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VERBAL MEDIATION AND MEMORY FOR NOVEL FIGURAL DESIGNS:
A DUAL INTERFERENCE STUDY

by
Noah Silverberg

A Thesis Submitted to the Faculty of Arts and Social Sciences through the Department of
Psychology for the Degree of Masters of Arts at the University of Windsor

Windsor, Ontario, Canada

2004

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Abstract

Verbal mediation is intrinsic in so-called "visual" memory processing, since all types of visual stimuli can be verbalized to some degree. This impurity complicates the interpretation of visual memory performance, particularly in certain neurologically impaired populations (e.g., aphasia). The purpose of this study was to investigate the relative contributions of verbal mediation to recognition memory for visual stimuli that vary with respect to the degree to which they can be verbalized. In Experiment 1, subjects attempted to verbally describe novel figural designs during presentation and then identify them in a subsequent recognition memory test. Verbalizing these designs facilitated memory. Stimuli that were found to be easiest or most difficult to verbalize at the group level were retained for the second study. In Experiment 2, control subjects evidenced superior recognition memory for the relatively easier to verbalize items. This advantage was attenuated in subjects who performed a concurrent verbal interference task during encoding, but not in those who performed an analogous visual interference task. These findings provide evidence that impoverished verbal mediation is sufficient to impair visual memory performance, and that this effect is more pronounced for material that is relatively easy to verbalize. Implications for the clinical assessment of visual memory are discussed.

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Verbal Mediation and Memory for Novel Figural Designs:

A Dual Interference Study

Introduction

The distinction between "material-specific" systems responsible for long-term memory for verbal or visual information has been supported by patient dissociations (Butters, Lewis, Cermak, & Goodglass, 1973; Chelune & Bornstein, 1988; Milner, 1971), differential activation on functional magnetic resonance imaging (fMRI; Martin et al., 1999), and factor analytic studies (Millis, Malina, Bowers, & Ricker, 1999; Price, Tuslky, Millis, & Weiss, 2002; Vanderploeg, Curtiss, Schinka, & Lanham, 2001; but see Smith, Malec, & Ivnik, 1992; Wilde et al., 2003). These verbal and visual memory systems appear to be asymmetrically represented in the human brain. A robust association between verbal memory and the left temporal lobe has been demonstrated, as well as a, albeit equivocal, relationship between visual memory and the right temporal lobe (Bell & Davies, 1998; Lee, Yip, & Jones-Gotman, 2002).

Although material-specific memory systems are structurally and functionally discrete, they are interconnected. Paivio's (1971) dual-code model posits that the encoding of information, at minimum, occurs at the representation level – words activate the verbal system and pictures activate the visual system. Representational encoding occurs automatically and can constitute an adequate memory trace (Paivio, 1990). Elaboration through referential encoding enhances the memory trace, making it more accessible. Referential encoding occurs when representations from the other system are generated, thereby promoting a dual trace (e.g., verbally labeling primarily visual

material). Healthy individuals spontaneously engage in this type of encoding (e.g., Brandimonte, Hitch, & Bishop, 1992), the degree to which depends on the task context and on individual differences in ability and propensity to do so (Paivio, 1990).

Upon presentation, to-be-remembered material is processed by the material-specific components of working memory. The verbal subsystem (the “phonological loop”) maintains speech-based information such as letters, numbers, and words (Baddeley, 1992). It includes a very brief acoustic store within which memories fade unless they are refreshed through subvocal rehearsal (Baddeley & Hitch, 1994). In addition to processing verbal information, the phonological loop is also capable of subvocalizing and rehearsing the verbal label of a visual stimulus (Baddeley & Hitch, 1994). The “visual-spatial sketchpad” processes both the identity and location of objects in space. There is an ongoing debate regarding the separability of this system into visual and spatial subcomponents; patient dissociations as well as selective distractibility in unimpaired individuals support this revision of the working memory model (Baddeley, 1992; Carlesimo, Perri, Turriziani, Tomaiuolo, & Caltagirone, 2001; Hecker & Mapperson, 1997). Although the process by which information in working memory is consolidated into long-term memory remains poorly understood (Baddeley, 2002), the way that information is encoded likely influences how it gets stored (Brandimonte et al., 1992).

The interconnectivity of material-specific memory systems has implications for the interpretation of so-called “visual” memory performance. Because supplemental verbal mediation contributes to the encoding of visual material, the “pure” measurement of visual memory is impeded. Visual or visuospatial memory tests typically require

subjects to study objects, geometric shapes, complex designs, or faces, as well as the spatial locations of these stimuli. These types of stimuli are amenable to supplemental verbal encoding to a greater or lesser extent. Common objects and simple figural designs can be easily labeled or described in verbal terms (e.g., "hat" or "bisected diamond"). Similarly, relative spatial locations can be captured by a few words ("upper right" or "just above"). More complex unfamiliar visual stimuli may require highly elaborative verbal descriptions. Even random polygons and scribbles are verbalized to some extent (Boller & De Renzi, 1967; Vanderplas & Garvin, 1959).

