects and preparatory set by varying the instruction.

The experimental results showed that a variation in cross-modal transfer can be predicted from a variation in preparatory set and distinctiveness. Transfer increases when the subjects are set to attend to common aspects, and transfer decreases when distinctiveness in a modality-specific aspect is increased. It was also found that an instruction, which directs the subjects to common aspects, to a considerable degree can compensate high distinctiveness in the modality-specific aspect.
In two of the experiments tactual-visual order gave a somewhat higher transfer than the visual-tactual order, and this effect was found to be the same at two different learning levels (.70 and 1.00). Asymmetric effects in this direction have earlier been reported by Rudel & Teuber (1963) in their experiments with the Miller-Lyer illusion and by Gaydos (1956) in a form discrimination experiment.

In discussing the results, Björkman et al. suggested that the subjects beginning with tactual learning were forced to attend to common aspects to a higher degree than subjects beginning with visual learning. It might be that the specific tactual aspect was too difficult to discriminate compared with the specific visual aspect. According to this explanation, the asymmetric effect should vanish or be reduced if this difference between the two conditions is eliminated.

In the two experiments reported below, variation in weight, colour and surface structure is eliminated. The subjects have to utilize variation in the common aspect of form in order to learn and to transfer between the two modalities. If the above reason for asymmetric effects is valid, transfer between the two modalities should be independent of modality order.

Experiment I

Stimuli and responses. Stimuli used in this experiment are in form similar to the stimuli used by Björkman et al., but not varying in weight, colour and surface structure (Fig. 1). To each of the seven objects a number between 1 och 7 was randomly assigned. By a paired associate procedure the subject had to learn to predict the number assigned when confronted with each object. Two different random assignment of numbers to objects were used and also two random orders of presentation.
Apparatus. During the experiment the subject is seated in front of a screen. When an object is presented tactually the subject puts his hands under the screen and can then manipulate the object without seeing it. During the visual exposures the objects are placed on a rotating disc behind the screen and at the same level as the upper edge of the screen (eye-level). The rate of rotation is two turns during one exposure. At the end of each exposure, which lasts for 10 seconds, the assigned number is presented by means of a tape-recorder.

Subjects. 24 students of psychology were randomly divided into two equal groups, one tactual-visual group (T-V) and one visual-tactual group (V-T).

Preliminary experiment. In order to prevent confounding at the measurement of transfer it is advantageous to hold the two groups at the same level of learning before shifting of the modality. It is also advantageous if this level is below the asymptote of the learning curve. If there are differences in difficulty between learning the objects visually and tactually, there is no technique for measuring the "true" associative strength of an item which has been carried beyond asymptote (Underwood, 1964). By preliminary experiment it was found that a response frequency of about 80 per cent was reached after 8 trials of visual training and after 15 trials of tactual training.

Procedure and instructions. Group T-V started with tactual training. The following instruction was read while the subject could follow the text in his own copy of the instruction: This is a learning experiment where your task is to connect a number of three-dimensional objects with as many numbers. Each object has only one number. There are 7 objects and accordingly you shall use the numbers 1 to 7. The experiment runs as follows. Put your hands under the screen in front of you. Let your arms rest on the table. You are allowed 10 seconds to touch and manipulate with each figure. At the end of this interval you will be told the number of the object by a tape-
This object is a specimen which is not used in the experiment. (Demonstration). During the first presentation of each object you have to guess the number as rapidly as possible. During the next and all the following exposures, however, you must attempt to respond with the number that belongs to the object. If you cannot give the number, guess. Be careful to speak clearly. At the end of each exposure you will hear the correct number from the tape-recorder. Any questions?

After 15 trials of tactual training the apparatus was changed for visual presentation and the following instruction was read: We shall now continue as before except that you will see the objects instead of touching them. The objects and their assigned numbers are the same as before. Just as before you have to tell, as soon as you can, the number of the object exposed. If you don't know the number, guess. Any questions?

