Verbal recoding of visual stimuli impairs mental image transformations

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Two experiments were carried out to test the hypothesis that verbal recoding of visual stimuli in short-term memory influences long-term memory encoding and impairs subsequent mental image operations. Easy and difficult-to-name stimuli were used. When rotated 90° counterclockwise, each stimulus revealed a new pattern consisting of two capital letters joined together. In both experiments, subjects first learned a short series of stimuli and were then asked to rotate mental images of the stimuli in order to detect the hidden letters. In Experiment 1, articulatory suppression was used to prevent subjects from subvocal rehearsal when learning the stimuli, whereas in Experiment 2, verbal labels were presented with each stimulus during learning to encourage a reliance on the verbal code. As predicted, performance in the imagery task was significantly improved by suppression when the stimuli were easy to name (Experiment 1) but was severely disrupted by labeling when the stimuli were difficult to name (Experiment 2). We concluded that verbal recoding of stimuli in short-term memory during learning disrupts the ability to generate veridical mental images from long-term memory.

It is commonly believed that verbal processing facilitates subsequent memory performance. Indeed, a beneficial effect of verbal rehearsal and elaboration on memory performance has been reported for both verbal (Craik & Tulving, 1975; Darley & Glass, 1975; Maki & Schuler, 1980) and visual materials (Bartlett, Till, & Levy, 1980; Daniel & Ellis, 1972; Ellis & Daniel, 1971). However, as has been shown by a number of studies in which visual materials were used (see, e.g., Bahrack & Boucher, 1968; Bartlett et al., 1980; Nelson & Brooks, 1973; Schooler & Engstler-Schooler, 1990), the effect of facilitation cannot be regarded as a general phenomenon. Rather, it seems to be restricted to situations in which the verbal information is of some value in performing the task. In contrast, when the task requires visual analysis, verbal processing of visual stimuli may impair memory performance. For example, in a well-known study, Carmichael, Hogan, and Walter (1932) showed that associating ver-

bal labels with ambiguous shapes affects the way in which people later draw the shapes. More recently, Schooler and Engstler-Schooler (1990) have shown that verbally describing the appearance of a memorized face impairs subsequent recognition. Moreover, this effect, which they referred to as "verbal overshadowing," was found to depend on the verbalizability of the stimuli: although verbalization impaired memory for faces or colors, it facilitated memory for a spoken statement. The verbal overshadowing effect generalizes to other domains of cognition, such as insight problems (Schooler, Ohlsson, & Brooks, in press).

In another recent study, Brandimonte, Hitch, and Bishop (1992) found that the ability to manipulate visual mental images generated from memory is markedly affected by the type of code (visual or verbal) used when learning the stimuli. In that study, an image transformation task called "subtraction" was used. It consists of mentally taking away a part of an image in order to identify a new construal in the remainder of the image. For example, if the rope of a skipping rope is subtracted, the handles look like two ice cream cones (see Figure 1). Subjects had to learn a series of pictures that were either easy or difficult to name. Half the subjects engaged in articulatory suppression while memorizing the series of pictures (i.e., during encoding), and half remained silent. Then, they were asked to form an image of each picture and were shown a part of the picture. Subjects were instructed to

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Figure 1. Example of easy and difficult-to-name stimuli used by Brandimonte, Hitch, and Bishop (1992). When subtracting B from A, the remainder looks like a new construal.

subtract the part from the whole of their image in order to identify in the remainder a new pattern (objects or letters) that could be named (see Figure 1). Results showed that performance in the imagery task was significantly better when initial learning was accompanied by articulatory suppression for nameable stimuli but showed no effect of suppression for stimuli that are difficult to name. It was suggested that subjects have a strong tendency toward verbal recoding of the stimuli in short-term memory (STM) whenever possible, and this influences encoding in long-term memory (LTM) in such a way as to impair subsequent mental image operations. By blocking the tendency to recode visual stimuli in verbal STM, suppression improved performance in the imagery task.

