Relational and item-specific information in the determination of "blocking effects"

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Items organized ("blocked") by membership in common categories are generally better remembered than unorganized items. In experiments conducted by Gollin and Sharps (1988), however, this blocking effect was largely confined to verbal stimuli. In the present manuscript, we show that this result may reflect differences in the processing of item-specific and relational information, as first described by Einstein and Hunt (1980). This hypothesis requires that the blocking effect for verbal stimuli diminish over longer retention intervals and that this diminution be attenuated or arrested by instructional manipulations at encoding. The present results verified these conjectures and replicated the result of Gollin and Sharps (1988). The findings suggest that the results of Gollin and Sharps were predictable from the application of item-specific/relational information theory and that the theory may appropriately be applied to paradigms involving both verbal and nonverbal stimuli.

It is essentially axiomatic that the organization of stimulus materials into coherent units contributes to the efficiency of their recall (see Bower, Clark, Lesgold, & Winzenz, 1969; Cofer, Bruce, & Reicher, 1966; Cole, Frankel, & Sharp, 1971; Moely & Shapiro, 1971; Pollio, Richards, & Lucas, 1969; Tversky, 1973). However, the effects of stimulus organization on memory may vary among experimental situations. For example, the organization of verbal materials influences recall performance more than it influences recognition performance (e.g., Kintsch, 1968, 1970). The organization of verbal materials by category may improve memory for nouns that occur with high frequency in normal discourse but not memory for low-frequency nouns (Cofer et al., 1966). Finally, the imagery associated with specific nouns contributes to recall within uncategorized noun sets but not within categorized sets (Ritchey & Beal, 1980).

Gollin and Sharps (1988) showed that the organization of materials by category membership interacts with stimulus type to influence free recall. Adult subjects saw a sequence of small stimulus objects or the names of those objects printed on cards. The items came from four categories (animals, vehicles, kitchen things, and medical things) and were either presented "blocked" by category (all the animals followed by all the vehicles, etc.) or in an unorganized (unblocked) condition with the four cate-

gories mixed together. A 2-min retention interval was imposed, after which item recall was tested.

The expected blocking effect was observed within the printed name condition; the blocked printed names were significantly better remembered than unblocked names. However, no such effect was observed for objects. Additional experiments replicated these findings and also demonstrated the absence of a blocking effect when photographs of objects were used as stimuli.

A potential explanation for these findings was found in the work of Einstein and Hunt (e.g., Einstein and Hunt, 1980; Hunt & Einstein, 1981), who distinguished between the processing of information specific to individual items and the processing of relational information, such as category membership, shared between items. Both relational and item-specific processing are necessary for optimum recall, but the influences engaging those types of processing may be redundant under specific task circumstances (Hunt & Einstein, 1981). Since the verbal items used by Gollin and Sharps (1988) were simply the printed names of the stimulus objects and consequently bore the same categorical relationships as the objects, the verbal items did not differ from the objects in the relational information they provided. However, the objects and verbal items did differ in item-specific imaginal information. The objects, with which no blocking effects were observed, were encoded both with their specific mental images and with their names. The verbal items were not encoded with *specific* mental images. The names of objects, of course, provide imaginal information to subjects, as has been repeatedly demonstrated (e.g., Paivio, 1971, 1986; Paivio & Yuille, 1969). However, object names cannot provide *specific* item-relevant imaginal informa-

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tion: if a subject sees the word *elephant*, for example, the image created mentally is of a generic or perhaps ideal elephant, not of the specific elephant referenced by the name. Therefore, the names or verbal labels of objects provide what might be termed generic, rather than item-specific, imaginal information. This means that in the experiments of Gollin and Sharps, both verbal and imaginal *item-specific* types of information were present in the object conditions of these experiments; only verbal, not imaginal, *item-specific* information was available in the verbal-label conditions. Consequently, the mnemonic effect of relational information may have varied between the object and verbal-label conditions of Gollin and Sharps. The objects, which presented a high level of item-specific imaginal information, may have engaged sufficient relational and item-specific processing to render the additional relational information provided by blocking redundant, obviating the blocking effect. In the absence of item-specific imaginal information in the verbal-label condition, the relational information provided by blocking possessed nonredundant mnemonic value, resulting in the observed blocking effects (see Paivio, 1971, 1975, 1986).

The results of Gollin and Sharps (1988), then, appear explicable within the context of Hunt and Einstein's (1981) item-specific/relational information theory. Relational processing is clearly important for object memory. However, the mnemonic effect of the relational information provided by blocking may have been rendered redundant by the increased item-specific information provided by the use of actual objects as stimulus items. This may have removed the blocking effect observed in the verbal-label conditions. This interpretation of Gollin and Sharps's results implies that item-specific information may function differently, and perhaps be more critical, than relational information for free recall within the research framework used by Gollin and Sharps. Experiment 1 was a test of this hypothesis.

