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THE SUPPRESSION OF VISUALIZATION BY READING

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Four experiments are described which demonstrate a conflict between reading verbal messages and imagining the spatial relations described by those messages. Listening to the same messages did not produce comparable interference with visualization. The conflict between reading and visualizing was obtained even when the subject previously had seen the referent of the message. In contrast, when the subject was induced to treat the messages as rote strings of words instead of visualizing their referents, reading was a more effective means of presentation than was listening.

Two interpretations of these results were proposed. (*a*) Visualization and reading compete for the use of neural pathways specialized for visual perception. (*b*) The process of reading hinders the conversion of input material into any non-verbal form; that is, reading forces the subject to deal with information in a more exclusively verbal form than does listening. It was suggested that regardless of interpretation this method provides a means of investigating the internal processes underlying concrete verbal reference.

INTRODUCTION

Assume that one is given a verbal description of the layout of the streets in a town or the positions of furniture in another room. An immediate response to these descriptions would probably be to imagine how the layout of those items might look. If called upon to act on this information or to repeat the description to someone else, it is likely that one would refer to his visualization of the information while responding. Introspectively, at least, the notion that this type of internal representation involves the visual or visual-motor systems is a compelling one. Even if one does not experience visual images, the phrases "imagine what it would look like," and "visualize the relations" seem to describe some part of this mental process.

The hypothesis that this type of internal representation involves the visual system has been persistent in psychology. The early associationist and introspective psychologists assigned an important role in thinking to visual images, which were considered to be at least a partial revival of the immediate effects of visual perception. Since the ascendance of behavioural methods, numerous psychologists have searched for objective indices which implicated the visual and visual-motor systems in visual imagery. Eye movements, for example, have been correlated with thinking about visual tasks (Deckert, 1964; Lorens and Darrow, 1962). Studies of this type have been collected and set in the context of the peripheralist–centralist controversy by McGuigan (1966). Arguments supporting the importance of orientation movements, such as eye movements, for covert representations of information have been presented by Berlyne (1965).

The research in this paper uses gross performance measures rather than EEG or eye-movement recordings as a means of implicating visual activity in thinking.

Before describing this approach, the model implicit in the opening paragraph will be made more explicit. A subject is presented with a verbal message which describes a set of spatial relations. Concurrent with receiving the message, he generates an internal representation which involves some portion of the visual or visual-motor systems. If the subject is required to repeat or act on the message, the internal representation is again generated and serves as one determiner of output. The visual or visual-motor systems are thus partially occupied during both input of the message and output tasks which use the information in the message.

If the verbal message itself were written, then the subject would be required to use his visual system simultaneously for two separate purposes: namely, to represent covertly the spatial relations and to identify the written words. If there is some overlap in the mechanisms which are used to accomplish these two tasks then the subject ought to experience a conflict which he would not experience if he *listened* to the message. Similarly, if the act of output involves looking at words, for example inspecting a written passage for errors or writing down the verbal message, then a conflict ought to be produced which would not be present if the output involved only listening or speaking. Experiments 1 and 2 are designed to test these two implications.

Experiment 1

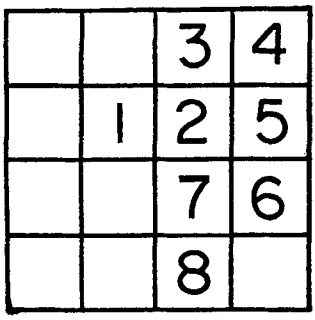
Subjects were presented with a series of messages which described spatial relations. Some of these messages were spoken to the subject; others were spoken at the same rate but were accompanied by the simultaneous exposure of a typewritten copy of the message. The subjects were asked after each message to repeat it verbatim. According to the above model, reading the message should lead to less accurate repetition than listening to the message, since listening alone would not conflict with the use of the visual system for visualization of the spatial relations. However, for this evidence to be pertinent, it also must be shown that there is not some peculiarity of the method of presentation which biases against reading *per se*. To demonstrate this, nonsense messages were presented which had the same sentence form and length and which would therefore have the same presentation characteristics as the spatial messages. If there were no difference between performance after reading and performance after listening with this nonsense material, then the characteristics of the physical presentation could be eliminated as a sufficient explanation for the results with the spatial material.