These results are broadly consistent with the verbal overshadowing effect, although Schooler and Engstler-Schooler's (1990) approach and paradigm were quite different. For instance, Schooler and Engstler-Schooler's (1990) paradigm involved overt verbalization subsequent to stimulus encoding, whereas the phenomenon studied by Brandimonte et al. (1992) involved covert verbal processing concurrent with stimulus encoding. Therefore, Brandimonte et al.'s results encourage the view that verbal overshadowing is a general phenomenon that is not limited to one narrowly defined experimental paradigm.

On the other hand, some methodological difficulties in Brandimonte et al.'s (1992) research leave open the possibility of alternative interpretations. For example, the easily nameable stimuli were objects, whereas the pictures that were difficult to name were meaningless figures (see Figure 1), and the correct responses were either objects (when the stimuli were objects) or letters (when meaningless figures were used). Although none of these confounding factors challenges the basic finding that articulatory suppression can improve visual imagery, it is obviously important to confirm that they were not in any way responsible for the differential effect of suppression that Brandimonte et al. attributed to nameability. For example, one might argue that identifying letters after the subtraction task is much easier than identifying objects and that this difference in difficulty contributed to the differential effect of suppression.

The general aim of the present study was to explore further the effects of articulatory suppression and stimulus nameability on visual imagery. We used an imagery task that involved mental rotation to establish whether results obtained with mental subtraction (Brandimonte et al., 1992) would generalize to a different kind of image transfor-

Figure 2. The two sets of stimuli used in Experiments 1 and 2.

mation. The stimuli were such that when rotated counterclockwise through 90°, a new pattern consisting of two conjoined capital letters was revealed (Figure 2). Subjects first memorized the stimuli and then attempted to rotate a mental image of each item and to segment it in such a way as to allow the two letters to be identified. There were two sets of either nameable or unnameable stimuli, and, since the solution to the imagery task was always a pair of letters, the confounding between type of stimulus and type of response present in Brandimonte et al. was avoided.

In Experiment 1, half the subjects articulated irrelevant sounds ("la-la") when learning the pictures, and half remained silent. After learning, they were required to use imagery to rotate each picture 90° counterclockwise and to name the two letters that were thereby revealed. If the results of Brandimonte et al. (1992) were due to an artifact associated with the particular stimuli that were used, no relationship between the effect of suppression (if any) and the nameability of the stimuli would be expected. Alternatively, if the previous interpretation was correct and the results can be generalized, an interaction between the effects of nameability and articulatory suppression is predicted such that suppression during learning will improve imagery performance only for easily nameable stimuli.

EXPERIMENT 1

Method

Subjects. Sixty subjects took part in the experiment as volunteers. They were recruited from the University of Manchester library and were randomly assigned to four experimental conditions: easy nameability with articulatory suppression, easy nameability without articulatory suppression, difficult nameability with articulatory suppression, and difficult nameability without articulatory suppression.

Materials. Two sets of stimuli were prepared on cards measuring 20×20 cm. Each set consisted of six pictures that were either difficult or easy to name and a training figure. When rotated 90° counterclockwise, each shape revealed two capital letters. As illustrated in Figure 2, the letters were always joined together and could, occasionally, share one side. Within each set, half the pictures contained curved lines and half were formed by straight lines. The nameability of the stimuli was established through a preliminary nameability agreement test given to a different group of subjects from those tested in the proper experiment. Only those figures on which there was at least 50% agreement on a name were included in the nameable set. Conversely, a very low rate of agreement on specific names was required for the unnameable set, the most frequent response being typically "I don't know." Table 1 shows data on the ease of naming each picture.

Procedure. The subjects were run individually in a single session lasting about 10 min. They were first asked to memorize the series of pictures. No mention of embedded letters was made until after memorization. Half the subjects were required to articulate the word "la" during the learning of the stimuli, whereas half were asked to remain silent. Pictures were presented sequentially at 5 sec per picture for a total of three presentations each. A pilot study had established that this presentation procedure was sufficient for all six pictures to be learned. Immediately after learning, the subjects were asked to make a mental check that they could recall all the members of the series in the order in which they had learned

Table 1
Ease of Naming Each Picture in the Two Sets

Figure	Name	n
DN Series*		
1	drop	3
2	DK†	6
3	DK	3
4	geometric shapes	3
5	DK	3
6	DK	4
EN Series*		
1	mask	15
2	lamp	8
3	ball	12
4	chair	15
5	bridge	8
6	music stand	8

Note—Entries show the most common response for each picture.