Another corollary of interconnectivity is that supplemental verbal codes can enhance visual memory performance. For example, pictures of common objects presented with their verbal labels are remembered better than pictures presented alone or with unrelated labels (Snodgrass, Wasser, Finkelstein, & Goldberg, 1974). Moreover, memory performance for pictures or shapes in unimpaired participants or amnesic patients can generally be improved by instructing subjects to engage in verbalizing (Ellis & Daniel, 1971; Federico & Montague, 1975; Mayes, Meudell, & Neary, 1980; Paivio, 1990; Price & Slive, 1970), although this finding has not been universally supported (e.g., Vanderplas & Garvin, 1959). In fact, memory for visual material can be impeded by verbalization under certain conditions – a well established effect referred to as "verbal overshadowing." This phenomenon arises when individuals are explicitly instructed to verbalize inherently nonverbal information (e.g., taste; Schooler, 2002; Schooler & Engstler-Schooler, 1990).

This exception aside, loss of the opportunity to apply verbal codes appears to impede visual memory, as aphasic patients perform poorly on a variety of visual memory

tests. Gainotti, Caltagirone, & Miceli (1978) found that aphasic patients actually performed worse than right hemisphere-damaged patients on a memory test of abstract color designs. Boller and De Renzi (1967) and De Renzi (1968) demonstrated that left hemisphere-damaged patients with aphasia were more impaired than patients with right hemisphere damage (and no aphasia) on tests of memory for both common objects and nonsense figures. Similarly, Boller and Spinnler (1967) found that a sample of aphasic patients performed worse than non-aphasic patients on memory for color stimuli (with distinctive names) and hues falling within the same color name (e.g., shades of green). These studies included patients with lesions that were restricted to one hemisphere, but of heterogeneous location (within that hemisphere), severity, and etiology. Therefore, in addition to some variety of aphasic syndrome, these patients likely had a other cognitive deficits that may have contributed to their impaired performance.

Aphasics may do poorly on so-called "visual" memory tasks because of their word-finding problems or paraphasic errors, since either problem would render them unable to benefit from verbal mediation (Brewer, 1969; Goodglass, Denes, & Calderon, 1974; Kelter, Cohen, Engel, List, & Strohner, 1977). Language deficits could result in poor description generation, impoverished verbal rehearsal, phonemic confusion, or susceptibility to linguistic interference (Kelter et al., 1977; Locke & Deck, 1978; Riege, Metter, & Hanson, 1980). Multiple lines of converging evidence have prompted this account of the findings, including a strong correlation between visual memory performance and a measure of language functioning in a mixed clinical sample (Gainotti et al., 1978). Moreover, when verbal labels of targets and distracter items were phonemically similar, memory performance decreased for controls, but not for aphasics

(Goodglass et al., 1974). Whereas control subjects recalled pictures with high frequency verbal labels more easily than those with low frequency verbal labels, aphasic patients recalled both stimulus types with equal accuracy (Locke & Deck, 1978). The visual memory functioning of patients with left-hemisphere damage and no or minimal aphasia is better than patients with left-hemisphere damage and aphasia (De Renzi, 1968) and similar to that of control subjects (Riege et al., 1980). In addition, after co-varying out scores on confrontational naming and sentence comprehension tasks, left hemisphere patients were no longer more impaired than right hemisphere patients on two visual memory tasks (De Renzi, 1968).

Alternatively, aphasics may perform poorly on visual memory tasks not because of language impairment per se, but because of concomitant verbal memory difficulties. Overt and covert verbal mediation are highly related, but distinct; an aphasic's confrontational naming ability may be insufficient for accurate oral naming, but still contribute to covert verbal mediation (Buchanan, McEwen, Westbury, & Libben, 2003; Locke & Deck, 1978). Left hemisphere-lesioned patients with or without aphasia are often impaired on digit span, word list learning, and story recall tasks (Burgio & Basso, 1997). Aphasic patients are impaired at retrieving target words (through spontaneous recall) and discriminating target words from distracters (recognition) after a short or long delay, whether they are presented orally or visually (Cermak & Tarlow, 1978; Riege et al., 1980). In other words, impaired visual memory in aphasia may arise from problems remembering verbal descriptions rather than generating them. Finally, as De Renzi (1968, pg. 184) suggested, impaired visual memory in left-hemisphere patients may result from a deficit in “transforming meaningless figures in meaningful ones.” For novel

designs to be verbalized, they (or components of them) must first be recognized to resemble something meaningful, and left hemisphere structures (in proximity to language zones) may be important for this process.

Stimulus type may be an important moderator of the effect of impoverished verbal mediation on visual memory performance. Goodglass et al. (1974) compared aphasics and non-aphasic brain-damaged controls on two visual memory tasks. Whereas the recall of controls was far superior for pictures of common objects than for nonsense designs, the difference was minimal in the aphasic group. These results are difficult to interpret because common objects are not only easier to name, but may also be more easily remembered because they possess rich semantic associations based on retrograde knowledge, both verbal and nonverbal (visual, olfactory, tactile, auditory, gustatory, affective, and so on).

Using novel visual stimuli (faces, scenes, and abstract patterns), Golby et al. (2001) examined the memory performance of healthy subjects with or without a concurrent letter string recall task during encoding. Memory for each stimulus type was assessed under an old/new recognition paradigm. Subjects in the interference condition identified fewer target items on all three tasks. The magnitude of this effect was most pronounced for the scenes, less so for faces, and less still for patterns. These findings were taken to suggest that verbal processes contribute to memory for all three types of visual stimuli, and that scenes were more verbalizable than faces, which were more easily verbalizable than patterns. However, there are other tenable interpretations of these data. The observed effects of the interference task may have been attributable to the added attentional demands of the task, rather than its verbal nature. Without an additional nonverbal

interference task to serve as a comparator, the attribution to disrupted verbal processes cannot be confirmed. Also, the authors' post-hoc determination of differential verbalizability between the stimuli types is questionable in light of evidence that more difficult-to-verbalize stimuli are more affected by disruptions in verbal coding.