It has been known for at least six decades (Bartlett, 1932) that information in long-term memory is not permanently stored in a static manner but is gradually altered in the direction of loss of detail and retention of gist. Support for the contention that material in long-term memory may be altered has come from a variety of research areas (e.g., Butter, 1970; Loftus, 1979; Lynch & Yarnell, 1973; Yuille, 1971). As time passes, less-critical information is lost from memory. If relational information is less critical (see Penney, 1989) within the present task framework than item-specific information, then relational information should be more readily lost from memory than item-specific information, without regard to stimulus type (verbal versus nonverbal stimuli). Consequently, if memory for object and verbal-label stimuli were examined over longer retention intervals than has previously been the case, it would be expected that the recall of object stimuli would remain uninfluenced by blocking but that verbal-label stimuli would exhibit a blocking effect that diminishes with the passage of time.

EXPERIMENT 1

Method

Subjects. Eighty adults (mean age 20.8 years, *SD* 4.8) were recruited from introductory psychology classes. All subjects were shown by Snellen test to be able to resolve items smaller than those used in the experiment at the distance employed. The subjects were assigned at random to either a 2-min or 24-h retention-interval condition; they were assigned to the other conditions, detailed below, in a completely between-subject design.

Materials and Procedure. Forty small, common toy objects were used as stimulus materials. The objects came from four categories: animals, vehicles, medical things, and kitchen things. There were 10 items from each category. These items were similar but not identical to the objects used by Gollin and Sharps (1988). The categories were the same as in the earlier work. A pilot study of 20 subjects from the same population and age range demonstrated that all objects in all four categories were clearly recognizable and familiar to all subjects.

The names of these objects were printed in black letters approximately 3.2 cm high on 13 × 18 cm white cards. The objects and cards, respectively, were used in the object and label conditions of the experiment. Although it was not possible for the printed labels and the objects to subtend the same visual angles both horizontally and vertically at presentation, the differences in absolute size between objects and printed names were small, and the ratio of object/printed-label sizes did not differ between the conditions of the experiment.

The subjects were seated approximately 2 m from the experimenter, in small groups as is usual for this type of procedure (Gollin & Sharps, 1988; Hunt & Einstein, 1981). The subjects were informed that they would see a number of items and that they were to remember what these items were. The items, either objects or name cards, were then presented sequentially to the subjects for 5 sec per item. Items were presented by hand, by a trained and highly rehearsed experimenter. The experimenter was blind to the purpose and conditions of the experiment. This live-experimenter procedure was employed in order to duplicate as precisely as possible the conditions of Gollin and Sharps (1988).

The experimenter named each item orally as it was presented, in a procedure identical to that of Gollin and Sharps (1988). As in the previous studies, this oral naming was intended to minimize idiosyncratic and therefore unscorable responding on the part of the subjects. The previous studies and additional pilot work have demonstrated unequivocally that oral labeling or its absence have no observable effect on recall results (see Experiment 3 below for an additional test). Also, since the same labeling was applied to all conditions, it is exceedingly unlikely that any effects could have derived from its influence.

The items were presented either blocked by category or unblocked in prearranged orders in which no more than two items from the same category were presented sequentially. No buffer items were used at the beginning and end of the presentations because such items might interfere with the processing of category information. (However, as discussed below, primacy and recency effects between conditions were examined at analysis.) Item presentation was followed by a 2-min retention interval, during which the subjects solved multiplication problems. All subjects, both those in the 2-min and those in the 24-h conditions, engaged in this interpolated task, which was intended to control for the idiosyncratic effects of immediate rehearsal on recall performance. After 2 min, the subjects in the 2-min condition were asked to write the names of all the items they remembered. The subjects in the 24-h condition left the laboratory and returned between 23 and 25 h later for the recall task. It was, of course, not possible to control for potential differences of rehearsal or other activity in the 24-h groups after they left the labora-

Table 1
Mean Free-Recall and ARC Scores, With Standard Deviations,
From Experiment 1

	Names				Objects			
	Blocked		Unblocked		Blocked		Unblocked	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Free-Recall Scores								
2 min	27.90	4.43	16.00	2.26	22.90	5.22	26.50	3.57
24 h	15.50	3.57	18.30	3.94	20.80	4.96	23.00	4.90
ARC Scores								
2 min	.45	.29	.51	.24	.81	.19	.72	.25
24 h	.69	.19	.46	.12	.76	.21	.53	.24

tory. However, given that these groups were formed by random assignment, there is no reason to expect any difference in pertinent activity levels between groups other than those directly attributable to manipulation of the independent variables.

Following the free-recall task, the subjects were asked to identify the categories from which the items had come and were asked what memory strategies they had employed. Those few who were unable to do so or who employed unorthodox strategies (classical mnemonics such as the method of loci, the use of complex, integrative stories about items, or the construction of bizarre relations among items) were not included in the analysis of data.

