The Effect of Presentation Modality on Text Memory as a Function of Difficulty Level

Machiko SANNOMIYA

Osaka University

The effect of presentation modality on text memory was investigated by manipulating the difficulty level of text content. An easy and a difficult texts, which were almost equal in length, were presented in one of three modalities (auditory, visual, and audiovisual) and remembered. Free recall was used and recall protocols were scored for 20 idea units. The results showed a modality effect, that is, the superiority of auditory over visual and audiovisual presentation in recall performance. Auditory superiority, however, was found for the difficult text only, and was not restricted to the recency part. These results cannot be explained by the precategorical store hypothesis which is a widespread interpretation of the modality effect on word-list memory. Instead, one possibility was suggested in terms of capacity shortage owing to the translation of printed letters into an auditory form which impaires the processing of the difficult text.

Key words: the modality effect, presentation modality, text memory, difficulty level, text content, capacity shortage, translation.

The effect of presentation modality on memory for semantically unrelated verbal materials has been reviewed by Penny (1975). The modality effect, which was obtained with lists of words, nonsense-syllables, letters, and digits, denotes the superiority of auditory over visual presentation as measured by recall or recognition methods. The main characteristics of the modality effect were the following: (1) The effect is restricted to the recency part of a list. (2) Adding auditory presentation or subjects’ vocalization to visual presentation results in a performance equal to that obtained with auditory presentation. (3) The effect is stronger when presentation rate is high.

Since text processing includes processing of words, we can expect some influence of presentaion modality on text memory as well. It is doubtful, however, whether the effect is the same as that for word-list memory, because additional factors are most probably involved in text memory. Kintsch et al. (1975) compared text comprehension and memory after listening and reading. They reported the absence of modality difference. But these results cannot be generalized because the texts used were relatively easy, and the authors themselves noted that the equivalent performance under both modalities might not hold for more difficult texts. Moreover, they permitted subjects of the reading group to return to earlier parts of the text and to make arbitrary time allotment to different parts of the text within a limited overall time. Subjects of the listening group did not share these advantages. They could neither return to earlier parts nor stop the presentation at some particular points in order to reflect upon difficult description. It is true that a perfect equivalence of auditory and visual presentation cannot be obtained, but it is possible, at least, to diminish the un equivalence to a large extent.

The above considerations suggest the need for an investigation of the modality effect on memory for difficult texts under more equivalent conditions. Therefore, in the present

---

1) This research forms part of a master thesis of the author which was submitted to Osaka University. The author is grateful to Professor Ono for his helpful comments on an earlier version of this paper.
experiment, the modality effect on text memory was examined for two levels of difficulty in comprehension. Other factors which were known to influence text memory were held constant, that is, number of words, number of noun concepts, and judged interest level. Audiovisual presentation was examined in addition to auditory and visual presentation in order to find out whether the superiority of audiovisual over visual presentation holds for text memory as well.

Method

Subjects
Sixty undergraduate students at Osaka University and Konan University served as subjects. They were randomly assigned to six conditions. The ratio between male and female was made equal in all conditions.

Design
A 3 × 2 between-subject design was used. There were three types of presentation modality (auditory, visual, and audiovisual). And there were two types of difficulty level of comprehension (easy and difficult).

Materials
First of all, three easy and three difficult texts were selected by the author and rated by ten judges on five-point scales for difficulty of comprehension and interest level. The judges were post-graduates and undergraduates of psychology at Osaka University. Of the above six texts, two texts were selected for the experiment. They were rated as of approximately equal interest (Mean value and SD were 1.9; .70 for the easy text and 2.0; .63 for the difficult text; t(18) = .45) but different difficulty (Mean value and SD were 2.3; .46 for the easy text and 4.5; .50 for the difficult text: t(18) = 13.74, p < .01). Both texts, divided into idea units, are shown in the appendix. Each text consisted of 110 Japanese words (Bunsetsu). The number of noun concepts was 31 in the easy text and 30 in the difficult text.