*N = 15. †DK = don't know.

them with 100% accuracy. All subjects reported that they could do so.

Next, the subjects practiced, using the training figure, in the mental rotation operation that they would be asked to perform shortly thereafter. After practice, they were requested to form an image of the first picture of the learned series, to mentally rotate it 90° counterclockwise, and to identify the two letters compounded in the original shape. It was specified that the two letters were always joined together and that they could occasionally share one side. The subjects were asked to report the two letters verbally. After naming the two letters forming the first picture, the subjects were asked to generate an image of the second picture, and so on. They were encouraged to find both letters. No mention of guessing strategies was made, and the subjects were given as much time as they needed.

Results

Each subject's response to each stimulus was given a score reflecting the number of letters correctly identified in mental imagery (0, 1, 2). The mean scores for the easy-nameability condition were 6.93 out of a possible 12 for subjects who did not suppress articulation during learning and 9.93 for those who did. In the difficult-nameability condition, the corresponding mean scores were 9.07 (without suppression) and 9.13 (with suppression). A two-way analysis of variance (ANOVA) for a between-group factorial design showed a significant interaction between nameability and articulatory suppression [$F(1,56) = 7.88$, $MS_e = 4.47$, $p < .01$] and a main effect of suppression [$F(1,56) = 7.21$, $p < .01$]. The main effect of nameability was not significant [$F(1,56) = 1.49$]. Performance in the difficult-nameability condition both with and without articulatory suppression was as good as that in the easy-nameability condition with articulatory suppression.

The main effect of suppression and the interaction between suppression and nameability were also found when data were analyzed by items rather than by subjects [suppression, $F(1,10) = 21.88$, $MS_e = .016$, $p < .01$; interaction, $F(1,10) = 26.05$, $p < .01$]. As can be seen from Figure 3, the difficult-nameability items show no consistent effect of suppression (panel A), whereas for all six

Figure 3. Item analyses on data from Experiment 1. Ordinate measures mean number of letters (out of 2) identified for each picture in each condition.

easily nameable items, performance with articulatory suppression is higher than without (panel B).

Discussion

The results for the nameable pictures confirm Brandimonte et al.'s (1992) findings in showing that articulatory suppression during learning can improve performance on a subsequent imagery task, and they demonstrate that this effect generalizes to different stimuli and different image transformations. The absence of any effect of suppression for stimuli that are difficult to name once again supports the view that the crucial factor is verbal recoding in the learning phase. Results from the item analyses indicate that the differential effect of suppression observed in the difficult- and easy-nameability conditions is not due to item differences. As is clear, there is no indication that

the effect of articulatory suppression was specific to particular items within the two sets.

If our interpretation is correct, then, other manipulations besides nameability and articulatory suppression that influence the tendency to use verbal codes during learning should lead to a consistent pattern of results. One such manipulation is supplying verbal labels for both easy and difficult-to-name pictures. It is assumed that making a plausible verbal label available to subjects in the difficult-nameability condition will encourage them to use verbal recording when memorizing the series. Hence, supplying a name to an otherwise meaningless stimulus should hinder performance in the image transformation task. On the other hand, no effect of labeling is expected for easily nameable stimuli since it is assumed that subjects will rely on verbal coding even in the absence of labels.

EXPERIMENT 2

In this experiment, the subjects performed the same imagery task as in Experiment 1, except that here labels representing names of the pictures were applied below each shape (see Table 2). Names were taken from the list obtained through the nameability agreement test. Those names that obtained the highest percentage of agreement were used as labels (in the difficult-nameability set, the highest percentage of agreement on a name was, of course, much lower than in the easy-nameability set).