Free-recall scores were recorded. Clustering at retrieval was measured by means of the adjusted ratio of clustering (ARC) score (Roenker, Thompson, & Brown, 1971).

Results

The results of this experiment are shown in Table 1. The effects of retention interval and stimulus type on free recall were significant [$F(1,72) = 16.02, p < .001, \omega^2 = .10$, and $F(1,72) = 20.72, p < .001, \omega^2 = .13$, respectively]; more items were recalled after 2 min than after 24 h, and objects were better recalled than printed names. The interactions of blocking with retention interval and of blocking with stimulus type were significant [$F(1,72) = 11.19, p = .001, \omega^2 = .07$, and $F(1,72) = 14.32, p < .001, \omega^2 = .09$, respectively]. The interaction of blocking, retention interval, and stimulus type was also significant [$F(1,72) = 16.91, p < .001, \omega^2 = .10$]. All ω^2 effect sizes were in the moderate-to-large range (Cohen, 1977). These effect sizes, coupled with the repeated previous finding of very similar patterns of results (Gollin & Sharps, 1988; Sharps & Gollin, 1986) with different populations, indicate the probable reliability of these findings. A Tukey B procedure ($p < .05$) was used for post hoc evaluation of these effects. This analysis demonstrated a significant blocking effect within the verbal-label condition at the 2-min retention interval. However, no such effect was in evidence at the 24-h interval, and no trend toward a blocking effect was observable at 24 h; indeed, the nonsignificant trend was in the opposite direction (see Table 1). No blocking effects were observed within the object condition at either interval. Primacy and recency effects were not shown to differ among the conditions of the experiment. No significant differences were observed

in the numbers of items recalled from each of the four categories.

The effects of blocking and of stimulus type were significant on ARC scores [$F(1,72) = 13.39, p < .001, \omega^2 = .13$, and $F(1,72) = 6.26, p = .015, \omega^2 = .05$]. Blocked stimuli tended to be clustered at recall more than unblocked items, and objects tended to be clustered more than verbal labels. Neither the effect of retention interval nor any interaction of these factors was significant on clustering.

Discussion

These results demonstrated that the blocking effect depended not only on stimulus type but also on retention interval. Within the object condition, no blocking effects were observed at either of the intervals employed. The absence of any blocking effect resulting from the use of object stimuli repeats the findings of Gollin and Sharps (1988) and, as discussed above, probably reflects the strength of the item-specific information involved.

Verbal-label stimuli, as expected, resulted in a powerful blocking effect at the 2-min retention interval. However, no such effect was observed with verbal labels over the 24-h interval. These verbal-label data are consistent with the hypothesis, advanced above, that within this task framework the type of relational information provided by blocking appears to lose relative mnemonic importance over time. Two minutes after encoding, blocking exhibited a powerful influence on the recall of printed names. Twenty-four hours after encoding, no such effect was in evidence. This is consistent with the idea of a differential decay of the utility of relational and item-specific information for recall performance.

The pattern of ARC scores observed was not predictable from the recall scores, although some predictable effects on ARC scores were observed (a significant effect of blocking and the absence of a significant effect of retention interval). Objects were found to be clustered at recall more than were verbal labels. This effect was not predicted, but it is at least understandable. The greater trace strengths associated with the object condition probably made their recall less effortful for subjects, allowing additional resources for the grouping of items by category in that condition. Similar results were obtained in earlier studies (Gollin & Sharps, 1988). These ARC results are consistent with the bulk of other work in this area, in which the correlation of clustering and recall scores has in general been shown to be less than perfect (Hunt & Einstein, 1981). The reasons for this still await empirical examination. However, as a working hypothesis, it seems reasonable to propose that clustering may reflect the beliefs of subjects about memory, rather than the actual mechanisms underlying recall performance: subjects may expect that clustering will aid their recall and therefore engage in clustering behavior, even though this activity actually has minimal mnemonic value within this

context. Consequently, it would be expected that clustering and recall scores would bear little relation to one another.

The subjects engaged in virtually the same clustering behavior (measured by ARC) at both 2-min and 24-h retention intervals. Clustering was associated with a significant blocking effect on recall after 2 min but not after 24 h; in other words, clustering within the blocked condition aided memory after 2 min but not after 24 h, even though the subjects engaged in the same level of clustering activity at both retention intervals. This means that the subjects who were presented with blocked stimulus materials were clearly aware of the category memberships of those materials at the longer retention interval; however, this awareness had no effect on their actual recall performance.

This finding that clustering did not diminish over the longer retention interval presents an interesting question. Although the blocking effect for verbal materials decreased over 24 h, clustering did not decline over this period. Subjects clearly remained aware of the category memberships of the stimulus items employed. So if the category framework was remembered, why did it fail to influence recall over the longer retention interval?