Procedure
Subjects were instructed to try to comprehend and remember the presented text so as to be able to recall it after three times of presentation and to reproduce it using the original expressions if possible. For auditory presentation the text was recorded by the taperecorder with female voice. Presentation rate was about 5 letters/sec in terms of Kana letters. Care was taken to read the material monotonously without strong intonations and pauses which could serve as remembering cues. In visual presentation, subjects were permitted to read the material, printed on a sheet of paper, at their habitual pace, satisfying the following two restrictions: (1) They should not return to earlier parts of the text. (2) They should read at a constant pace without stops and pauses for thinking. These restrictions were imposed in order to equalize the number of presentations in the visual and auditory conditions. In audiovisual presentation, subjects listened to the taped material in the same way as in auditory presentation, and read the corresponding Japanese characters simultaneously from a sheet of paper, which was the same as that used for visual presentation. Asynchronous reading was not permitted. Overt vocalization was not permitted for all conditions. The presentation of a text was repeated three times, because in a preliminary experiment once or twice of presentation was reported to be quite insufficient for comprehension of the difficult text.

Immediate recall was required and recall protocols were written on a blank sheet of paper without time limit.

Results

In the case of visual presentation which was self-paced, the average presentation rate (reading rate) was 5.20 letters/sec in the easy text, and was 5.23 letters/sec in the difficult text. They hardly differed from that of auditory and audiovisual presentation rate, 5 letters/sec (t(9) = .81; t(9) = .92).

Recall protocols were scored for the presence of the 20 idea units of the respective texts. Scoring was based on the discussion of two

2) Japanese texts include not only Kana letters (i.e. the phonogram which corresponds to one syllable) but also Chinese letters (i.e. the ideogram which does not have fixed relationship to syllables). When calculating presentation rate, Chinese letters were converted into Kana letters. Therefore 5 letters/sec is equivalent to 5 syllables/sec.
judges including the author. They scored one point if the gist of an idea unit was reproduced. Table 1 shows the average number of idea units correctly recalled in each group. A $3 \times 2$ (modality by difficulty) analysis of variance yielded significant main effects for modality ($F(2, 54) = 3.40, p < .05$) and difficulty ($F(1, 54) = 24.49, p < .01$). Above all, the interaction was significant ($F(2, 54) = 4.28, p < .05$). Multiple comparison was performed for the number of correct recall after three modalities by using Sheffe’s method. There was no significant difference among them in the easy text, whereas it was greater after auditory than visual and audiovisual presentation in the difficult text ($p < .01$). And comparing two difficulty levels, there was no significant difference in recall after auditory presentation, whereas the easy text was better recalled than the difficult one after visual and audiovisual presentation ($p < .01$).

In previous researches, modality differences have been reported to be specific to the recency items in the memory for semantically unrelated materials (Penny, 1975). Therefore it seems to be meaningful to examine the relationship between the modality effect and serial positions also in the case of text memory. Fig. 1 shows recall of the difficult text for each presentation modality as a function of serial position of idea units. Obviously auditory superiority is not specific to the recency positions. Fig. 2 was introduced to make clearly the relation between modality differences and serial positions. It shows the recall performance for each modality in the primacy, middle, and recency part of the text (Each part comprises 6, 8, and 6 idea units, respectively). A $3 \times 3$ (modality by part) analysis of variance yielded significant main effects of modality ($\chi^2(2) = 25.48, p < .01$) and part ($\chi^2(2) = 67.62, p < .01$), but no significant interaction ($\chi^2(4) = 2.20, p > .05$).

