THE DETECTION AND IDENTIFICATION OF PICTORIAL CHANGES BETWEEN SUCCESSIVE PRESENTATIONS

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ABSTRACT

The present research examines the ability to detect and identify particular changes between successive pictorial scenes. This investigation focussed on two particular types of change in complex black and white pictures: the addition of objects or patterns, or the deletion of similar objects or patterns in a successivly presented picture. In Experiment 1, additions were found to be more easily identified than deletions but only for pattern changes and not for objects. This difference decreased in magnitude with a longer interval between pictures of a pair. A potential problem with this experiment is that subjects were required to report five changes per picture pair and systematic output competition effects may have interacted with picture memory as a function of delay. In Experiment 2 the picture pairs contained only one change. The results showed that additions were more often detected than deletions and object changes more often than pattern changes. A planned comparison revealed that the detection of pattern-additions were significantly better than the detection of pattern-deletions. Experiment 3 again replicated this finding. The results of this research are discussed in terms of a dual-code theory and its utility in a variety of applied settings.

Research on picture recognition has emphasized the ability to recognize a picture as identical or different from a previously presented picture. In the conventional picture recognition task, subjects are initially shown a series of pictures followed by a recognition test of the previously presented (target) pictures and distractors. Rather than examing the ability to recognize whether a picture has been presented before, the present research adresses a somewhat different aspect of picture memory: the ability to detect and identify particular changes between successive pictorial scenes.

The ability to identify changes between successive scenes is important in a variety of applied settings. For example, consider the task of an air-traffic controller comparing successive glances at a radar screen. The task is not to decide whether the screen has changed between glances because it probably has. Rather, the controller's task is to identify what has changed, and how. The task of comparing successive aerial photographs of the same scene in weather prediction or military reconnaissance is another illustration where additional knowledge about human performance in this type of task would be important.

It can be argued that the detection and identification of change is a more "ecologically valid" skill than simply deciding whether a picture has been seen before. For example, Gibson (1979) has argued that local changes against a background of invariants in the optic array provide the critical information for adaptive behavior in an organism's environment. Rarely in the natural environment are we required to decide merely whether a scene (analogous to a picture) is identical to one experienced at some remote time in the past.

Of concern to the present investigation, Mandler (Mandler & Ritchey, 1977; Mandler & Read, 1980) has provided tabled data for additions and deletions of objects. The results of the Mandler & Ritchey (1977) are suggestive somewhat better performance for additions over deletions at immediate testing in organized pictures though this comparison was not statistically reliable. A replication of this study (Mandler & Read, 1980) showed no difference between additions and deletions in the proportion correct data; however, a subsequent d' analysis suggested that performance for additions may be higher than deletions, though again this difference was not statistically reliable. Mandler has described recognition of additions and deletions as involving changes in inventory information. That is, their detection mediated by noticing something is added or missing from a memorial inventory of the items from the original presentation picture. Presumably, the inventory information is like a list of labels for the items in the picture. In her research, Mandler only added or deleted objects from the pictures. In the present investigation, however, both objects and patterns were added and deleted. If verbally labeling the patterns is more difficult than labeling objects, then it would be expected that detection of pattern changes to be less likely than detection of object changes.

Of particular concern in this series of experiments is whether additions of objects or patterns are more easily detected and identified than their deletions. The order of the slides were strictly counterbalanced: each stimulus change appeared equally often as both an addition and a deletion. The present experiments utilize a different methodology in an attempt to examine retention of single pictures over short blank intervals before test. The task is different in that allows for the immediate assess-

ment of retention of individual pictorial scenes rather than following a list of pictures. A between-subjects design for on- and off-times was used since subjects might adopt a processing strategy suited to one on/off condition to the disadvantage of others.