The most logical and parsimonious answer to this question is that relational information *per se* did not deteriorate but rather became less *accessible*. Although relational information still obviously existed in memory at the longer retention interval, it may not have been readily connected to item-specific information to influence recall. In other words, it is proposed that the *connections* between relational and item-specific information, not relational information *per se*, declined over the longer retention interval. Experiment 2 provided a partial test of this hypothesis.

EXPERIMENT 2

Tulving (1982) has presented a theory of synergistic ecphory, a general model of the retrieval of episodic information. In its most basic terms, the theory holds that an item to be remembered is encoded into a memory trace, together with cues and retrieval instructions from both the internal and external environment. Retrieval, then, requires the extraction of appropriate environmental information and the combination of that information with trace information. This is what is meant by ecphory, and the resultant combined information product is termed ecphoric information.

Item-specific information is central to the retrieval of items *per se*. Relational information may serve more to delineate the class of items from which items to be remembered are to be drawn. When considered in the context of the theory of synergistic ecphory, relational information therefore falls under the heading of cues and retrieval instructions from the internal environment rather than under the heading of the central memory trace, which includes item-specific information. Within this framework, the results of Experiment 1 and of Gollin and Sharps (1988) may be explained in terms of the difference be-

tween the memory trace (item-specific information) and associated retrieval instructions and cues (relational information). If, as proposed above, what is lost over long retention intervals is the connection between relational and item-specific information rather than relational information *per se*, then this can be viewed from Tulving's (1982) perspective as a loss of connections between the central memory trace and more peripheral environmental information.

Although the present results and those of Gollin and Sharps (1988) are consistent with this hypothesis, a considerable amount of empirical work will be required to verify or disprove it. As an initial effort, in Experiment 2 we attempted to create a situation in which relational information would be part of the central memory trace rather than being part of the more peripheral realm of environmental information. If this could be accomplished successfully and the hypothesis advanced above were correct, then the blocking effect would be restored for verbal materials at long retention intervals. This finding would indicate that the diminution of the blocking effect over time resulted not from any essential loss of relational information or of its potential importance for recall but rather from its location within an ecphoric system (central trace or peripheral environment) and the subsequent degree of difficulty in integrating or connecting it with the item-specific information included in the central trace.

Experiment 2 was predicated on the finding that prior knowledge of the subject matter of material to be remembered results in more effective recall of that material. Prior knowledge about the principles likely to govern incoming information may help to establish a framework for blocking and organizing that information, thus facilitating recall. In Experiment 1, prior knowledge of the category membership of items was not provided; the categories were identified by subjects as the items were presented. Although with only four categories subjects were of course aware of the category structure of the item set as the items were presented, there is strong evidence that being provided with such information *prior* to encoding enables the subject to create a prior strategic plan for encoding and retrieval and thereby enhances recall significantly (Bransford & Johnson, 1973). In Experiment 2, knowledge about relational information (category membership) was provided prior to the presentation of the items. This prior information was intended to form a central framework for recall: the working hypothesis was that this type of prior relational information, giving rise to a strategic plan for retrieval, would occupy the same central location as item-specific information, since it would be central to the process of encoding the stimulus materials. Category information not provided prior to encoding, although obviously preserved in memory, would not provide such a central, prior memory strategy and would consequently be more peripheral, in Tulving's (1982) scheme, to the retrieval process. Therefore, the mnemonic influence of relational information would not be expected to decline over time; the mnemonic connection of relational to item-specific information would be preserved. It was expected that with

Table 2
Mean Free-Recall and ARC Scores, With Standard Deviations,
From Experiment 2

	Names				Objects			
	Blocked		Unblocked		Blocked		Unblocked	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Free-Recall Scores								
2 min	30.40	3.66	24.00	3.86	32.00	3.20	28.10	5.0
24 h	22.10	4.46	13.70	3.23	23.20	5.14	25.40	6.13
ARC Scores								
2 min	.80	.19	.79	.27	.98	.03	.64	.31
24 h	.73	.30	.46	.18	.91	.13	.79	.21

the provision of prior knowledge of category, the blocking effect would be observed for printed name stimuli at both 2-min and 24-h retention intervals.

Method

Eighty adults (mean age 22.0 years, *SD* 6.6) were recruited from introductory psychology classes. The materials and procedures of Experiment 2 precisely replicated those of Experiment 1, except that in Experiment 2, the subjects were informed of the categories of the items to be remembered prior to their presentation.

