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Presentation Format Effects in a Levels of Processing Task

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Abstract

Three experiments were conducted to examine better performance in long-term memory when stimulus items are pictures or spoken words compared to printed words. Hypotheses regarding the allocation of attention to printed words, the semantic link between pictures and processing, and a rich long-term representation for pictures were tested. Using levels of processing tasks eliminated format effects when no memory test was expected and processing was deep (E1) and when study and test formats did not match (E3). Pictures produced superior performance when a memory test was expected (E1 & 2) and when study and test formats were the same (E3). Results of all experiments support the attenuation of attention model and that picture superiority is due to a more direct access to semantic processing and a richer visual code.

Keywords: Presentation Format; Levels of Processing; Picture/Word, Memory, Auditory/Visual

Introduction

One of the benefits of living in the information age is that we have the tools to present information in one of a number of formats and modalities. Which one we choose should be guided by our desire as scientists and educators to maximize the impact of the flow of that piece of information. Although the effect of presentation format has had a long and rich research history, it is somewhat fragmented: and as a result, there are few general principles that psychological science can offer as a guide for efficient processing of stimulus information. The present research integrates previous work with picture/word (e.g., Kosslyn, 1980; Paivio, 1975) and auditory/visual (e.g., Greene, 1985; Penney, 1989) comparisons by exploring why printed words are not recalled as well as other presentation formats (e.g., pictures and spoken words) (Foos & Goolkasian, 2005; Goolkasian & Foos, 2002). Three experiments extend the investigation of format effects beyond encoding processes and working memory by using a levels of processing (LoP) approach (e.g., Craik & Lockhart, 1972) to examine whether effects of presentation format remain in long-term memory even after participants have encoded the stimulus items to the same levels.

The present experiments examine two complementary explanations for picture superiority (i.e., Nelson, 1979 and Larkin & Simon, 1987). In Experiment 1 we use a LoP task with three styles of presentation under conditions of shallow and deep processing. The question of main interest is whether effects of presentation format remain in long-term memory even after participants have been forced to encode stimulus items to varying levels of depth. In this experiment we also compare intentional vs. incidental learning conditions since one might expect greater conscious attention to encoding under intentional learning. Experiment 2 repeats some of these conditions in a recall experiment to rule out test format as a possible alternative explanation for improved performance with printed words. In both of these experiments Nelson's (1979) model predicts better performance with pictures.

Finally, in Experiment 3, we force deep processing on items presented as pictures, spoken words, and printed words and test long term recognition under conditions where the test items are presented in the same or a different format. If presentation format is an essential component in processing the stimulus item, that is, if format is encoded together with semantic information, then recognition of test items presented in a different format at study and test should be relatively low. Furthermore a comparison of performance with same and different study-test formats allows us to examine the effect, if any, of the hypothesized rich, visual, long-term representation for pictures compared to semantic codes for all items processed at a deep level (e.g., Larkin & Simon, 1987)

Experiment 1

In Experiment 1 we investigate presentation format effects in long-term memory. According to the attention allocation hypothesis (Foos & Goolkasian, 2005) printed words are at somewhat of a disadvantage because of attenuated conscious processing. If we control the processing level we control the amount of conscious encoding and might therefore eliminate format effects in retrieval from long-term memory. At the very least we should eliminate those components that results from differences in semantic coding. Furthermore, we manipulate levels of processing to direct the allocation of attention to meaning as well as to physical features of the presented items.

During the study phase, stimulus items are presented in one of three formats—picture, spoken word, or printed words and participants perform a deep or shallow processing task on each of the items presented. In the incidental memory condition, participants respond without any expectation that a recognition memory test will follow; while in the intentional learning condition, participants are informed of the test. In a third control condition, participants study the items for a later test without the LoP task.

Method

Participants. Seventy-one men and women student volunteers drawn from the University of North Carolina, Charlotte participated to obtain credit in psychology. Fifty were randomly assigned to one of the two levels of processing groups (incidental and intentional processing) and 21 to a control group. Participation was restricted to those with normal (or corrected-to-normal) color vision.