<table>
<thead>
<tr>
<th>Difficulty Level</th>
<th>Presentation Modality</th>
<th>Auditory</th>
<th>Visual</th>
<th>Audiovisual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Easy</td>
<td>13.6 (68.0%)</td>
<td>3.07</td>
<td>13.7 (68.5%)</td>
<td>3.80</td>
</tr>
<tr>
<td>Difficult</td>
<td>13.0 (65.0%)</td>
<td>2.57</td>
<td>8.5 (42.5%)</td>
<td>2.42</td>
</tr>
</tbody>
</table>

Table 1. Mean number and SD of recalled idea units

![Fig. 1. Correct recall in each modality as a function of serial position of idea units (for the difficult text).](image1)

![Fig. 2. Correct recall in each modality as a function of serial part of idea units (for the difficult text).](image2)
Nevertheless there seems to be some trend of interaction between modality and part. As can be seen in Fig. 2, it is true that there is no significant main effect of modality in the primary part \( F(2, 27)=1.39 \), while there exists the main effect both in the middle \( F(2, 27)=11.19, p<.01 \) and in the recency part \( F(2, 27)=8.62, p<.01 \). But we can say, at least, that auditory superiority is not restricted to the recency part only.

**Discussion**

The present experiment showed the existence of a modality effect on text memory. It is different from the modality effect on semantically unrelated verbal materials in the following three points:

1. A modality effect was found for the material judged difficult to comprehend but not for the material judged to be easy, although both texts were almost equal with respect to number of words and noun concepts as well as judged interest level.

2. Auditory presentation was superior not only to visual but also to audiovisual presentation, while audiovisual presentation was not significantly superior to visual presentation.

3. Auditory superiority was not specific to the recency part of the material.

For the modality effect on memory for letter-, digit-, nonsense syllable- and wordlists, two main interpretations have been put forward:

1. The “Precategorical Store Hypothesis” postulates separate precategorical stores for auditory stimuli (precategorical acoustic store: PAS) and for visual stimuli (precategorical visual store: PVS). The information stored in PAS facilitates recall from short-term memory and produces stronger recency effect. The information in PVS decays much faster than that in PAS and therefore cannot be made use of at the time of recall (Crowder & Morton, 1969).

2. The “Translation Hypothesis” postulates the translation of visual input into an auditory form when verbal materials are visually presented. This additional processing requires cognitive capacity and therefore less cognitive capacity is available for further processing in the case of visual presentation as compared with auditory presentation (Laughery & Pinkus, 1966).

The translation hypothesis cannot explain why the modality effect is restricted to the recency part of a list. Therefore the precategorical store hypothesis has been more broadly accepted. The latter hypothesis explains also the superiority of audiovisual over visual presentation based on the availability of auditory information in PAS.

However, the properties of the modality effect on text memory are at variance with the predictions from the precategorical store hypothesis. Neither the restriction of the effect to the recency part of the learned material nor was the superiority of audiovisual over visual presentation was observed. Since the modality differences were specific to the text difficult to comprehend, it seems that the search for an explanation must be directed towards the process of comprehension rather than towards precategorical process. Considering that the translation hypothesis takes into account the further processing than sensory memory, this hypothesis appears to be more promising. It suggests the following interpretation: The difficult text requires more cognitive capacity for its comprehension than the easy one. Therefore, in the case of visual presentation, the processing necessary for comprehension is more liable to be impaired by the shortage of capacity which is caused by the translation of visual input into an auditory form. Probably the presentation time was not sufficient for comprehending the difficult text, while it was sufficient for comprehending the easy text. In other words, the presentation rate was substantially high for the difficult text but it was substantially low for the easy one, although real presentation rate was constant for both texts. On the basis of this interpretation, our result seems to be quite congruous with the fact that visual inferiority is augmented when presentation rate is high (Murdock & Walker, 1969).

On the other hand, the inferiority of audiovisual presentation in the difficult text seems to be a more complicated phenomenon. Translation process is not necessary in this modality since it already includes auditory stimuli.
Therefore, if we assume that printed letters were not translated into an auditory form in the audiovisual condition, the translation hypothesis cannot explain this result.