Results

The results of the experiment are shown in Table 2. The effects of blocking, retention interval, and stimulus type were all significant at the $p < .001$ level [$F(1,72) = 17.27$, $\omega^2 = .08$, $F(1,72) = 63.18$, $\omega^2 = .31$, and $F(1,72) = 24.36$, $\omega^2 = .12$, respectively]. These main effects (ω^2) were moderate to very large in magnitude (Cohen, 1977). The interactive effect of blocking and stimulus type was significant [$F(1,72) = 10.71$, $p = .002$, $\omega^2 = .05$], as was the interaction of retention interval and stimulus type [$F(1,72) = 3.90$, $p = .05$, $\omega^2 = .02$] and the interaction of blocking, retention interval, and stimulus type [$F(1,72) = 3.90$, $p = .05$, $\omega^2 = .02$]. A Tukey B post hoc analysis ($p < .05$) was used to evaluate these effects. As in Experiment 1, no blocking effects were observed when objects were used as stimulus items. However, as expected, significant blocking effects were observed with verbal-label stimuli at both 2-min and 24-h retention intervals.

The effects of blocking and stimulus type were significant on ARC scores [$F(1,72) = 18.93$, $p < .001$, $\omega^2 = .16$, and $F(1,72) = 5.98$, $p = .017$, $\omega^2 = .04$, respectively]. The interaction of retention interval and stimulus type was also significant [$F(1,72) = 4.47$, $p = .04$, $\omega^2 = .03$], as was the interaction of blocking, retention interval, and stimulus type [$F(1,72) = 8.64$, $p = .004$, $\omega^2 = .07$]. No other interactions or main effects were significant on ARC scores.

Discussion

The absence of any effects of blocking in the object condition was expected; the absence of a blocking effect with this type of stimulus material has now been demonstrated in at least six experiments (including Gollin & Sharps, 1988; Sharps & Gollin, 1986). The ARC scores observed in the present study were again not entirely con-

sistent with the observed recall scores. Again, certain predictable trends such as a significant effect of blocking were observed, but the pattern of interactions was not consistent. As in Experiment 1, this pattern of ARC scores is believed to reflect subjects' employment of idiosyncratic memory strategies based on their knowledge and beliefs about memory rather than the actual mechanics of the recall process. Although this is conjectural, it appears at present to be the most parsimonious explanation of the results.

Provision of prior information about the category memberships of items resulted in blocking effects both 2 min and 24 h after encoding. These results were entirely consistent with the hypothesis advanced above and with the extrapolation of the synergistic ecphory theory and the Hunt and Einstein (1981) work previously discussed. The most parsimonious explanation of the findings would appear to be the one suggested above: that relational information on category membership may be encoded as part of a central memory trace and may remain a functioning part of the memory trace over the long term if the framework is installed prior to the learning of the materials to be remembered.

EXPERIMENT 3

Live-experimenter presentation was chosen for Experiments 1 and 2 to reproduce the procedures of Gollin and Sharps (1988) as closely as possible. Although a blind experimenter was employed in these procedures, it is possible that some form of experimenter bias might have influenced the results. Also, as in Experiments 1 and 3 of Gollin and Sharps (1988), the names of items presented were stated orally by the experimenter. Although in all previous studies this has been shown to produce no main or interactive effect on results, it was desirable to ascertain that oral presentation of item names did not interact with retention interval in some manner to produce the observed pattern of results. Finally, it seemed important to replicate the new effects observed within the verbal-label conditions of Experiments 1 and 2 and to examine these effects within the same experimental context. Experiment 3 was conducted to address these issues.

Method

Eighty adult subjects (mean age 20.96 years, *SD* 5.08) participated. In this experiment, the verbal-label items of Experiments 1 and 2 were presented using a Lafayette Instruments 41010-A projection tachistoscope controlled by a Lafayette 58010 timer. Presentation was entirely under automatic control. The experimenter did not label the items orally. The items were presented either unblocked or blocked, with either 2-min or 24-h retention intervals. The subjects were either informed of the category memberships of the items, as in Experiment 2, or were not so informed, as in Experiment 1. The object stimulus conditions were dropped from Experiment 3. Since no significant effects within those conditions were produced in either Experiments 1 or 2 and since the absence of a blocking effect has now been demonstrated with object stimuli in at least six experiments, it was not deemed necessary to include object presentation in the present experiment. With these exceptions, all procedures were exactly the same as those of Experiments 1 and 2.