The "verbal-loop hypothesis" (Brewer, 1969; Glanzer & Clark, 1964) predicts that unfamiliar abstract visual material requires more complex verbal codes and so aphasic patients have even greater difficulty with these. In support of this model, Kelter et al. (1977) demonstrated that aphasic patients performed similar to controls when the memory stimuli were readily verbalizable (common objects), but performed worse than controls when the stimuli were more difficult to verbally recode (snowflakes).

Whitehouse (1981) found that a faster stimulus presentation rate (thought to limit secondary verbal recoding) caused a larger drop in right hemisphere-lesioned patients' recall of nameable pictures compared to abstract pictures, whereas a similar decrement in recall for both types of pictures was observed in left-hemisphere-lesioned patients. A study with unimpaired subjects also found that a concurrent verbal task (counting backwards) similarly decreased recall of seemingly easy to verbalize stimuli (letters) and difficult to verbalize stimuli (disguised Hebrew characters) (Postma & de Haan, 1996).

In summary, verbal mediation appears intrinsic to visual memory processing, but the effect of impoverished verbal mediation on visual memory test performance is not well understood. It is clear that left hemisphere damage impairs performance on an array of experimental and clinical measures of visual memory. It is less clear whether language deficits underlie this phenomenon, and whether stimulus type mediates this effect. As such, the purpose of the present study was to determine if impoverished verbal

mediation is sufficient to impair visual memory performance, and whether relatively easy- or difficult-to-verbalize material is most affected. These research questions would be difficult to address by testing left hemisphere-lesioned patients, because the alternative explanations discussed above could not be ruled-out. Selectively disrupting verbal/visual mediation in neurologically intact individuals would allow for better control.

Dual interference tasks have been used to mimic the effects of circumscribed brain damage (Andrade, 2001). They have been shown to selectively disrupt verbal, visual, or spatial aspects of working memory. An effective interference task that disrupts the phonological loop without influencing visuospatial performance is a concurrent digit span task (Baddeley, 1992; Smyth, Pearson, & Pendleton, 1988). Interfering with the phonological loop should also limit the contributions of supplementary verbal codes to memory for visual items by disrupting their generation and rehearsal. In support of this, articulatory suppression has been shown to remove the phonological similarity effect (poorer short-term memory for similar sounding words) when word stimuli are presented visually (Baddeley, Lewis, & Vallar, 1984). The visual-spatial sketchpad has proven insensitive to a variety of visual distractions including irrelevant visual noise and irrelevant non-language noise (Andrade, 2001; Kortenkamp, 2001). However, concurrent spatial tasks (e.g., perceptuomotor tracking) interfere with memory for spatial locations (e.g., Corsi Blocks Test performance), but not for visual stimuli (e.g., matrix pattern recall; Della Sala, Gray, Baddeley, Allamano, & Wilson, 1999; Smyth et al., 1988). The converse pattern is seen with a concurrent visual interference task with little spatial demand (Cocchini, Logie, Della Sala, MacPherson, & Baddeley, 2002; Della Sala et al., 1999).

Long-term memory performance unequivocally drops when attention is divided during encoding (Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Fernandes & Moscovitch, 2000). The magnitude of this decline varies systematically with the difficulty of the concurrent task (Craik et al., 1996). Whereas encoding appears to place heavy demands on attention, processes involved in recall or recognition appear far less susceptible to interference. When subjects perform a retrieval task (e.g., word list recall) and a dissimilar concurrent task (e.g., digit monitoring), memory performance is only marginally affected (Baddeley, Lewis, Eldridge et al., 1984; Craik et al., 1996). However, interference with retrieval processes can be achieved with similar memory and concurrent tasks, such as word recall and word monitoring (Fernandes & Moscovitch, 2000).

Experiment 1

One purpose of the current study was to demonstrate the positive effects of verbal mediation on memory for novel figural designs. This was a necessary first step because (a) the hypotheses for Experiment 2 rest on this assumption, and (b) previous research has shown that verbal mediation does not universally improve memory for all types of visual material. The second purpose of this study was to obtain verbalizability data on a set of novel visual stimuli. With this information, empirically demonstrated easy-to-verbalize and difficult-to-verbalize figural designs that are all novel could be selected for Experiment 2.

Method

Participants

Participants were undergraduate students from the University of Windsor. A total of 29 subjects volunteered in the study, and received bonus credit.

Materials

112 stimuli were constructed using OmniGraffle 2.0.4 for Macintosh. Stimuli were all novel figural designs such as scribbles, irregular polygons, and combinations of geometric objects of moderate complexity, inspired by published clinical tests of visual memory. See Figure 1 for some examples. All items were equal in line thickness and overall size. Of the 112 stimuli, a randomly selected set of 92 items was shown to subjects in the presentation phase. The remaining 20 items were used as foils for the recognition phase. A subset of 20 items from the 92 studied items was randomly selected as targets in the recognition task.