Materials. The stimuli used in the levels of processing task were 60 items randomly selected from a pool of items used in prior work (Foos & Goolkasian, 2005). The items appeared as either a picture, printed word or spoken word. Three versions of the stimulus lists were developed so that across participants, all 60 items appeared equally often as pictures, spoken words, and printed words. Each picture was imported into Adobe Photoshop and its size was adjusted to approximately 4 X 4 cm. A black border (.1 cm) was added to some of the pictures. The printed words were either uppercase or lowercase characters printed with a Geneva font in a character size of 24 points. Spoken words were sound files created by a human female or male voice as a Macintosh system sound file.

The items were randomly assigned to either shallow or deep processing tasks. For both, an orienting question preceded the presentation of the item and participants answered by depressing the “F” (for “yes) or “J” (for “no”) keys with their left or right index fingers. The orienting questions followed the guideline established by Intraub and Nicklos (1985) that shallow questions could be answered without reference to meaning and could be answered for meaningless stimuli. Shallow tasks always focused attention on some physical feature of the items. For pictures, the question asked was “Is the item framed?”; for spoken words the question was “Is the item in a female voice?”; for printed words the question was “Is the word printed in uppercase?”. The deep task for all item types was whether the item belonged to some category (e.g., Is the item a type of food? Is the item found in a garden?). For half of all items in each condition the correct answer was yes and for the other half the correct answer was no.

All stimuli were centered on a 15” Apple flat screen monitor. Stimulus presentation and data collection were controlled by SuperLab running on a Power Mac G4.

Recognition memory test contained a list of 120 item names presented alphabetically. The 60 old items were mixed together with 60 new items matched for concept frequency with the old items and selected from the same item pool. For each item the participant wrote a yes/no to indicate whether the item had been presented and indicated confidence in their answer by using a three point scale where 1 = not very confident, 2 = somewhat confident, and 3 = very confident.

Procedure. All participants were randomly assigned to one of three conditions and run individually in sessions of around 30 minutes. In the incidental and intentional processing condition, an orienting question appeared for 2 s followed by an item presented as a picture, spoken word or printed word. Participants considered whether the item had a physical feature (shallow processing) or belonged to a semantic category (deep processing) and responded with a (yes or no) key press. The next trial started as soon as the participant made a response. The procedure continued until 60 items were presented. Within the list of 60 items there was random arrangement of shallow and deep items and presentation formats. There were 5 practice trials before the experimental trials.

Following the levels of processing task, participants were asked to engage in a filler task. They counted backwards by two out loud starting with the number 99. Participants were then given a printed recognition test. The groups differed in their expectation for the memory test. The intentional processing group was instructed to study the items for a recognition test but the incidental processing group was not and for them the test was a surprise. In the control condition items were presented without the orienting question for 1200 msec each. The exposure duration was determined by averaging response times to the LoP task in the other two conditions. We wanted to make sure that study time was equated across the three groups of participants.

The 60 items in the levels of processing task represented 5 replications of each presentation format (picture, spoken word, printed word) by levels of processing (shallow, deep) by response type (yes, no) condition. Response times and accuracy were recorded on each trial of the levels of processing task.

Hit and false alarm rates were calculated from the yes responses to the recognition test. Hit rates were calculated from the number of times the participants correctly identified an old item and false alarm rate noted the number of times a new item was incorrectly labeled as old. To correct for guessing, recognition memory scores were computed by subtracting the proportion of false alarms from the proportion of hits. Confidence ratings were combined with the recognition responses to produce a 6-point scale where 6=very confident yes, 5=somewhat confident yes, 4=not very confident yes, 3=not very confident no, 2=somewhat confident no, 1= very confident no.

Results

Table 1 presents the means computed from the recognition memory scores and confidence scale data for each participant across the 10 items within each of the presentation format by level of processing conditions. Data from one participant in the intentional study condition was removed because the participant's performance was at chance. Data from the remaining 49 participants were analyzed with a 2 X 3 X 2 ANOVA where study condition was between-subjects (i.e., intentional/incidental processing) and presentation format (i.e., pictures, spoken words, and printed words) and level of processing (i.e., deep and shallow) were within-subjects.