Table 3
Mean Free-Recall and ARC Scores, With Standard Deviations,
From Experiment 3

	Names				Objects			
	Blocked		Unblocked		Blocked		Unblocked	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Free-Recall Scores								
2 min	26.90	3.73	17.00	3.56	24.20	3.08	16.90	4.15
24 h	14.80	3.97	17.40	5.02	20.60	4.35	13.80	3.36
ARC Scores								
2 min	.85	.17	.61	.25	.90	.17	.70	.26
24 h	.89	.18	.59	.27	.95	.12	.92	.16

Results

The results of this experiment are shown in Table 3. The effect of blocking was significant [$F(1,72) = 36.82$, $p < .001$, $\omega^2 = .21$]; blocked stimuli were significantly better remembered than unblocked items. The effect of retention interval was also significant [$F(1,72) = 27.22$, $p < .001$, $\omega^2 = .16$]; recall was better at 2 min than at 24 h. The interaction of blocking and retention interval was also significant [$F(1,72) = 13.59$, $p < .001$, $\omega^2 = .07$]. The effect of information was not significant: whether or not subjects received prior information about the category structure of items made no difference to their recall across conditions. However, the interaction of blocking, retention interval, and information was significant on recall [$F(1,72) = 11.58$, $p = .001$, $\omega^2 = .06$]. This result replicates the pattern obtained in Experiments 1 and 2. When subjects were uninformed of category structure, a significant blocking effect was observed with a 2-min retention interval but not with a 24-h interval. When information about category structure was provided, however, significant blocking effects were observed at both retention intervals.

The effects of blocking and information were significant on ARC scores [$F(1,72) = 18.29$, $p < .001$, $\omega^2 = .16$, and $F(1,72) = 8.45$, $p = .005$, $\omega^2 = .07$, respectively]. Both the blocking of stimuli and prior information about category membership increased clustering at recall. No other effects or interactions were significant on ARC scores.

Discussion

These results are consistent both with the pattern established in Experiments 1 and 2 and with the hypotheses advanced above. The results of Experiment 3 indicate that neither experimenter bias nor oral labeling was important for the preceding results and that these results are reliable within this experimental paradigm.

EXPERIMENT 4

One unanswered question concerning these findings was the degree to which the nature of the stimulus items might have influenced their assignment to categories. Toy items

used in the object conditions, for example, might have been recognized and categorized as toys in a way that verbal items would not. This was addressed in an experiment in which 10 adult subjects (drawn from the same population as that of Experiments 1, 2, and 3; mean age 19.83 years, SD 2.08) were presented with either the verbal-label slides of Experiment 3 or with object slides (slides of the objects employed in Experiments 1 and 2 photographed from the same perspectives and subtending approximately the same visual angles as the label slides). The slides were presented sequentially for 10 sec each using the Lafayette tachistoscope apparatus described in Experiment 3. Slides were not named orally in either condition. The subjects were simply asked to assign the items to the first category that occurred to them and to write the name of that category.

No systematic or significant differences in category assignment were observed between the verbal and object conditions. Other than minor idiosyncratic changes in the names of categories (e.g., "first aid things" for "medical things" and "transportation" for "vehicles"), the subjects assigned items to the same four categories in both conditions. No subjects assigned any items to the category of toys or prefaced any item with the modifier "toy" (as in "toy truck"). These results indicate that subjects were equally likely to give one of the four category labels to the toy objects as to the verbal label of the objects and that the findings of the preceding experiments cannot be attributed to differences in the category structures of the verbal and object conditions.

EXPERIMENT 5

The preceding experiments, and those of Gollin and Sharps (1988), all involved four categories of 10 items each. Much of the previous work in this area has employed larger numbers of categories with smaller memberships (e.g., Tulving & Pearlstone, 1966). The four-category structure employed in Experiments 1 through 4 was chosen so that the procedures would be as similar as possible to those of Gollin and Sharps (1988). Initially, this small number of categories was chosen so that the subjects would be easily able to hold the categories in working memory. Mandler (1967) demonstrated that a limited number of categories of items to be recalled (4 to 7) was optimum for recall performance; we wished to address recall without introducing extraneous factors such as idiosyncratic difficulty in the accessing and organization of large numbers of category groupings at retrieval. However, it should be noted that performance differences based on category structure would not be unexpected: Hunt and Seta (1984) found that elements of smaller categories are better recalled following relational processing, whereas items of larger categories are better recalled following item-specific processing. We wished to determine whether the pattern of results reported above and in our previous work would generalize to paradigms involving

larger numbers of categories or whether it was confined to the type of category structure employed in our previous studies.

Another question that arose in the present studies concerned category recall. In the previous experiments, the number of categories (four) was so low that all subjects recalled all categories. It was therefore not possible to evaluate category recall. However, experimental conditions that involved more categories would make it possible to use category recall as an independent index of item processing. An analysis of category recall and item-per-category recall, as suggested by Hunt (in his review of an earlier draft of this paper), would make possible an assessment of the effects of category structure and stimulus-type on relational and item-specific processing within the various cells created by the blocking-by-stimulus-type design.

Accordingly, Experiment 5 was designed to test item recall, category recall, clustering, and blocking effects under two types of category conditions, specifically, 4 categories of 10 items each and 10 categories of 4 items each.

Method

Eighty adults (mean age 19.6 years, SD 3.26) were recruited from introductory psychology classes. Forty subjects saw 10 categories of 4 items each, and the other 40 saw the 4 categories of 10 items each used in the preceding experiments. The items were either verbal-label slides or object slides as used in Experiment 4. Items were presented by the Lafayette apparatus of Experiments 3 and 4, using exactly the same procedures employed in Experiment 3. Subjects received no prior information about category. The retention interval for all subjects was 2 min.