Procedure

Ninety-two items were presented in random order, for 2 seconds each and 3 seconds apart. The task instructions, adapted from Vanderplas and Garvin (1959), were as follows: "I will show you a number of pictures, one at a time. What I want you to do is to look at each of them and tell me the first thing that comes to your mind when you see it. You may or may not think of something, so if nothing comes to your mind, you can just say *No*." They were also warned that their memory for those items would be tested. Subjects' responses to each item were recorded verbatim.

Immediately following the presentation trial, subjects were instructed to work through a series of mazes, drawing a line from *start* to *finish* without crossing through walls or cutting corners. They were also told to work as quickly and efficiently as they could until told to stop. The examiner monitored their performance and pointed out rule-breaks. Participants were told to stop after 2 minutes elapsed, regardless of their progress through the mazes. Following the completion of this filler task, participants completed a forced-choice recognition task in which they were shown 40 items, one at a time, and asked to decide whether each was or was not shown to them previously. Target and foil items were ordered randomly, but presented in a fixed sequence to all subjects. If no response was spontaneously provided within 10 seconds, they were encouraged to take their best guess.

Figure 1. Examples of visual memory stimuli.

Results

Responses were coded according to criteria that were adapted from Eadie and Shum (1995). Items were considered to have been verbalized when the subject provided (i) a concrete label (e.g., "overlapping circles", "down arrow", "flat building"), or (ii) a letter or number they thought the item resembled (e.g., "weird S", "sideways four"). Items were considered not to have been verbalized when the subject (i) did not offer any verbal description (responded negatively or 3 seconds elapsed), or (ii) provided a vague category descriptor (e.g., "some lines", "squiggles", "random shapes"). Ambiguous responses (e.g., "roads", "puzzle piece", "pick-up sticks", "piping") that could seemingly describe the visual appearance of many items equally well were considered to be category descriptors if they were provided for two or more items. Verbal labeling was predicted to be highly idiosyncratic, so inter-subject label agreement was not considered.

The percent of correctly recognized targets (ratio of hits to targets) was calculated separately for verbalized targets and those not verbalized. The number of targets verbalized by each subject ranged from 5 to 19 (Median = 10). Subjects correctly identified 90.5% ($SD = 11.0$) of the items that they verbalized during presentation. In contrast, they only correctly identified 74.6% ($SD = 15.9$) of the items that they did not verbalize during presentation. A t -test revealed that this difference was significant, $p < 0.01$. This discrepancy was unlikely due to item differences in visual complexity, since the relationship between the proportion of subjects verbalizing each item and the visual complexity (number of figure inflexions) of each item in the entire corpus was not significant ($r = .02$, $p > .05$). This weak association was likely secondary to the low variance in item complexity. The extent to which subjects engaged in verbalization was

also found to be positively related to recognition memory performance. The number of targets that subjects verbalized correlated at $r = .35$ ($p < .05$) with total recognition scores (hits + correct rejections).

A verbalizability index (VI) was calculated for each item. This index was the proportion of subjects who verbalized that item, and could potentially range from 0.0 to 1.0. VIs in the 92-item corpus ranged from 0.178 to 0.964, with a mean of 0.554 ($SD = 0.247$).

Experiment 2

The purpose of this experiment was to investigate the effect of impoverished verbal mediation on memory for different types of visual stimuli. To this end, subjects who performed a concurrent verbal interference task during the encoding of visual stimuli were compared to subjects who either performed no interference task or an analogue visual interference task. The visual memory stimuli were relatively easy-to-verbalize and difficult-to-verbalize items selected from Experiment 1. Because verbalizing the designs was shown to facilitate memory performance in Experiment 1, participants in the no interference condition were predicted to show an advantage for the items with high-VIs (high-VI) over the items with low-VIs (low-VI). Because other important properties of the stimuli (novelty, visual similarity, and visual complexity) were held constant, this difference would reflect the relative verbalizability of the high-VI items.

In light of the literature demonstrating that dividing attention during encoding impedes memory performance, a reduction in overall recognition accuracy in the two interference conditions compared to the no interference condition was expected. With regard to the pattern of high-VI versus low-VI memory performance in the verbal distraction condition, the verbal-loop hypothesis (Brewer, 1969) predicts that stimuli with low-VIs will be more affected by disruptions in verbal mediation because they have lengthier, more complex verbal descriptions and therefore represent a more difficult verbal task. Although subjects in Experiment 1 usually declined or appeared unable to provide overt verbal labels for low-VI items, they may have covertly generated lengthy ones. Therefore, this hypothesis seems reasonable. In contrast, the verbal descriptions associated with high-VI items tended to be only a word or two. The opposing view

(Golby et al., 2001) holds that subjects have difficulty generating any useful verbal descriptions of low-VI stimuli and so verbalizations do not significantly contribute to memory performance under passive viewing conditions. Consequently, according to this view, disrupting verbal mediation will have relatively little affect on memory for these items because subjects, for all practical purposes, cannot verbalize them. On the other hand, verbal mediation does make a considerable contribution to memory for high-VI items, and so any compromise in verbal mediation will impede recognition of these items. Insofar as the concurrent visual interference stimuli (matrix patterns) are not readily verbalizable, high-VI/low-VI performances should mirror that of the no interference condition (i.e., relatively better recognition memory for high –VI items).