EXPERIMENT 1

Method

Materials and Apparatus. The pictures used were black line drawings on a white background depicting fairly complex scenes. While some of our subjects have seen similar cartoons in newspapers, it is unlikely that they had seen the particular pictures in this study. The experimental picture series comprised 24 picture pairs. Pictures within a pair differed by five changes, many of which were classifiable by strict criteria as an addition or deletion of an object or pattern. A pattern change was defined as presence or absence of interior marking or coloration without change of drawn object contours. An object change was defined as presence or absence of an item compatible with the picture scene. The entire sequence of pictures contained 27 pattern changes and 26 object changes. The pictures also contained other kinds of changes (e.g. substitution of an object or pattern); this data will not be reported here.

An overhead Kodak Carousel Custom 800H slide projector was used to project the pictures onto a projection screen approximately five feet in front of the subjects in a dimly lit room. The projector was controlled by four BRS Foringer TI-902 timers connected to a BRS Foringer PF-901 pulse former and a Grason-Stadler 1166 relay panel. The subjects' responses were recorded by a protable cassette recorder.

Subjects. Thirty-two University of South Florida students from an undergraduate psychology perception class participated voluntarily for extra credit. The subjects were assigned to one of four conditions: 10 seconds "on" with 5 seconds "off"; 10 seconds "on" with 1 second "off"; 5 seconds "on" with 5 seconds "off"; and 5 seconds "on" with 1 second "off". Half the subjects in each condition were shown the slides in reverse order from the other half. This insured that every object or pattern change was presented equally often as a deletion or an addition.

Procedure. Each subject was tested individually. The experimenter read instructions that explained that they would be presented sequential pairs of picture slides and were told that the pictures within a pair were almost identical except they differed by five changes. Further, subjects were told that they would be presented initially with one of the two pictures and they should try to memorize as much as they could about this picture. Subjects were also told that the first picture of the pair would be

removed from view, and after a delay, the second picture would be shown. They were further told that as soon as the second picture was shown their task was to find the differences between the immediately preceeding picture and the one presently being shown. They were told to try to name the differences outloud as quickly and as specifically as possible. Further, the subjects were instructed that if they were unsure what a particular change was exactly, then they could describe it as best they could (e.g. by giving the approximate place in the picture where the change occured). The presentation duration of the second picture of each pair, and the blank time between each paired set were held constant at 20 and 5 seconds, respectively. Before beginning, subjects were shown a pair of pictures vertically aligned on paper to illustrate the kind of pictures to be expected in the experimental series. The subjects' vocal responses were collected on recording tape, and then later transcribed to paper for analysis.

Results

The results were analyzed as a 2x2x2x2 mixed model factorial design experiment with on-time (5 vs. 10 sec.) and off-time (1 vs. 5 sec.) as between-subject variables, and addition vs. deletion and object vs. pattern as within-subject variables. The ANOVA indicated that the longer on-time (.54) led to significantly better detection performance than the shorter on-time (.45), $F(1,28)=5.67,p<.05$. Since on-time did not interact with the other variables (all p's>.10) and for simplification of the presentation of the other results, Table 1 shows performance (in proportion correct) collapsed across on-time. Examination of the means displayed along the far right-hand column of this table indicates that, in general, additions are better detected than deletions. The analysis of variance indicated this source to be reliable, $F(1,28)=6.51,p<.05$. No significant main effect was found for pattern vs. object, $F(1,28)=3.60,p>.05$. However this variable interacted with addition vs. deletion, $F(1,28)=31.85,p<.001$. Comparison of the means within Table 1 shows that this interaction was due to additions being detected more readily than deletions but only for patterns and not for objects (Fisher's Least Significant Difference= .09 at p=.05). The off-time manipulation produced no main effect, $F(1,28)=3.60,p>.05$ nor was this variable involved in any two-way interactions (all p's>.10). However off-time did enter into a triple interact with addition vs. deletion and pattern vs. object, $F(1,28)=7.76,p<.01$. This interaction is displayed within Table 1 which shows that the greater detection pattern-additions over pattern-deletions was somewhat more evident for the 1 second off-time than for the 5 second off-time (Fisher's L.S.D.=.14 at p=.05).