Method

Material. Figure 1 shows an example of a spatial message, the matrix which it describes and a nonsense message derived from it. The first sentence of each spatial message was always the same, and the same square in the four-by-four matrix was always designated as the starting square. The numbers were always the digits one to eight and were always mentioned in consecutive numerical order. The only way in which spatial messages differed was the sequence of transitions (up, down, right, left) from one square to another. These sequences were designed so that two different digits were never assigned to the same square by a message, and that a digit was never placed outside the matrix. Messages used for practice were reduced to only the first four sentences.

The nonsense material was derived from the spatial material by replacing the words *right, left, up, down,* with the words *quick, slow, good, bad.* In this way, material was obtained that is identical to the spatial material in length and form of presentation, and which involves strings of polar opposites with the same sequential restraints. However, for the present experiment (but not for Experiment 2), it was necessary to introduce another difference between the two types of material. Pilot subjects performed so poorly with the eight sentence nonsense messages that differentiating the presentation conditions would have been impossible. Consequently, only five sentences were used in each nonsense

FIGURE 1



A sample of the experimental material.

Spatial material	Nonsense material
In the starting square put a 1.	In the starting square put a 1.
In the next square to the *right* put a 2.	In the next square to the *quick* put a 2.
In the next square *up* put a 3.	In the next square to the *good* put a 3.
In the next square to the *right* put a 4.	In the next square to the *quick* put a 4.
In the next square *down* put a 5.	In the next square to the *bad* put a 5.
In the next square *down* put a 6.	In the next square to the *bad* put a 6.
In the next square to the *left* put a 7.	In the next square to the *slow* put a 7.
In the next square *down* put an 8.	In the next square to the *bad* put an 8.

message. The spatial messages could not also be reduced to five sentences without both eliminating the need to visualize and resulting in so few errors that once again the presentation conditions could not be differentiated.

Design. The two types of material, spatial and nonsense, were each presented in two ways: (1) *Listening* (*L*) the message (set of sentences) was played from a tape recorder. (2) *Listening and reading* (*LR*) a series of 3 × 5 index cards, each with one sentence of the message typed on it, were presented concurrently with the tape. The listening and reading condition was chosen over a reading alone condition so that differences in performance could be attributed to the presence of absence of the visual presentation and not to the presence or absence of the auditory presentation. In addition, the LR condition minimized the effect of individual differences in reading speed. Subjects reported a strong tendency to read each word in time with the auditory presentation, which tended to insure that even the fast readers did not have time to glance away from the card before the presentation of the next sentence.

For each of the experimental conditions, the task was simply to repeat the message verbatim. Each condition was given two times to each subject. The spatial and the nonsense trials were run in separate blocks; the material in each block was presented in one of the following sequences: L, LR, LR, L or LR, L, L, LR. Both the order of blocks of material and the order of types of presentation within these blocks were counterbalanced across subjects.

In summary, the experimental design was two-by-two within-subjects, one variable being spatial or nonsense material, and the other variable being listening (L) or listening plus reading (LR) presentation.

Subjects. The subjects were eight summer school students who were serving to fulfil a course requirement in introductory psychology. Subjects were tested individually.

Procedure. For the initial practice period, each subject was shown a diagram similar to that in Figure 1, and listened to the message that went with it. He was told that he would be asked to either read or listen to a set of similar messages which would *not* be accompanied by a diagram, and that immediately after each message was presented he was to repeat it word for word. He was then given a practice series of four, four-sentence spatial messages without visual matrices; two of these messages presented by listening and two by listening and reading. This practice block was sufficient to encompass most of the very large practice effect which occurs with this material At the conclusion of the practice block, the subject was given either the block of spatial trials or the block of nonsense

trials. The block of nonsense trials was preceded by the information that four meaningless adjectives were going to be substituted into the sentences but that the task was still to repeat the message verbatim. He was given two, four-sentence nonsense messages for practice and then the block of nonsense trials.