Method

Subjects

Participants were University of Windsor undergraduate students recruited from the Research Participation Pool. A total of 96 subjects took part in the study. Subjects participated on a voluntary basis and received course credit.

Materials

Visual memory stimuli.

Of the 92 stimuli used in Experiment 1, 30 high-VI and 30 low-VI items were retained for the present study. The VI's of the high-VI item set ranged from 0.643 to 0.964, with a mean of 0.812 (SD = 0.108). The low-VI item set had VIs between 0.178 and 0.393, with a mean of 0.279 (SD = 0.071). Note that not only did the mean VIs of these stimulus groups significantly differ, the frequency distributions do not overlap. To provide context, these verbalizability indices can be compared to stimuli from two

published visual memory tests. Eadie and Shum (1995) administered stimuli from the Biber Figural Learning Test (Glosser, Cole, Khatri, DellaPietra, & Kaplan, 2002) and the Shum Visual Learning Test (Shum, O'Gorman, & Eadie, 1999) to 80 healthy individuals under the same instructions adopted in Experiment 1 of this study. Items from the former measure were combinations of geometric objects. Their VIs ranged from 0.4 to 1.0, with a mean of 0.67 ($SD = 0.24$). VIs for items from the latter measure (Chinese characters) ranged from 0.2 to 0.8, with a mean of 0.40 ($SD = 0.24$). This comparison confirms that our high-VI and low-VI items were relatively very easy and very difficult to verbalize, respectively.

Attneave (1957) explored the contribution of various perceptual variables to visual memory performance. He had subjects rate randomly generated polygons on curvedness, symmetry, and complexity. Only complexity, defined as the number of inflections (angles or curves) was (inversely) related to memory performance. Murphy and Hutchinson (1982) found a main effect of both symmetry and complexity in memory for unfamiliar polygons, but did not investigate the effect of symmetry independent from complexity. After equating similar stimuli on information content, Attneave (1955) found no difference between memory for symmetrical and asymmetrical designs. In summary, it appears that, other factors being equal, visual complexity is the most important perceptual variable involved in visual memory. Our high-VI items averaged of 7.47 inflections ($SD = 3.22$), as did the low-VI items ($SD = 1.78$). In other words, the high-VI and low-VI items were equated on visual complexity.

Another fundamental principle of recognition memory is that distracter similarity moderates task difficulty. In other words, the more visually similar target items are to

distracter items, the more challenging discriminating between them will be. To ensure that high-VI and low-VI items did not differ in inter-item similarity, 10 randomly sampled pairs of each were presented to 12 undergraduate students at the University of Windsor in alternating order. Subjects were asked to rate each pair on visual similarity, using a 4-point scale (“very dissimilar” to “very similar”). A *t*-test revealed that high-VI and low-VI items did not differ on these ratings ($p = .67$).

A recognition paradigm was chosen because it has demonstrated the best sensitivity and specificity to right temporal lobe pathology (Barr, 1997). A yes-no response format was selected over a forced-choice format because the former requires recollection-based judgments whereas familiarity-based judgments (relative feelings of familiarity) are sufficient for the latter (Bastin & Van der Linden, 2003). Half of the high-VI and low-VI items were randomly assigned as targets and the other half as distracter items. Recognition memory for random shapes has been demonstrated to be invariant across 0, 15, and 30 minute delay intervals under conditions of passive observation and instructed verbalization (Ellis & Daniel, 1971). As such, a long delay between the presentation and recognition task appears not to add important information. The proposed experiment therefore adopts a 2-minute delay (with a filler task) in order to eliminate any contribution of short-term memory processes.

Digit recall.

Participants listened to the examiner read randomly generated number strings at a rate of two digits per second and were asked to recall the strings in serial order following a 3 second delay. Up to 10 seconds was allowed for a response. A digit span was determined for each subject by first administering them three trials of three-digit strings.

If subjects' recalled at least two of the strings correctly, the string length was increased by one digit. Administration of three trials at each difficulty level continued until the subject failed at least two out of three equally long strings. Individual digit span was determined to be the longest string that the subject succeeded on at least two out of three trials.

Visual pattern recall.

For this task, checkerboard-like patterns similar to those used in the Visual Patterns Test (Della Sala, Gray, Baddeley, & Wilson, 1997) were created. These stimuli are thought to be very difficult to verbally encode (Della Sala et al., 1999). Grids of 2.5cm-sided squares ranged from 3 x 3 to 6 x 6, and half of the squares in each grid were filled in black randomly. Individual pattern span was determined by a procedure adapted from Cocchini and colleagues (2002). Participants viewed patterns for 3 seconds each and were then provided with an empty grid and asked to place an *X* in the squares that were filled in the target pattern following a 3 second delay. Up to 10 seconds was allowed for a response. Subjects were first administered three trials of 3 x 3 patterns. If they correctly reproduced at least two out of three of these grids, they were administered three trials of incrementally larger (3 x 4, 4 x 4, ... 6 x 6) ones. This task was discontinued when a subject could not correctly recall at least 2 of 3 patterns at the same difficulty level. Individual pattern span was taken as the number of information units (filled squares on a grid) of the patterns of greatest difficulty that subjects correctly reproduced two or more of (e.g., 4 x 4 pattern = 8 units).