Results

The results of the experiment are shown in Table 4. The effects of blocking and stimulus type were significant on free recall [$F(1,72) = 14.49$, $p < .001$, $\omega^2 = .12$, and $F(1,72) = 5.70$, $p = .02$, $\omega^2 = .04$, respectively]. The interaction was also significant [$F(1,72) = 12.02$, $p < .001$, $\omega^2 = .10$]. However, the effect of category size (4

categories of 10 items each vs. 10 categories of 4 items each) was not significant, nor were any interactions involving category size.

The effect of blocking was also significant on ARC scores [$F(1,72) = 4.11$, $p = .046$, $\omega^2 = .04$]. No other effects on ARC scores were significant.

Neither the effects of blocking or stimulus type were significant on the number of categories recalled. The effect of category size was significant [$F(1,72) = 109.74$, $p < .001$, $\omega^2 = .51$]. The interactions of blocking and stimulus type, blocking and category size, and the three-way interaction of blocking, stimulus type, and category size were significant [$F(1,72) = 12.99$, $p < .001$, $\omega^2 = .06$, $F(1,72) = 4.19$, $p = .046$, $\omega^2 = .015$, and $F(1,72) = 10.79$, $p = .002$, $\omega^2 = .05$, respectively]. A Tukey B analysis ($p = .05$) showed that there was no significant difference in category recall between the several blocking/stimulus conditions within the 4-category condition. However, within the 10-category condition, although blocked and unblocked pictures and blocked verbal labels were statistically indistinguishable, unblocked verbal labels were recalled at a significantly lower level. This effect appears to account for the significant interactions.

It was not meaningful to analyze for item-per-category recall within the 4-category condition because all subjects recalled all categories. However, this analysis was conducted for the 10-category condition. The effect of stimulus type was significant [$F(1,37) = 4.49$, $p = .04$, $\omega^2 = .06$]. The interaction of blocking and stimulus type was also significant [$F(1,37) = 8.38$, $p = .006$, $\omega^2 = .14$]. A Tukey B analysis ($p = .05$) demonstrated that unblocked-labels performance (see Table 4) was significantly lower than performance in any of the other three cells examined.

Discussion

The results indicate that the same type of blocking-by-stimulus-type interaction that was observed by Gollin and

Table 4
Mean Free-Recall, ARC, Category, and Item-Within-Category Scores,
With Standard Deviations, From Experiment 5

	Names				Photographs			
	Blocked		Unblocked		Blocked		Unblocked	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Free-Recall Scores								
4-Category	26.20	3.26	19.40	3.87	24.40	7.27	25.40	5.21
10-Category	27.90	5.82	17.20	6.04	27.10	5.95	25.80	4.85
ARC Scores								
4-Category	.48	.88	.37	.80	.63	.81	.59	.88
10-Category	.78	.24	.21	1.09	.79	.25	.63	.27
Mean Number of Categories Recalled								
10-Category*	8.90	1.29	5.70	1.77	7.10	1.63	8.80	1.25
Recall of Items Within Category†								
10-Category	96.8	7.30	82.6	15.14	94.5	8.25	97.6	4.29

*Four-category analysis could not be conducted, as all subjects within this condition recalled all categories. †Expressed as the percentage of items recalled that came from categories that were also recalled.

Sharps (1988) and in Experiments 1–3 of the present manuscript generalizes to stimulus sets with greater numbers of categories. Verbal labels exhibited a highly significant blocking effect; photographs of actual items did not. This was true for both the 10-category and the 4-category conditions. These results indicated that the previous findings of Gollin and Sharps are not bounded by the category structure used in those experiments. It is likely that the demand characteristics of other types of stimulus situations might very well produce other patterns of effects than those observed here. Additional work will be needed to assess the limits of these effects and the absolute generality of these findings. However, it is clear from the present data that this pattern of results is relatively robust across category structure, at least within the present research framework.

The findings from the ARC analysis were again not entirely predictable: the blocking of stimulus items increased clustering, but the usual effect of stimulus type and the interaction of blocking and stimulus type were not in evidence. However, closer inspection of the data (as presented in Table 4) reveals a pattern of ARC scores within the 4-category condition that is consistent with previous findings, although in the 10-category condition, the pattern of scores is anomalous. Although further work will be needed to confirm this, a reasonable working hypothesis at present is that the greater number of categories made it more difficult for subjects to cluster consistently at recall, causing idiosyncratic factors in clustering and categorization to increase in influence and to increase error variance. It should be noted, as discussed in Experiment 1, that in previous work in this area clustering scores have been much less consistent than recall scores, underlying the importance of idiosyncratic subject factors in this area (e.g., Gollin & Sharps, 1988; Hunt & Einstein, 1981; Sharps & Gollin, 1986).