The subjects were asked to be sure to keep their eyes on the cards during the reading trials and were reminded of this on the infrequent occasions that they glanced away. The messages in all conditions were presented at the rate of approximately one sentence per 1·5 sec. No specific knowledge of results was given, although all subjects were periodically encouraged about their performance.

Results

The subjects uniformly reported that they performed the spatial task by "picturing the pattern formed by the numbers," and then "reading from the pattern" when repeating the message. The nonsense task was reported to have been performed by trying to retain the sequence of adjectives alone, and then, in output, reinserting them into the grammatical context.

TABLE I

AVERAGE ERRORS PER MESSAGE

	Spatial material	*Nonsense material*
Listening	1·2	2·3
Listening and reading	2·8	1·3

The average errors out of seven possible for the spatial conditions, and four possible for the nonsense conditions are shown in Table I. A within-subjects analysis of variance showed the material by presentation interaction significant at the 0·05 level ($F(1, 7) = 6{\cdot}67$) but neither of the main effects significant (material $F(1, 7) < 1{\cdot}0$; presentation $F(1, 7) = 4{\cdot}73$). Seven of the eight subjects made more errors after reading the spatial messages than listening to them. Seven of the eight subjects made more errors after listening to the nonsense material than after reading it.

It can be concluded that the listening–reading condition (LR) hindered the repetition of the spatial material but did not hinder the repetition of the nonsense material. This result is consistent with the hypothesis that reading interferes with the generation of an internal representation of the spatial relations. The performance with the nonsense material indicates that this effect is not due to some feature of presentation which made reading inherently more difficult.

EXPERIMENT 2

The purpose of this experiment was to demonstrate the conflict between reading and visualizing during output instead of input as in Experiment 1. Subjects learned a message to a criterion of one verbatim repetition. They then were asked either to say the key words of the message (the spatial relations themselves) or to underline those same key words on a multiple choice test (a written copy of the message which listed the four possible options at each choice point). It was predicted that saying the spatial relations would be more rapid and involve fewer long pauses than would underlining. To underline the written spatial relations the subject would have to read them, and reading should conflict with his visualization of the spatial relations.

The same procedure also was run with the nonsense materials described in Experiment 1. This was designed to control for the possibility that the sheer movements involved in underlining take more time than does speaking, regardless of visualization.

Method

Design. The same two types of material were used, with the modification that each of the nonsense as well as each of the spatial messages consisted of eight sentences. Each message was taught to a criterion of one verbatim repetition in order to obtain differences in output that were not due to different levels of acquisition of the two types of material.

After criterion was reached on a given message, the subject was requested to give one of two types of output (1) *spoken*: the key words alone were spoken by the subject (right, up, right, down, down, etc.; or, quick, good, quick, bad, bad, etc.). (2) *underlining*: a sheet of paper was uncovered in front of the subject on which each of the sentences in the messages was typed, one under the other with a double typewriter space between. All of the four possible key words were bracketted within each sentence. The subject's task was to proceed down the page, underlining the appropriate word in each sentence—much in the manner of taking a multiple-choice test.

Each of the four conditions were given twice to all subjects. One trial was run on each of the conditions before the second trial in any condition was administered. The sequence in which the four conditions were run was counterbalanced across subjects. In summary, the experimental design was two-by-two within-subjects, with one factor being spatial or nonsense material and the other factor being underlining or spoken output.

Subjects. The subjects were eight first-year university students, who were participating to fulfil a course requirement in introductory psychology.

Procedure. Each subject was introduced to the material in the same way as in the previous experiment. He then was given two practice trials, one with a spatial message and one with a nonsense message, and was asked to give both types of output for each message. The instructions for the mode of output required on a particular trial was given by saying either "spoken" or "written" within 5 sec. after informing the subject that he had repeated the message correctly in acquisition. The initial response times and the inter-response times were recorded on a Gerbrands event recorder, driven at 1 cm./sec., by depressing a telegraph key each time the subject either said or marked a key word.

To facilitate original acquisition all messages were presented at a slower rate than in the previous experiment: approximately one sentence per 2·5 sec. rather than one per 1·5 sec. As in the first experiment, no specific knowledge of results was given regarding output performance.