Procedure

Subjects were randomly assigned to the verbal interference, visual interference, or no interference condition. Subjects in the verbal interference condition were first

administered the digit span task and subjects in the visual interference condition were first administered the pattern span task. The difficulty of the interference task was determined by subjects' spans, to account for individual differences in working memory capacity. If the concurrent distraction task is too easy (subjects attain ceiling performance), it may not sufficiently interfere with the desired encoding processes. If it is too difficult, it may interfere with central processing, causing "subordinate processes to suffer" (Logie, Zucco, & Baddeley, 1990; Postma & De Haan, 1996). By giving each subject their maximum span in the concurrent interference task, their attentional resources will be fully taxed. This method enables better identification of "inadequate" performance on the interference task.

All stimuli were presented on a computer screen. Subjects in the no distraction condition were simply shown each target stimulus for 3 seconds each with a 10 second inter-stimulus interval. For subjects in either distraction condition, the presentation sequence went as follows: distracter item presentation, target presentation, distracter item recall, new distracter item presentation, new target presentation, and so on. In this way, subjects had to retain the distraction material during and immediately following the presentation of each memory target. So, a distracter item was presented immediately prior to the viewing of a target stimulus on each trial. Regardless of the length or complexity of distracter items, the duration of this part was 5 seconds for the concurrent digit recall task and 3 seconds for the concurrent pattern recall task. Next, a target stimulus was presented for 3 seconds, immediately after which recall for the prior distracter stimulus was prompted. Figure 2 illustrates this presentation procedure. Subjects in the concurrent digit recall task were provided with a period of 5 seconds in

which they were to respond. Those in the concurrent pattern recall task were encouraged to respond promptly, but no time restraints were imposed. On average, they took 6.16 seconds ($SD = 2.59$) to respond. In other words, the interstimulus duration was fixed at 10 seconds for the no distraction and verbal distraction conditions, but varied in the visual distraction condition (9.2 ± 2.6 seconds). Prior to this presentation phase, subjects in both distraction conditions first participated in four practice trials, consisting of 4 targets items with interspersed with 4 (verbal/visual) distracter items. All subjects were shown the same presentation list in a fixed order, which contained 30 intermixed high-VI and low-VI items.

Following the presentation phase, subjects worked on a maze task for 2-minutes, identical to the one described in Experiment 1. This task was intended to eliminate the recency effect from the presentation list. Finally, 60 intermixed targets and distracters were presented one at a time. Subjects were required to make a judgment about each item, indicating whether they were presented previously (“Yes”) or were not shown earlier (“No”). They were further instructed to guess if they were not sure.

Results

Participants were excluded if they performed at or below chance levels (total correct < 35 or total hits < 15/30) on the recognition memory task. In these cases, high-VI/low-VI difference scores could not be meaningfully interpreted. In addition, participants were excluded if their performance on the concurrent distraction task was extremely good (>90% correct) or extremely poor (<10% correct). The interference task

Figure 2. Pictorial representation of the presentation phase of Experiment 2 in the interference conditions: (a) verbal interference condition, (b) visual interference condition.

was thought to be insufficiently demanding if participants could perform nearly flawlessly on it while maintaining adequate recognition memory performance. Extremely poor concurrent performance was interpreted as this task being too difficult and likely infringing upon central resources, or the participant did not devote sufficient attention to it. After these exclusion criteria were applied, 75 subjects were retained for analysis, 25 in each condition: no interference, verbal interference, and visual interference.

The distributions of total correct scores on the recognition memory test (true positives + true negatives) across all conditions were negatively skewed, particularly in the no interference group. This was largely driven by correct rejections (true negatives), whereas hits (true positives) were relatively normally distributed. As a result, “hits” were adopted as the most reliable measure of recognition memory. A one-way analysis of variance indicated that there were significant differences in total hits between the three conditions, $F(2, 73) = 14.83, p < 0.01$. Tukey’s post-hoc testing revealed that subjects in the no distraction condition ($M = 25.00, SD = 3.06$) outperformed those in the verbal ($M = 21.12, SD = 3.37$) and visual ($M = 20.68, SD = 2.81$) interference conditions, which did not significantly differ from each other. On average, participants in the verbal interference group obtained a digit span of 5.76 ($SD = 1.05$) and achieved 70.27% correct ($SD = 18.63$) on the concurrent digit recall task. Those in visual interference condition obtained a pattern span of 6.40 ($SD = 1.41$) and achieved 55.47% correct ($SD = 23.27$) on the concurrent pattern recall task.

High-VI/low-VI discrepancies were examined through multiple methods. Within-group analyses (see Figure 3) demonstrated that the no interference group showed a

relative advantage for high-VI items over low-VI items, $t(24) = 6.90, p < 0.01$. The verbal interference group showed no such advantage, correctly recognizing high-VI items and low-VI items with similar accuracy, $t(24) = 1.13, p = 0.27$. In contrast, the visual interference group, like the no interference group, showed a significant high-VI over low-VI item advantage, $t(24) = 2.62, p < 0.05$. Next, the relationship between item verbalizability (as a continuous variable) and probability of correctly identifying it as a target was examined. The Pearson correlation coefficients were .46 for no interference group ($p < 0.05$), .15 for the verbal interference group ($p = 0.43$), and .31 for the visual interference group ($p < 0.05$). In other words, item verbalizability was positively related to item difficulty in the no or visual interference groups, but not the verbal interference group.