The findings from the analysis of category recall and of item-within-category recall are revealing. Simply stated, very few items were recalled from categories that were not also remembered. However, this was less true of the unblocked-labels cell, within which only about 83% of the items recalled came from remembered categories, as opposed to about 96% for the other three cells within the 10-category condition. As will be noted from Table 4, these findings cannot be attributed to a ceiling effect. There was clearly a strong tendency for subjects to recall items from those categories they recall, implying that category structure was utilized mnemonically to a great degree in all conditions. It is of interest, however, that the unblocked-labels condition resulted in lower recall than any of the other 10-category conditions (again, it should be noted that this type of analysis was impossible in the 4-category conditions, within which no subjects failed to recall all categories). Blocked photographs and verbal labels obviously engaged relational processing, which contributed to relatively high levels of recall in these conditions. The present results, however, are consistent with the hypothesis that the randomly ordered photographs elicited sufficiently strong item-specific and relational

processing to obviate the blocking effect, whereas randomly ordered verbal labels did not (as suggested by Hunt in his review of a previous draft of this manuscript). These results imply that both relational and item-specific processing contribute to optimal recall across conditions and that it is the balance between these two types of factors, rather than the elimination of importance of one or the other, that is responsible for the present results.

GENERAL DISCUSSION

Gollin and Sharps (1988) found that blocking effects occurred with verbal stimuli but not with actual objects. This was surprising, especially in light of the widespread acceptance and use of category grouping as a mnemonic. The present experiments, however, demonstrated that the results of Gollin and Sharps were predictable within the context of item-specific/relational information theory and the theory of synergistic ecphory.

Taken together, the results of the present experiments were as follows:

1. Strong item-specific information resulting from the use of actual objects as stimuli rendered relational information mnemonically superfluous, as predicted from earlier work with verbal materials (e.g., Hunt & Einstein, 1981).
2. When verbal materials were employed as stimuli, the influence of relational information was strongly observed 2 min after encoding, although the utility of relational information deteriorated with time so that no salutary effect of blocking was observed after 24 h.
3. However, the blocking effect could be maintained with verbal stimuli over at least 24 h by the simple expedient of providing category information prior to encoding. Relational information, then, appears not to deteriorate as such over long retention intervals but merely to become less accessible.
4. The category structure reported by subjects did not differ between verbal and nonverbal materials.
5. This pattern of results extends to item sets that involve both small and large numbers of categories.

To the authors' knowledge, the present findings represent the first empirical demonstration of the application of Einstein and Hunt's (1980) theory of item-specific and relational processing to verbal and nonverbal memory within the same research context. These results are consistent with the hypothesis that within the present research framework, relational information largely serves to delineate broad classes of items rather than to isolate specific items and that in general such information is supportive of what might be termed the central memory trace rather than part of the memory trace *per se*. Relational information can, however, be made part of the trace through the manipulation of appropriate situational factors.

A caveat concerning this research should be noted. The present experiments were not intended to convey the existence of a specific four-way interaction of blocking, stimulus type, retention interval, and prior information or its absence. Such interactive analysis between experiments would be statistically meaningless. Also, at least

with reference to such broad concepts as prior knowledge and stimulus type, any theorizing about specific four-way interactions would be insufficiently precise to be of any value. The goals of the present experiments were more limited and more specific. Experiment 1 was intended to verify the hypothesis that the blocking effect on verbal materials, which results from the mnemonic use of relational information, would decline over time. Experiment 2 was intended to provide an example of a task context within which relational information would become part of a central memory trace, as suggested by the theory of Tulving (1982), and thereby retain mnemonic value over the long term. Experiment 3 was intended simply to replicate and confirm the results of the first two experiments regarding verbal materials under more precisely controlled conditions. Experiment 4 was an empirical check on the category structure between the two stimulus types, and Experiment 5 was a specific test of the generality of these results to stimulus sets involving greater numbers of categories. The experiments were intended to test specific, separate hypotheses. The only context within which the results should be considered jointly is the overall theoretical framework, derived from the work of Hunt and Einstein (1981): the hypotheses confirmed separately by these experiments are necessary for the extrapolation of the item-specific/relational information theory to the results of the blocking paradigm.

The present findings demonstrate that the initial findings of Gollin and Sharps (1988) regarding the stimulus dependency of the blocking effect do not pose a challenge to current theories of memory organization but are explicable in terms of the item-specific/relational information theory and of the theory of synergistic ecphory. The evidence provided in the present paper is consistent with this perspective and implies that the theory involved may be generalized to mixed paradigms involving verbal and nonverbal stimulus materials. Further research should clarify the degree to which these findings generalize to different category structures and stimulus situations.

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