Discussion

Increased on-time facilitates subsequent detection and identification performance and seems to have similar effects on both additions and

deletions. Off-time,however, seems to have its greatest effect on the detection of pattern-deletions. Although the detection of pattern-additions was greater than pattern-deletions at both off-times, the magnitude of this difference increased at the shorter off-time. Pattern-additions result in gross differences in local brightness, perhaps making pattern changes more perceptually salient in the second picture. The information relevant to a pattern detection decision might be more readily elicited by the contents of the second picture than memory of the first picture. Since deletions are not externally elicited by the second picture, deletion information must be generated from a possibly deficient memory of the first picture. Subjects may make a decision based on familiarity of the pattern details in the seccond picture—responding to those features that they would have noticed if they had been contained in the first picture. Indeed, many subjects prefaced some of their responses by saying "I don't remember seeing .... before."

There is a possibility that the differences found for the detection of additions and deletions of patterns and objects may have been due to response competition rather than actual differences in memory. There were always five correct identifications between pictures in each pair. The output of early responses may have interfered with the vocal identification of other changes that may have been noticed initially, but went unreported. For example, perceptually salient pattern-additions might affect order of scanning details of the second picture when there are multiple changes per picture pair.

EXPERIMENT 2

Experiment 2 eliminates the possible problem of response competition by having only one change per picture pair rather than five changes. This would alleviate the possibility that detection differences were merely due to output interference and not due to actual memory differences.

On-time for the first of each pair was held constant at 10 seconds because the results of Experiment 1 indicated that this manipulation had purely an additive effect. Since in Experiment 1, off-time entered into a triple interaction with addition vs. deletion and object vs. pattern, Experiment 2 was also intended to test the reliability of this interaction.

Method

Materials and Apparatus. The pictures depicted the same scenes as in Experiment 1 except that each picture pair had only one pattern or object change. These pictures were constructed from the picture set used in Experiment 1 by deleting one object or one pattern in every picture. This new set of pictures along with the originals from Experiment 1 provided two sets of picture pairs of each scene. There was a pattern and an object change for every scene. The two

sets were matched for basic scene content differing only for the type of change in the scene pair between sets: either an object or pattern change. This insured that each scene occurred equally often as an object or pattern change. The order of the scenes were randomized, but were kept in a constant order between sets. Half the subjects were shown the slides in reverse order from the other half. This insured that every object or pattern change occurred equally often as an addition or deletion. The same slide presentation equipment as in Experiment 1 was used.

Subjects. Thiry-two University of South Florida students from an introductory psychology class participated voluntarily for extra credit. Subjects were assigned to one of two off-time conditions, either one second or five seconds. Subjects were balanced for picture lists, sets 1 or 2, and for picture sequence order, either forward or backward.

Procedure. The procedure used was similar to that of Experiment 1 with two exceptions: First, only a single change could be reported. Second, on-time was held constant at 10 seconds.

Results

The results were analyzed as a 2x2x2 mixed model factorial design experiment with off-time (1 vs. 5 sec.) as a between-subject variable and pattern vs. object and addition vs. deletion as within-subject variables. The three-way mixed model analysis of variance indicated that additions were significantly better detected than deletions, $F(1,30)=4.37, p<.05$. The means for thse conditions are displayed along the right-hand column of Table 2. Further, the ANOVA indicated that object changes were detected significantly more often than pattern changes, $F(1,30)=12.24, p<.01$. The means for these conditions are displayed along the bottom row of Table 2. Object vs. pattern did not significantly interact with additon vs. deletion, $F(1,30)=2.71, p>.05$. There was no effect of off-time $(F<1)$, nor did this factor interact with the other two variables (all $F's<1.0$).