Results

Seven of the eight subjects reported that they "pictured the pattern" described by the spatial material, and that they referred to this pattern during output. All subjects reported that they learned the nonsense material by noticing sequential patterns in the key words, and that at output these patterns of words "just came."

The average number of trials to acquisition of each message was 1·2 for the spatial material, and 2·0 for the nonsense material. Seven of the eight subjects made more errors on the nonsense material than on the spatial material, and the eighth subject made the same number on each type of material. The subjects claimed that being able to figure out a spatial pattern for the spatial material helped considerably in acquisition.

TABLE II

AVERAGE PERFORMANCE TIME IN SECONDS

	Spatial material	*Nonsense material*
Speaking	7·6	8·0
Underlining	15·5	11·1

The average total output time per message is shown in Table II. A two-by-two within-subjects analysis of variance on these times showed the main effect due to type of output significant with a probability of less than 0·01 ($F(1, 7) = 14{\cdot}51$) and

the interaction of output and material significant with a probability of less than 0·05 ($F(1, 7) = 5{\cdot}74$). The main effect due to material was not significant ($F(1, 7) = 2{\cdot}59$). Thus, the relative difficulty of the written output differed for the two types of material.

An informal observation was made that the subjects glanced away from the page occasionally during underlining of the spatial material. When this was pointed out after the experiment, the subjects explained the glancing away as "getting the pattern back." It seemed that this phenomenon could be demonstrated by plotting the average inter-response times sequentially through a trial and looking for a peak which would indicate that the subject had glanced away. However, the exact inter-response time during which a subject glanced away was so variable that the average curve was essentially flat for inter-response times three through six. Another approach to measuring the phenomenon is to look for skewness in the distribution of inter-response times on each trial. If there are in fact one or two abnormally long inter-response times, then a skewness statistic should show the effect. The statistic chosen for this purpose was the mean minus the median. The average deviation of the mean from the median was 0·71 for written spatial, 0·26 for spoken spatial, 0·18 for written nonsense, and 0·21 for spoken nonsense. Comparisons made by *t*-test for correlated means showed written spatial to be different at 0·05 from all other groups, with no differences among the other groups.

The combination of these two findings, i.e. the interaction in total output times and the skewness of the individual inter-response time distributions, supports the conclusion that the subjects found conflict between internally representing the matrix and underlining the key words, and that they solved the conflict by taking relatively long pauses during the output. This conflict is not inherent to the underlining mode of output as is shown by the lack of similar effect for the output of the nonsense material.

Experiments 1 and 2 together support the conclusion that, for this situation, reading suppresses spatial organization. Both the performance data and the reports of the subjects indicate a conflict between reading and imagining the matrices described by the spatial messages. Two interpretations of this result can be made. The first interpretation, *specific visual involvement*, is that which was mentioned in the introduction: namely, that both reading and internal representation of spatial organizations utilize some of the mechanisms specialized for handling visual perception. The second interpretation, *general overload*, of the conflict between reading and spatial organization rests on the assumption that both reading and spatial organization are more complicated than the tasks with which they were contrasted in these experiments: namely, listening and sequential organization. The subject attempts to treat reading and visualizing successively in order to reduce an overload on his *general* processing capacity. In contrast, the notion of specific visual involvement attributes the conflict to competition for the same *visual* processing mechanisms. Experiments 3 and 4 were designed to obtain information more critical to the specific visual involvement interpretation.

Experiment 3

Two considerations influenced the design of this experiment. (*a*) The plausibility of the general overload explanation would be weakened if it could be shown that a conflict still existed after the subject had already seen the matrix. It would seem reasonable that if the matrix had been seen, then imagining it while reading would be a good deal less taxing and conflict due to overload should disappear. (*b*) The assumption has been made that the conflict between reading and the spatial task is occasioned by the process of visualization, rather than by the material itself (or, more

precisely, by the immediate semantic response to the spatial words). Substance could be added to this argument if the conflict were eliminated when the subjects treated the spatial messages as a sequence of words rather than as a description to be visualized.