Group V-T started with visual training and was given the same instructions as Group T-V except that all passages referring to tactual training were changed to fit the visual conditions. After the shift of modality, training goes on for two trials. The exposure times were 10 seconds for both the visual and tactual training. Between exposures there was a pause of 5 seconds. Instruction and change of the apparatus between tactual and visual training took about 1 minute.

Results. Transfer was computed according to the ratio \( C/A = (p_1 - p_1) / (p_k - p_1) \) where \( p_1 \) is response probability at the very first trial, \( p_k \) the response probability at the last trial before change of modality and \( p_1 \) the response probability at the first trial after change of modality (Fig. 2). This ratio is to some extent an overestimation of transfer since \( p_k \) and \( p_1 \) are response probabilities at two consecutive trials. Reasons for the choice of this measure of transfer are discussed in detail in Björkman et al. (op.cit. pp. 4-6). The arithmetic means of \( p_1 \), \( p_k \), \( p_1 \) and transfer values for the two groups are given in Table 1.
Figure 1. Stimulus objects used in experiment 1 (the upper picture) and in experiment 2 (the lower picture).

Figure 2. Learning curves illustrating cross-modal transfer. A: visual performance during visual training. B: tactual performance during tactual training. C: tactual performance during visual training.
Table 1. Learning parameters in Exp. I

<table>
<thead>
<tr>
<th></th>
<th>$P_1$</th>
<th>$P_x$</th>
<th>$P_1$</th>
<th>C/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>T - V</td>
<td>.20</td>
<td>.76</td>
<td>.70</td>
<td>.89 (.92)</td>
</tr>
<tr>
<td>V - T</td>
<td>.29</td>
<td>.83</td>
<td>.62</td>
<td>.61 (.64)</td>
</tr>
</tbody>
</table>

Numbers in parentheses are medians of individual transfer values.

From Table 1 it can be seen that the tactual-visual order gives higher transfer than the visual-tactual order. This difference is significant ($p < .05$) as when tested with the Mann-Whitney U-test\(^1\). It should be noticed that this difference is an underestimation to a certain degree. The "real" $P_y$ value at the first trial after the change of modality will be relatively higher for the V-T group than for the T-V group. This is due to the fact that the visual learning is faster than the tactual learning when the learning rates before the change of modality are compared. The results in this experiment indicates that asymmetric effects of transfer between the tactual and visual modality remain, even if the modality-specific aspects (weight and colour) are eliminated.

Experiment II

In order to increase the possibility to generalize the asymmetric effects obtained in Exp. I, another experiment was performed. The same design was used but the stimuli were different in form (Fig. ).

As in Exp. I seven ceramic objects were used. All the objects had the same weight and they were all painted white. Consequently stimuli varied in form only.

1) The Mann-Whitney U-test has been used in these experiments since the distribution of individual transfer values appeared somewhat skewed.
Subjects. 24 students of psychology were randomly divided into two equal groups, one tactual-visual group (T-V) and one visual-tactual group (V-T).

Preliminary experiment. In accordance with the procedure in Exp. I the training was interrupted before the learning level reached the asymptote. By preliminary experiment it was found that a response frequency of about 70 per cent was reached after 18 trials of tactual training and after 10 trials of visual training.

Procedure and instructions. The same as in Exp. I. Group T-V started with 18 trials of tactual training whereafter training continued visually for two trials. Group V-T started with 10 trials of visual training whereafter training continued tactually for two trials.

Results. The treatment of data is the same as in Exp. I. Values of $P_1$, $P_k$, $P'$ and the transfer values are given in Table 2.

Table 2. Learning parameters in Exp. II

<table>
<thead>
<tr>
<th></th>
<th>$P_1$</th>
<th>$P_k$</th>
<th>$P'$</th>
<th>C/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-V</td>
<td>.13</td>
<td>.65</td>
<td>.52</td>
<td>.75 (.75)</td>
</tr>
<tr>
<td>V-T</td>
<td>.23</td>
<td>.77</td>
<td>.52</td>
<td>.54 (.60)</td>
</tr>
</tbody>
</table>

Numbers in parentheses are medians of individual transfer values.