Although there was no significant interaction of pattern vs. object with addition vs. deletion, examination of the means within Table 2 suggests a similar pattern of results found in Experiment 1. For example, Experiment 1 showed that for pattern changes, detection of additions was better than detection of deletions. Similarly, Experiment 2 appears to show this. Though the ANOVA yielded no significant interaction for the pattern vs. object and addition vs. deletion in this experiment, a planned comparison of the means was performed between pattern-additions and pattern-deletions. This comparison suggested that detection of pattern-deletions was significantly less likely than pattern-additions (LSD= .10 at p=.05).

Discussion

The primary purpose of this experiment was to control for one possible extraneous variable that may have affected the results of the earlier experiment. Specifically, the possibility of output interference was controlled by having only one change per picture pair rather than five per pair. Experiment 2 showed object changes to be, in general, better detected than pattern changes. This result supports a verbal stategy explanation in that it would be expected that objects are more easily labeled than patterns, thus leading to differential memory performance between these two types of items. Patterns may only provide for additional detail of an object. During the encoding of the first picture, subjects may have had insufficient time to study all the details beyond the objects themselves. Furthermore, if subjects used a verbal labeling strategy for the objects in the first picture, then this lablel alone might be insufficient to detect a pattern change in the second picture because the label would still likely match the object even though its specific detail (i.e. its internal patterning) had changed. No effect of off-time was found in this experiment. In Experiment 1, off-time entered into a triple interaction with addition vs. deletion and pattern vs. object. The triple interaction appeared to show a somewhat larger difference between pattern-additions and pattern-deletions at the shorter off-time compared to the longer off-time. In that experiment subjects were required to report 5 changes per picture pair and systematic output competition effects may have interfered as a function of delay.

EXPERIMENT 3

The pattern of results for the first two experiments were explained by invoking a labeling strategy for the detection and identification of the picture changes. There were two purposes of Experiment 3. Most importantly, Experiment 3 was an attempt to replicate the basic finding of Experiment 2 of an asymmetry for the detection of pattern changes. Secondarily, Experiment 3 was an attempt to examine whether differential instructional strategies would effect performance in this task. An attempt was made to get subjects to use different strategies in the hope that the results would yield a pattern of detection performance that would reflect differential processing.

Method

Materials and Apparatus. The same picture slides from Experiment 2 were used. Subjects' responded by identifying the changes in an answer booklet rather than orally as was done in Experiments 1 and 2. A slide projector was controlled by an enhanced version of the Radio Shack TRS-80 Model 1 computer.

Subjects. Seventy-two Rice University students from introductory psychology classes participated volutarily for extra credit. Subjects were randomly assigned to one of three strategy conditions. Sex was balanced across conditions. Subjects were also balanced for picture lists, sets 1 or 2, as well as for picture sequence order, forward or backward.

Procdure. The procedure was similar to that of Experiment 2 with three exceptions. First was the the manipulation of an instructional strategy factor. In general, the instructions were very similar to those used in Experiments 1 and 2, differing only by a paragraph that attempted to bias subjects into using either a visual, verbal, or self-generated strategy. This paragraph indicated that previous research has found that the strategy leads to best performance in this task. For example, the instructions for the self-generated strategy condition were: "We have found that subjects notice changes better when they figure out for themselves the best way to go about learning the first picture, i.e. subjects who learn by using the strategy most effective for them individually tend to do the best at this task." A second difference between this experiment and Experiment 2 was that off-time was held constant to a one second interval between the first and second picture of each pair. The third difference was that subjects in this experiment responded by writing answers in a response booklet rather than orally as was done in the earlier experiments.