Method

Subjects. One hundred twenty undergraduates recruited from the university library participated in the experiment as volunteers. They were randomly assigned to four experimental conditions in a 2×2 factorial design (easy/difficult nameability, with/without labels). Groups were balanced with regard to sex.

Materials and Procedure. The same sets of pictures used in Experiment 1 served as materials. They were presented either with or without labels. Labels were applied 1 cm below the picture. The procedure utilized in Experiment 1 was exactly replicated.

Results

The mean scores for the difficult-nameability condition were 8.53 out of a possible 12 for subjects who were not shown verbal labels and 6.33 for those who were. In the easy-nameability condition, the corresponding groups scored 7.03 (without labels) and 7.10 (with labels). A two-way ANOVA for factorial designs showed an interaction between nameability and labeling [$F(1,116) = 6.71$, $MS_e = 5.74$, $p < .05$] and a main effect of labeling [$F(1,116) = 5.95$, $p < .05$]. No main effect of nameability was found ($F < 1$). The main effect of labeling [$F(1,10) = 11.53$, $MS_e = .022$, $p < .01$] and the interaction between labeling and nameability [$F(1,10) = 6.54$, $p < .05$] were again significant when data were analyzed by items rather than by subjects. The main effect of nameability did not reach significance ($F < 1$). As illustrated in Figure 4, for all six items in the difficult-nameability condition, performance was disrupted by labels (panel A), whereas no overall effect of labeling was found for items that are easy to name (panel B).

Discussion

In contrast to the clear effect of suppression in Experiment 1, there was no effect of labeling when items were easy to name. Conversely, the clear-cut effect of labeling observed for items that were difficult to name is con-

sistent with the suggestion that the use of the verbal code impairs performance on a subsequent task requiring generation and manipulation of visual mental images. Item analyses clearly showed that the differential effect of labeling was not due to specific items. Another possible interpretation of the results is that assigning labels to figures that are difficult to name could have distracted subjects and thus may have influenced performance. That is, during encoding, rather than concentrating on the figures, the subjects might have been struggling to figure out how the names fit the figure. However, such an explanation is not compelling, and if it were correct, performance in the difficult-nameability + label condition should have been much lower than in the easy-nameability conditions.

In sum, two main conclusions can be drawn from these results. First, it seems that whenever possible, subjects tend to use verbal recoding when memorizing a series of pictures. Even pictures that are difficult to name are verbally recoded when verbal labels are immediately available. Second, verbal recoding significantly impairs performance in a subsequent imagery task that requires the use of the visual code to be correctly performed (see also Schooler & Engstler-Schooler, 1990).

GENERAL DISCUSSION

The results of Experiment 1 confirm and extend those of Brandimonte et al. (1992) in showing that imagery performance is significantly improved by articulatory suppression during learning when stimuli are easy to name but not when stimuli are difficult to name. Experiment 2 provided evidence for a complementary effect when stimuli are supplied with verbal labels during learning. Thus, giving labels hindered performance in the visual imagery task for low-nameability items but had no effect for high-nameability stimuli.

The present results are consistent with a simple theoretical interpretation that maintains that what subjects learn about the visual characteristics of a stimulus is influenced by the availability of verbal codes. Thus if verbal codes are readily available, as is the case with high-nameability items or low-nameability items supplied with a label, subjects will learn less about the appearance of the stimuli and consequently will perform worse on an imagery task that requires the generation of a veridical visual image. Similarly, the beneficial effect of articulatory suppression on imagery performance is assumed to stem from the reduced availability of verbal codes and consequent improved learning of the visual characteristics of the stimuli.

One possible implication of these results may be that the phenomenon of verbal overshadowing (Schooler & Engstler-Schooler, 1990) has considerable generality. As originally demonstrated, this phenomenon involved the effect of verbal processing some time after learning on standard tests of visual memory. The present results suggest that verbal overshadowing may extend to verbal processing during learning and may influence performance on visual imagery tasks in addition to visual memory

Table 2
Labels Used for Easy and Difficult to Name Stimuli in Experiment 2

Figures	Difficult	Easy
1	teardrop	mask
2	door	lamp
3	eye	ball
4	roof	chair
5	shell	bridge
6	window	music stand

Figure 4. Item analyses on data from Experiment 2. Ordinate measures mean number of letters (out of 2) identified for each picture in each condition.

per se (see also Brandimonte & Gerbino, in press). However, it remains to be seen whether the present effects will bear a close resemblance to verbal overshadowing when they are analyzed in greater detail than is possible here.