The design of Experiment 3 is as follows. The initial, spoken presentation of each message is accompanied by one of two displays; either a matrix showing the numbers in the appropriate squares, or a written listing of the key words alone (right, up, right, down, etc.). After each of these initial displays, the verbal message alone is presented either by listening, or by listening and reading, as in Experiment 1. When the subject treats the message as describing a matrix, then reading should interfere with the visualization and thus slightly delay the subsequent repetition of the message. However, when the subject treats the message as a sequence of words, then reading should have a slightly facilitating effect, as it did with the nonsense material in Experiment 1.

Method

Design. The spatial material from Experiment 1 was used, and all details of the verbal presentation and output were the same as for the spatial material in Experiment 1. However, prior to the L or LR presentation of the message, each subject was given an L presentation of the same message together with either (*a*) a 5 in. × 8 in. card on which was drawn a four-by-four matrix containing the numbers in the locations described by the message, or (*b*) a 5 in. × 8 in. card on which each of the seven key words (directions describing the transitions from one number to another) were typed in vertical sequence. Thus, on each trial there was a "set presentation" (matrix or word sequence), followed by a "verbal presentation" (listening or listening and reading, as defined in the first experiment), followed by a verbatim repetition of the verbal message by the subject.

Each of the four conditions were given two times to each subject. One trial was run with each of the conditions before the second trial in any condition was administered. The sequence in which the four conditions were run was counterbalanced across subjects. In summary, the experimental design was two-by-two within-subjects, with one variable being matrix or word sequence as the set presentation and the other variable being L or LR verbal presentation.

Subjects. The subjects were eight first-year university students, who were participating to fulfil a course requirement in introductory psychology.

Procedure. Each student was introduced to the material in the same way as in the previous experiment. He was then shown the two types of initial presentation and was told that it was of the utmost importance that he deal with the materials in the manner that they were given. That is, for the word sequence condition he was not to try to picture the referent of the words, but rather to deal with them as if they were simply an arbitrary verbal sequence. He was then given two practice trials on each of the types of material. To emphasize the instructions he was asked on the practice trials using the matrix to fill in a blank matrix after he had given a verbatim repetition, and on the practice trials using the word sequence he was asked to give the string of key words alone as rapidly as possible. On all subsequent trials, he was asked to give only the verbatim repetition.

Results

The average time to give a verbatim repetition of the message is given in Table III for each of the experimental conditions. The anticipated result was found; output after reading (LR) took longer than output after listening (L), but only when the subject was asked to visualize the matrix described by the message. A two-by-two factorial within-subjects analysis of variance on the average times for each subject for each condition showed the main effect due to set presentation significant with a probability less than 0·01 ($F(1, 7) = 15{\cdot}72$) and the interaction of verbal presentation and set presentation significant with a probability less than 0·05 ($F(1, 7) = 6{\cdot}12$). The main effect due to verbal presentation was not significant ($F(1, 7) = 1{\cdot}23$).

The simple effect of L *vs.* LR was tested for both levels of the set presentation and found to be significant at 0·05 for both levels.

TABLE III

AVERAGE PERFORMANCE TIME IN SECONDS

	Matrix	*Word sequence*
Listening	12·5	22·5
Listening and reading	14·0	17·5

The average number of errors per repetition was not as useful in this experiment as it was in Experiment 1, since five of the eight subjects made no errors after a matrix presentation. However, the error data for the sequence presentation are consistent with the time data given above; six subjects in this condition showed more errors after L than LR verbal presentation, one subject showed no errors in either, and the final subject reversed the trend by making one error after LR and none after L. The ceiling effect evident in these data is presumably due to having two presentations of each message (one set presentation and one verbal presentation) prior to the verbatim repetition, as well as the additional visual display during the set presentation.

This result for the time data and the tendency in the same direction for the error data demonstrate that the reading conflict can be varied by setting the subjects to treat the same verbal material in two different ways. In addition, it demonstrates that the conflict is not limited to a situation in which the subject has to deduce the referent of the verbal message.