*Difference between high-VI and low-VI hits is significant at $p > 0.05$ level.

** Difference between high-VI and low-VI hits is significant at $p > 0.01$ level.

Figure 3. Recognition performance (number of hits) for high-VI and low-VI items across all conditions.

Between-group contrasts were also performed. Intraindividual high-VI versus low-VI discrepancies were dichotomized as showing a high-VI advantage ($\text{high-VI} - \text{low-VI} > 0$) or not ($\text{high-VI} - \text{low-VI} \leq 0$). Of participants in the no interference condition, 92% (23/25) demonstrated an advantage. In contrast, only 48% (12/25) of participants in the verbal interference condition showed this advantage. Chi-squared analyses revealed that this difference was significant, $\chi^2(1, N = 50) = 11.52, p < 0.01$. Seventy-two percent (18/25) of participants in the visual interference condition evidenced a high-VI over low-VI advantage, which was not significantly different from those in the no distraction condition, $\chi^2(1, N = 50) = 3.39, p > 0.05$.

Finally, classification accuracy statistics were calculated to determine the potential utility of differentiating between groups of normal versus impaired verbal mediation. A difference score of zero was adopted as the optimal cut-off because it maximized sensitivity and specificity. The absence of a high-VI over low-VI advantage had mediocre sensitivity (52.0%), but excellent specificity (92.0%) at detecting impaired verbal mediation (verbal interference group versus no interference group). Positive predictive power and negative predictive power were 86.7% and 65.7%, respectively.

General Discussion

The main finding of Experiment 1 was that subjects better remembered items that they verbalized during presentation compared to those that they did not verbalize. Also, individuals' propensities to verbalize were significantly correlated with their memory performance. Thus, the results suggest a beneficial effect of spontaneously verbalizing novel figural designs.

Based on the proportion of subjects who verbalized each item, the easiest (high-VI) and most difficult (low-VI) to verbalize items from Experiment 1 were used as stimuli in Experiment 2. In this study, undistracted subjects demonstrated an advantage for easier to verbalize items in a recognition memory test. Because other important attributes of the stimuli (novelty, visual complexity, and visual similarity) were controlled, this discrepancy is attributed to the differential verbalizability of the stimulus sets. The finding that items that were more readily verbalized by an independent sample (Experiment 1 participants) were easier to recognize in a memory test in this sample suggests that although the content of verbal labels is idiosyncratic, the probability that an item will be verbalized can be reliably predicted.

This advantage for easier to verbalize items was attenuated when a verbal interference task was introduced during encoding, but not when the interference task was primarily nonverbal. Item verbalizability accounted for 21% of the variance in recognition memory performance in the no interference group, compared to only 2% in the verbal interference group. The contrast with the visual interference group made it clear that it was not merely the added attentional demands of the interference task, but the verbal nature of it that mitigated the pattern of recognition memory for high-VI and low-

VI stimuli. Although the high-VI/low-VI discrepancy patterns did not differ between the no and visual interference groups, there was a trend for the visual interference group to perform at an intermediate level to the other two. In other words, the concurrent pattern recall task appeared to attenuate the high-VI advantage somewhat, but much less so than the digit recall task. This suggests that, as expected, the matrix patterns were verbalizable to some degree.

The present study replicated those of Goodglass et al. (1974), but used all novel designs and “simulated clinical groups.” This more stringent design eliminated the possible confounds of differential familiarity of the stimulus sets and cognitive impairment outside of the language domain, allowing for the inference that controls better remembered the easy to verbalize stimuli because they were easy to verbalize, and that this advantage was attenuated in the simulated aphasia group because their verbal mediation was limited. By empirically determining item verbalizability ad-hoc and including a visual interference control group, the present results also provides support for the interpretations of Golby et al. (2001), who concluded that the greater the detriment to memory for a type of stimuli in the face of verbal interference conditions, the easier those stimuli are to verbalize. In other words, this study demonstrates strong support for the intuitively driven hypothesis that readily verbalizable visual material is more affected by disruptions in verbal mediation.

In so doing, the verbal loop hypothesis is refuted. This model predicted that dysfunctional verbal mediation would have exaggerated the high-VI over low-VI disparity rather than attenuate it. Verbal mediation may well contribute to memory for difficult to verbalize stimuli, but apparently, to a lesser extent than more readily

verbalizable items. This is consistent with the notion that when verbal recoding is exceedingly challenging, it may actually be detrimental to memory performance, as suggested by theories of verbal overshadowing. The present findings may be reconciled with previous studies showing support for the verbal-loop hypothesis when the type of stimuli used in those experiments are examined. Their “easily nameable” stimuli were all familiar pictures, and so are not directly comparable to novel material for reasons discussed above. Also, on the spectrum of ease of verbalizability, these stimuli are at such an extreme that they could be likely be named even in the face of a mild to moderate language disruption.