However, was the translation really not performed in the audiovisual condition? We cannot assert that our subjects in the audiovisual group did not translate the prints because it was not necessary. As a matter of fact, we cannot help but read (translate prints into sounds at the inner level, at least) even when we need not do so in a task to name the color of words (Stroop, 1935). And if the translation is inevitable process, it is possible to explain the inferiority of audiovisual presentation in the difficult text in the same way as that for the visual inferiority, that is, in terms of capacity shortage, which is based on the translation hypothesis. But it is queer that audiovisual inferiority is peculiar to text processing. The present research cannot provide any explanation on this point. It only suggests that some specific process of text comprehension is sensitive to audiovisual disadvantage. It might be syntactic processing, that is, the process of integration.

Finally, we should note difficulty level of texts. In this experiment, difficulty level of texts, which appeared to be one of the determinants of the modality effect on text memory, was measured by judgement on 5-point scales. So the level of difficulty depended on the readers' impression of texts. In order to investigate the modality effect on comprehension process, it is necessary to specify the factors of difficulty level of texts. We can assume some different factors of difficulty in the difficult text. That is, for instance, unfamiliarity of lexicon, complexity of syntax, abstractness of content, vagueness of expression, and so on. They may differently influence the modality effect. We have to examine those factors separately in the next step.

References

APPENDIX (LEARNING MATERIALS: EASY TEXT (A), AND DIFFICULT TEXT (B))

(A) A dietetic seminar for mothers
1) Vitamin A is measured in International Unit (I.U.).
2) That is because Vitamin A is obtained from carotenes also.
3) The I.U.-measure is derived from the effect of Vitamin A on the growth of a rat.
4) 1 I.U. of Vitamin A increases the weight of a rat by 3 gram per day.
5) when we feed a young one destitute of Vitamin A.
6) 1 I.U. corresponds to 0.3 microgram of Vitamin A.
7) β-carotene consists of two molecules of Vitamin A.
8) while other carotinoids consist of one molecule of Vitamin A.
9) Plants contain a lot of β-carotene.
10) 1 I.U. corresponds to 0.6 microgram of carotenes.
11) Since the absorption rate of carotenes is low,
12) the actual efficiency of Vitamin A in carotenes is about 1/3 of its value in a
food-element table.

13) So the amount of carotenes is represented as Vitamin A effect after dividing its amount by 3.
14) The carotene value of spinach is 8000 I.U.
15) and its Vitamin A effect is 2600 I.U.
16) The carotene value of carrots is 4000 I.U.
17) and its Vitamin A effect is 1300 I.U.
18) As processed cheese contains Vitamin A and carotenes,
19) its Vitamin A effect is 500 I.U.
20) by adding 410 I.U. and 90 I.U.

(B) Learning

1) There are two methods of testing human memory.
3) One is the recognition method
2) which tests whether a presented item is familiar to a subject.
5) Another is the recall method
4) which requires a subject himself to reproduce what he remembers by writing or speaking.
6) So far the term recall has been used in both meanings,
7) and it is actually difficult to regard both as fundamentally different.
8) Although it is not necessarily an external stimulus which is recognized,
9) a recognition process must be involved in both cases.
10) Our brain reproduces in some way internal stimuli,
12) thus giving rise to recall
11) due to the interaction between reproduced internal stimuli and the appropriate engram.
13) The mechanism of recall is still unclear at present.
15) Recall of a stimulus is possible within a period of a few minutes after its occurrence,
14) when the engram is sensitive to disturbance and damage.
16) If the engram is well established
17) recall can function within a few seconds.
18) Recall may occur later without conscious effort even after a momentary recall failure.
20) It is an example of the above
19) that we suddenly remember someone's name while thinking about something else a while after we have the name on the tip of our tongue but are not able to produce it.

Note 1) Japanese words (Bunsetsu) do not always correspond to English words.
2) Japanese nouns are sometimes embedded in the words which correspond to English adjectives.
3) The arrangement of clauses in a Japanese sentence sometimes differ from that in the corresponding English sentence. The serial numbers in this table correspond to the order in the original Japanese sentences.
4) The size of the above units is larger than that of idea units which is usually used.

—Received September 30, 1982—