EXPERIMENT 4

This experiment was designed to provide the same type of information as Experiment 3 and, in addition, to resolve an ambiguity specific to the interpretation of Experiment 2. In Experiment 2 an attempt was made to show that when a person visualized during output, his performance was hindered on a mode of output which entailed reading. To demonstrate this, two types of output were compared: speaking the key words and underlining the correct words in a written passage. However, there is an important difference between these two output modes; speaking does not require attending to anything outside of the responder, while underlining requires reading the words on the page. It is possible that the results were due to the necessity of attending to external stimuli rather than to the fact that reading specifically involves the visual system. The present, error detection, experiment was designed to eliminate this possibility.

Subjects are taught a message to a criterion of one verbatim repetition, as in Experiment 2. The subjects' task is to detect a possible error in a subsequent presentation of a sequence of three key words taken from the message. The major variable in the experiment is the manner in which the error messages are presented. After some spatial messages, the three key words are spoken rapidly to the subject; after other messages, the key words are displayed on an index card. It is expected that error detection will be slower with the written presentation. However, as in Experiment 3, this result is expected only when the subject is visualizing the material. Consequently, the error detection task is performed both when the subject is instructed to visualize the matrix and when he is given the spatial relations as a rote verbal sequence.

Method

Design. There were three phases to each trial: acquisition, error message presentation, and judgement. One acquisition condition was identical to the matrix condition of the last experiment; the subjects were shown the relevant matrix while they listened to a spatial message. In the other acquisition condition, the "word sequence" condition, the subject listened to a rapid presentation of the key words of a spatial message. Since it was important for interpretation of the error detection data that the subjects have the message fluently, they were given presentations until they could repeat the material without hesitation.

Each error message consisted of three words and was either spoken or typewritten. To generate an error message, a sequence of three successive key words (spatial relations) were taken from anywhere in the message except the initial three. On 50 per cent. of the messages an error was introduced by changing one of the words to its polar opposite (right to left, up to down, and vice versa). The resulting error is "plausible" in the sense that it would not describe a matrix in which two numbers were assigned to the same square (as would happen, for example, with the sequence "right, left"). A seemingly more straightforward way of running an error detection experiment would be to simply repeat the whole message with or without an error in it. However, when the experiment is performed in this manner the subjects simply generate the sequence of key words in slight anticipation of each word in the error presentation and are thus able to detect the error immediately and virtually without mistakes. By taking three key words from anywhere in the message, the subject is forced to receive the three words and then search the internal representation. This process forces a measurable delay prior to the subject giving his judgement.

In summary, the experimental design was two-by-two within-subjects, with one variable being matrix or word sequence initial presentation and the other variable being written or spoken error message presentation.

Subjects. The subjects were eight first-year university students, who were participating to fulfil a course requirement in introductory psychology.

Procedure. Each subject was introduced to the material in the same way as in the previous experiment. He was then shown a series of error messages while the demonstration matrix was still present. A total of six trials were given in the matrix presentation condition. After each of these six messages were learned a total of four error messages were presented in random order for judgement; correct written, correct spoken, incorrect written, incorrect spoken. The first two of these trials were treated as practice trials and the final four were used for data. Subjects were then given an identical six trials with the word sequence presentation condition.

As in the previous experiment subjects were cautioned to treat the material in the manner given; that is, not to visualize the word sequence material. Whenever a subject made an incorrect judgement on an error message, he was told that he was incorrect and was asked to check the message again. Before each error message was presented, the subject was told to run over the matrix or sequence to himself, and then to give a signal that he was ready. If the subject indicated that he was uncertain about the matrix or sequence he was given another acquisition trial.

Results

The average time from the beginning of a presentation of an error message until the subject's response is shown for each experimental condition in Table IV. As was anticipated, when the material was visualized, time to give judgement was longer with a written error message than with spoken. The same is not true when the material was retained as a verbal sequence. A two-by-two within-subjects analysis

TABLE IV

AVERAGE JUDGEMENT TIME IN SECONDS

	Matrix	*Word sequence*
Listening	4·4	3·4
Reading	5·0	3·1

of variance on the average judgement time per subject per condition showed a significant effect due to material ($F(1, 7) = 17{\cdot}44$) and material by presentation interaction ($F(1, 7) = 7{\cdot}13$) but not presentation ($F < 1{\cdot}0$). Both of the simple effects due to presentation were significant. Six of the eight subjects showed faster judgement times after listening than after reading when the material was visualized; seven subjects showed the reverse effect for rote verbal retention.