As can be seen from Table 2 a clear asymmetry is appearing again. The difference between C/A-values for tactual-visual order and visual-tactual order is significant at the 5 per cent level (Mann-Whitney U-test). The two values of $p_k$ are not quite alike but the "real" values of $p_k$ at the first trial after the shift of modality should lead to a greater difference in transfer between the groups as was pointed out in the discussion of Exp. I.
Summary and discussion. In Table 3 results from the experiments by Björkman et al. are given in the columns 1-2. Column 3 gives values obtained from a replication of the experiment in column 1 (previously unpublished data). The columns 4-5 contain results from the experiments presented in this report.

Table 3. Transfer values obtained in some previous experiments compared to those obtained in Exp. I-II (column 4 and 5)

<table>
<thead>
<tr>
<th>T - V</th>
<th>.60 (.75)</th>
<th>.72 (.64)</th>
<th>.66 (.75)</th>
<th>.89 (.92)</th>
<th>.75 (.75)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V - T</td>
<td>.42 (.55)</td>
<td>.40 (.50)</td>
<td>.44 (.50)</td>
<td>.61 (.64)</td>
<td>.54 (.60)</td>
</tr>
<tr>
<td>column</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Numbers in parentheses are medians of individual transfer values.

In the experiment reported in the first three columns stimuli were complex "nonsense" ceramic objects varying in weight, form, surface structure and colour. These stimuli can be described as consisting of specific tactual aspects (weight) specific visual aspects (grayness) and aspects common to the tactual and visual modality (form and surface structure).

In the columns 4-5 results are given based on stimuli where surface structure and the modality-specific aspects have been made equivalent for all the stimuli. Accordingly stimuli varied only in the common aspect form.

In all the experiments a higher transfer has been obtained in the tactual-visual condition as compared to the visual-tactual condition. Results pointing in this direction have earlier been reported by Rudel & Teuber (1963) and Gaydos (1958). Asymmetry in transfer between the visual and auditory modalities has been reported by Asher (1964)
who found higher transfer in the visual-auditive order as compared to the auditive-visual order. Walk (1965) however, found no difference in transfer in a comparison of visual and tactual learning of forms.

In spite of the two facts, (a) occurrence of transfer between different modalities, (b) asymmetry between modalities, no investigator has yet succeeded in explaining these phenomena satisfactorily. Usually they are referred to some kind of central processes. Asher for instance says that "..... the central mediation hypotheses suggests that the direction and amount of transfer is a function of data processing not at the sensory receptor level, but at some centralized location in the brain" (1964, op. cit. p. 255). Some authors (Gaydos 1956, Houck et al. 1965) have suggested verbal mediation as a plausible explanation of cross-modal transfer. This is an attractive suggestion because it seems to be in agreement with experiments on school-children where it has been found that improvement in cross-modal judgements is a function of increasing age (Birch & Lefford, 1963) and also because asymmetric effects could be explained.

Verbal associations formed during tactual and visual learning consist partly of associations emerged from modality-specific aspects and partly of associations emerged from common aspects (e.g. associations to form). It is often emphasized that the visual system has a higher information pickup capacity and gives a more accurate perception compared to other sensory systems (Rock and Harris, 1967). It is also found that the visual system is well developed very early after birth (Gibson and Walk, 1960). Facts such as these make it highly probable that man has more experience of the "visual world" than the "tactual world".

It then seems reasonable to assume that there are more associations or verbal labels for the visual modality than for the tactual modality. The ratio of common associations to tactual associations will then become larger than the ratio of common associations to visual
associations. If cross-modal transfer takes place via verbal mediation the probability of an association emerging from common aspects is larger after tactual learning than after visual learning.

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References