The results also shed light on the poor specificity and sensitivity of visual memory tests to right hemisphere pathology. Previous research has repeatedly demonstrated that left-hemisphere damage can lower scores on visual memory tests. These studies, however, could not divorce the effect of language deficits from other deficits (e.g., in verbal memory) that also may result from a left-hemisphere lesion. The present study provides experimental evidence that deficient verbal mediation is sufficient to impair memory for novel figural designs. In addition, the finding that individuals with dysfunctional visual processing automatically engaged in and benefited from verbal mediation adds further support to the hypothesis that the poor sensitivity of visual memory tests to right hemisphere pathology (Barr, 1997; Helmstaedter, Pohl, & Elger, 1995; Lee, Loring, & Thompson, 1989; Ogden-Epker & Cullum, 2001) is secondary to the inherent dual-codability of visual stimuli employed in research protocols (Glosser, Saykin, Deutsch, O'Connor, & Sperling, 1995). Support for this hypothesis also comes from research showing that less verbalizable stimuli show better sensitivity to right

temporal lobe pathology (Barr, 1997; Eadie & Shum, 1995) and greater right-lateralized fMRI activation (Golby et al., 2001).

The adverse impact of dividing attention during encoding on memory for novel figural designs was also demonstrated. This overall drop in recognition memory was observed whether the interference task was verbal or visual. This finding is consistent with previous research demonstrating that memory for various types of stimuli is impeded when attention is divided between encoding stimuli and performing some concurrent task. The results of Fernandes and Moscovitch (2000) suggest that a distraction task more similar to the primary stimuli would produce relatively more interference. Although the overall memory performances of the verbal and visual interference groups did not significantly differ, the latter performed more poorly on the concurrent task. However, equivalence between the two interference tasks cannot be assumed, and so this comparison may not be meaningful.

In addition to the theoretical implications above, the results may also better inform the clinical assessment of visual memory in neurologically impaired patients. Heilbronner (1992) argues that the measurement of memory for both easy and difficult to verbalize designs would enable a fractionation of "impaired visual memory." A comparison between these stimulus types may be useful for teasing apart the nature of visual memory impairment in brain-damaged individuals - deficient visual encoding or suboptimal employment of verbal mnemonic strategies. In turn, this may inform cognitive rehabilitations strategies, such as coaching patients to engage in verbal mediation.

The impurity of visual memory stimuli is typically considered problematic, and to

be the source of the disappointing utility provided by memory indicators of laterality. Indeed, there is large body of literature reporting the inadequacy of verbal versus visual memory comparisons at distinguishing unilateral epileptic foci (Morris, Abrahams, & Polkey, 1995; Sweet, Demakis, Ricker, & Millis, 2000; Kneebone, Chelune, & Lueders, 1997; Moore & Baker, 1997; Wilde et al., 2001; Loring, Hermann, Lee, Drane, & Meador, 2000; Ogden-Epker & Cullum, 2001). Perhaps the "confound" of verbalization can be capitalized upon by contrasting more pure versus less pure measures of visual memory. The classification accuracy analyses demonstrated that an absence of an advantage for more readily verbalizable stimuli may be a very specific, but fairly insensitive indicator of impoverished verbal mediation.

There is reason to believe, however, that this protocol would show greater discriminability between left and right hemisphere patient groups. Differences between memory for easy- and difficult-to-verbalizable stimuli in brain-damaged patients may be produced by a combination of their patterns of cognitive deficits and spared abilities. Unlike healthy individuals who can freely engage in secondary encoding, patients with focal brain lesions may be restricted in their mnemonic strategies (Golby et al., 2001). Patients with left-hemisphere damage may have difficulty generating, rehearsing, or consolidating verbal codes for visual stimuli. In contrast, patients with right-hemisphere damage may have an impoverished ability to store visual codes for verbal stimuli. Furthermore, patients may adopt compensatory strategies to capitalize on their spared cognitive processes and avoid their compromised abilities. For example, patients with right hemisphere lesions may rely more heavily on verbalizing visual material as a compensatory strategy (Chelune & Bornstein, 1988), whereas left hemisphere-lesioned

patients may depend more on encoding the visual characteristics of visual material.

These compensatory strategies should increase the likelihood that unique patterns of memory performance of right versus left hemisphere patients on easy versus difficult to verbalize visual stimuli can be observed.

The wide range of item VIs observed in this study indicates that novel figural stimuli such as those in common neuropsychological tests vary tremendously in their amenability to verbalization. Yet, the possibility that subjects can verbally recode stimuli of intended “visual” memory tests is not dealt with systematically in clinical interpretation. This highlights the need for objective measures of “ease of verbalizability” of the test stimuli as well as subjects’ ability and propensity to verbalize in order to obtain a valid index of visual memory skills. Some authors have attempted to circumvent this problem by creating stimuli that are extremely difficult to verbalize (e.g., Larrabee, Trahan, & Curtiss, 1992), thereby minimizing the influence of verbal mediation. While this approach shows promise, it weakens the ecological validity of visual memory testing (Heilbronner, 1992).

In conclusion, superior recognition memory for novel figural designs that were empirically-determined to be relatively easier to verbalize was demonstrated in unimpaired subjects. Introducing a concurrent visual task during encoding did not alter this pattern, but a concurrent verbal task eliminated the advantage for easier-to-verbalize items. This finding suggests that impoverished verbal mediation is sufficient to disrupt memory for novel visual material, and that this effect is more pronounced for material that is relatively easy- versus difficult-to-verbalize. With this knowledge, the visual memory test performance of individuals with language deficits can be interpreted with

greater accuracy. In addition, contrasting an individual's memory for easy- versus difficult-to-verbalize material appears to be a promising approach to determining the nature of their visual memory difficulties.

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