Results

The results were analyzed as a 2x3x2x2 mixed model factorial design experiment with sex and instructional strategy (visual, verbal, and self) as between subject variables and pattern vs. object and addition vs. deletion as within-subject variables. The four-way mixed model analysis of variance indicated that additions were significantly better detected than deletions, $F(1,66)=26.48$, $p<.01$. Object changes were detected significantly more often than pattern changes, $F(1,66)=26.78$, $p<.01$. However, the ANOVA also indicated that the pattern vs. object variable interacted reliably with the addition vs. deletion variable $F(1,66)=15.85$, $p<.01$. Examination of the means within Table 3 show that this interaction was due to additions being detected more often than deletions for the patterns, but not for objects. No reliable main effect was found for the instructional strategy variable ($F<1.0$), but this factor interacted significantly with pattern vs. object, $F(2,66)=3.99$, $p<.05$. These means showed superior detection of objects over patterns for both the visual and verbal instructions but not for the self-generated strategy condition. The ANOVA showed no main effect of sex nor were there any other significant interactions for these variables (all F's<1.0).

Discussion

In general, these results conform to those found in Experiments 1 and 2. Pattern-additions are better detected and identified than pattern-

deletions. However, this asymmetry does not hold for object additions and deletions. The only effect of strategy was an interaction with pattern vs. object. The interaction appeared to be due to lack of detection superiority of objects over patterns in the self-generated strategy condition. In this condition subjects may have been so over-taxed with attempting to find an effective strategy that it interfered with detecting objects.

GENERAL DISCUSSION

The present set of experiments show the advantage of additions over deletions occurred only for pattern changes and not for object changes. Paivio, Rogers, and Smythe (1968) have suggested that pictures are coded and stored in both verbal and pictorial forms. A somewhat modified dual-code model might be used to explain the present results. One code is primarily concerned with verbal/semantic information. This information can be easily labeled (e.g. object information). The other coding system is primarily concerned with the coding of pictorial detail (e.g. pattern information). This information would be difficult to label. Mandler (Mandler & Ritchey, 1977; Mandler & Read, 1980) has described recognition of additions and deletions of objects as involving changes in inventory information. That is, object detection is mediated by noticing something is added or missing from a memorial inventory of the items from the picture in the original presentation list. Mandler only added and deleted objects from pictures which might help to explain why she found no reliable differences. In the present studies patterns were also added and deleted. The lack of a difference for the detection of object additions and deletions might be attributed to the encoding of verbal labels as an inventory of objects in each successive picture which are then compared with equal efficiency. Patterns, on the other hand, may only provide for additional pictorial detail of a particular object. During the encoding of the first picture, subjects may have had insufficient time to study all the pictorial details beyond an inventory of the objects themselves. Labeling alone might be insufficient to detect a pattern change in the second picture because a generic label for an object would still likely match the object present in the second picture even though its specific detail (i.e. its internal patterning) had changed. Pattern-additions may provide a salient, sensorily-present cue which could aid in identifying the difference. Pattern-deletions, on the other hand, are not sensorily-present, and terefore subjects must rely on a possibly deficient pictorial representation of what was present earlier.

The present investigation utilizes a task that requires the processing of meaningful visual information contained in a complex scene, and then requires the subject to notice and identify a change in a subsequent examination of the scene. The task is more ecologically valid than the commonly used list learning recognition assesment. In the real world, we seldom have the requirement to select amongst distractors. It is important to notice and identify changes in the real world. The reliable finding of better detection of pattern-additions over that of pattern-deletions might have utility in the human interface in engineering and idustry. For example, the detection of flaws might be aided if the design of the product is made to show visual brightness contrast when an error has been made.

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TABLE 1

Mean proportion correct as a function of off-time, pattern vs. object, and addition vs. deletion (Experiment 1).

	1 sec.		5 sec.		
	Pattern	Object	Pattern	Object	mean
Additions	.62	.40	.63	.54	.55
Deletions	.36	.46	.47	.49	.45

TABLE 2

Mean proportion correct as a function of pattern vs. object and addition vs. deletion (Exp. 2).

	Pattern	Object	mean
Additions	.38	.45	.42
Deletions	.25	.44	.34
mean	.31	.44	

TABLE 3

Mean proportion correct as a function of pattern vs. object and addition vs. deletion (Exp. 3).

	Pattern	Object	mean
Additions	.51	.54	.53
Deletion	.29	.49	.39
mean	.40	.52	