More generally, the present results are in accordance with the existence of a dual form of encoding for visual stimuli (Paivio, 1971). However, Paivio's dual coding theory assumes that the contribution of the verbal and visual codes to memory performance is independent and additive (cf. also Bahrck & Bahrck, 1971; Nelson & Brooks, 1973; Paivio, 1975). That is, each code can be used independently from the other, and the use of both codes should lead to better performance than the use of either type of code alone (e.g., Paivio & Csapo, 1973). In showing a detrimental effect of having verbal and visual codes

available, the present results cannot be easily accommodated within this aspect of Paivio's theory, although it should be noted that, unlike in Paivio's work, the verbal information was of little (if any) value in performing our task.

To explain the improvement in performance in the imagery task when verbal coding is inhibited by articulatory suppression, it seems worthwhile to consider, on the one hand, the relationship between short- and long-term memory codes, and, on the other, the appropriateness of encoding for the task to be performed. For example, within a framework such as the working-memory model (Baddeley, 1986; Baddeley & Hitch, 1974), the effect of suppression is explained in terms of the disruption of phonological codes in an articulatory loop that is impli-

cated in verbal STM. We suggest that phonological recoding in verbal STM during learning prompts the establishment of some form of verbal or propositional code in LTM that, in turn, is detrimental when the task to be performed requires the recovery of visual information. We assume further that by preventing subjects from subvocally rehearsing names of the pictures in STM, suppression has the effect of emphasizing the establishment of a visual code. The effect of labeling (Experiment 2) is consistent with this interpretation if we assume that the presence of labels is another means of encouraging the establishment of verbal or propositional codes in LTM and that this is at the expense of visual coding in LTM.

An interesting and important further question concerns the possible role played by semantic coding in the effects we have described. In Experiment 2, for example, the disruptive effect of labeling on imagery for low-nameability items could reflect the increased availability of semantic codes. However, although it is true that differences between semantic and visual coding could account for the effects of labels, it seems very difficult to explain the effects of articulatory suppression in a similar way. There is ample evidence that articulatory suppression disrupts phonological coding in STM but no evidence that it interferes with the generation of semantic representations (see, e.g., Baddeley, 1986).

A related concern is that the high-nameability items may have been more "object-like" and that this may have influenced the results. However, although we accept this as a possibility, it is difficult to see how it could be used to explain the effects of suppression on performance. Hence, on grounds of parsimony we favor an interpretation of the present data in terms of a tradeoff between visual and verbal coding that is mediated by phonological STM, rather than in terms of a tradeoff between visual and semantic or object coding. Interestingly, the working-memory model (Baddeley & Hitch, 1974) predicts that there will be just such a tradeoff, since, although they are partially independent of one another, the visual and phonological subsystems of working memory compete for limited central processing capacity.

As already noted, the effects of articulatory suppression and labeling on mental image transformation raise the question of the appropriateness of encoding for the task to be performed. It is interesting that for certain types of imagery tasks, the use of verbal coding does *not* prevent subjects from successfully reinterpreting a mental image. For example, people hearing a name of a familiar item can easily generate a mental image of that item and reinterpret it in mental imagery (see, e.g., Finke, Pinker, & Farah, 1989; Kosslyn, 1980). However, this situation may be limited to tasks in which the generation of a *prototypical* image formed on the basis of a name is enough for the task to be successfully performed. When, as here, the imagery task requires that a *specific* visually accurate image is formed on the basis of a previously seen stimulus, the use of the verbal code is detrimental (see

also Cornoldi, De Beni, & Pra Baldi, 1989, on the distinction between general and specific images).

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