This experiment shows that reading during the course of output hinders visualization of material that had previously been learned. Unlike Experiment 2, the contrasting output condition entails listening rather than merely speaking from memory. Thus, the effect cannot be due to merely the necessity of taking in *any* information in the course of performance. This experiment also shows, as did Experiment 3, that the reading–visualizing conflict can be obtained even when the material being visualized had been seen previously.

General Discussion

These experiments demonstrate that in this situation reading competes with the internal representation of spatial information. Both the performance data and the reports of the subjects indicate a conflict between reading and imagining the matrices described by the verbal messages. The effect can be obtained when the messages describe either matrices with which the subject is unfamiliar or matrices the subject has learned or seen previously. The effect can be abolished by inducing the subject to treat the messages as rote sequences of words.

At the present time the most persuasive interpretation of this reading–visualization conflict is that the internal representation of spatial material use mechanisms specialized for *visual* perception. However, it is clear that this interpretation is tentative. It could easily be true that the important thing about the visualization carried out in the present experiment is not its sensory modality but rather that it is organized quite differently from the verbal message itself. That is, it is possible that reading interferes with re-organization of the information from the form given in perception, regardless of what the referent is. Evidence which would select between this interpretation and the specific visual involvement hypothesis could be obtained in a situation in which the same verbal message described characteristics of two different referents, one of which is spatially organized and the other of which is not. If the relative efficacy of reading and listening changed with the referent then one would have a strong argument that the basis of the reading conflict was more specific than simply re-organization from perception.

Regardless of interpretation, the subjects in these experiments did report that they "pictured" the patterns described by the messages. However, when they were presented with a list of features that they would have seen if they had actually inspected a matrix (e.g. outline of the four-by-four matrix, lines between the squares, the digit being described at the moment, other digits than the one being described at the moment), they ascribed to "seeing" anything in only the most gingerly fashion. All of the subjects except one asserted with some conviction that the non-verbal portion of their representation of the information was important to their performance, but only two subjects reported anything which would correspond to a clear image. These two subjects were indistinguishable from the others in speed and accuracy of performance, as was expected from many previous findings on both sensory and thought imagery (Fernald, 1912; review in Oswald, 1962). This result, however, should not be interpreted as indicating that internal representation of visual properties is either entirely verbal or unrelated to the visual system. The 23 subjects who reported picturing the matrix maintained that this activity was not just verbal and

did not back down from this position (although some were in an evident quandary) after they denied actually "seeing" many of the details which would be obvious in vision.

If one accepted the subjects' reports that the way in which they dealt with the matrices was "visual," this still would not be sufficient to establish that visualization used specifically the visual system. The phenomenal property "visual" could be more a result of the subjects' knowledge of what is being described than a result of the part of the nervous system involved in the internal representation. The basic device in this paper for establishing the type of processing is still the conflict with other visual stimulation.

This suggests a final point. If the specific visual involvement interpretation is in fact applicable, it should be possible to show that attending to *any* visual stimulus hinders concurrent visualization. There are two reasons why this research used written descriptive passages instead of other types of visual stimuli to provide interference for visualization. (1) If the stimulus being used for interference were irrelevant to the information being visualized, then it would be likely that an attentional limitation would be met which would force the subject to attend to either the stimulus or the visualization but not both (that is, he would be unable to "think of two things at once"). This would not be bothersome except that the same limitation would probably be met regardless of the modality in which the interfering stimulus were delivered. This situation thus would be inappropriate for demonstrating that visualizing was a specifically *visual* function. (2) One of the most interesting possibilities suggested by the reading conflict is the investigation of the relations between verbal and non-verbal components of internal representation. If reading suppresses some types of visually-mediated organizations, then one has a technique for momentarily changing the relative availability of the verbal and the visualized components of the same thinking process. Using this technique, one could evaluate the subject's relative dependence on verbal and non-verbal components of thought in various operations on different types of material. This type of evidence could form an interesting attack on the psychological problem of concrete verbal reference.

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