Recognition memory. The analyses on recognition memory and confidence scores were similar so only the ANOVA on recognition scores are reported. Study condition was found to interact with presentation format and LoP, F (2, 94) = 3.73, $p < .03$, $\eta^2 = .07$. There was also a significant interaction of study condition with LoP, F (1,47) = 7.05, $p < .01$, $\eta^2 = .12$. The interaction of condition by format was not significant F (2, 94) = 2.33, $p < .10$. There were also significant main effects of presentation format, F (2, 94) = 15.04, $p < .01$, $\eta^2 = .25$; and LoP, F (1,47) = 330.32, $p < .01$, $\eta^2 = .88$;. However, there was no main effect of study condition, F (1,47) = 1.30, $p < .26$.

To understand what was happening to recognition memory with these complex interactions, simple interactions of presentation format by LoP were conducted for each of the study conditions. Under incidental study, the effects of presentation format were found only when items were shallowly encoded. For those items, pictures were recognized more readily than either spoken or printed words. When items were deeply encoded, there were no differences evident across presentation formats. There was a significant interaction effect of format by LoP, F (2, 48) = 3.97, $p = .027$, $\eta^2 = .14$; and follow-up within subject contrasts (at $p<.05$ significant level) showed no format differences with deeply processed items and an advantage for pictures relative to the other format conditions with shallow processed items. The analysis on the incidental study condition also showed two significant main effects of presentation format, F (2, 48) = 7.31, $p = .01$, $\eta^2 = .23$; and LoP, F (1,24) = 198.16, $p = .01$, $\eta^2 = .89$. As expected the main effect of LoP indicated that recognition memory was higher for deep rather than shallow processed items. In the intentional study condition, there were similar main effects but no interaction effect. Pictures were recognized better than the other two formats, F (2, 46) = 10.36, $p = .01$, $\eta^2 = .32$; and recognition was higher for deeply encoded items, F (1, 23) = 134.53, $p = .01$, $\eta^2 = .86$. The interaction was not significant, F < 1. The data from the control condition was also treated with a repeated measures analysis; and these data show a strong effect of presentation format, F (2, 40 = 24.92, $p = .01$, $\eta^2 = .55$. Follow- up within subject contrasts (at the $p<.05$) showed that pictures (.64) were remembered better than words and spoken words (.47) better than printed words (.34).

Table 1:Mean (SD) recognition scores

Condition	Recognition	Confidence Score
Incidental—Deep		
Picture	.69 (.17)	4.9 (.7)
Spoken Word	.64 (.22)	4.7 (.8)
Printed Word	.69 (.19)	5.0 (.8)
Incidental—Shallow		
Picture	.37 (.20)	3.5 (.9)
Spoken Word	.15 (.20)	2.6 (.9)
Printed Word	.23 (.20)	3.0 (.9)
Intentional—Deep		
Picture	.68 (.17)	5.3 (.6)
Spoken Word	.55 (.25)	4.7 (.8)
Printed Word	.54 (.23)	4.6 (.9)
Intentional—Shallow		
Picture	.35 (.18)	3.9 (.7)
Spoken Word	.27 (.19)	3.6 (.8)
Printed Word	.20 (.18)	3.3 (.8)
Control		
Picture	.64 (.18)	5.2 (.6)
Spoken Word	.47 (.19)	4.4 (.7)
Printed Word	.34 (.19)	3.8 (.9)

Note. Confidence was measured on a 6-point scale (1 = not very confident no 2 = somewhat confident no 3 = very confident no 4 = not very confident yes 5 = somewhat confident yes 6 = very confident yes)

Discussion

As expected, under the control condition both pictures and spoken words produced superior performance to printed words. This replicates previous work on picture superiority and long-term modality effects. However, when individuals were directed to process each presented item at a deep or shallow level, the advantage of pictures and spoken words over printed words was greatly reduced and, in the incidental/deep processing condition, entirely eliminated. These results provide strong support for the attention allocation model (Foos & Goolkasian, 2005). When participants' attention is fully focused on semantically processing the stimulus item, the item's format does not influence recognition from long-term memory. A small effect of format is found in the intentional learning condition when participants are aware that a memory test will occur however the format effect is limited to a picture advantage. Differences are not found for recognition of material presented in spoken and printed word formats.

The present results also support the sensory-semantic model of picture memory (Nelson, 1979). Pictures produced superior performance in both intentional learning conditions and in the incidental shallow processing condition. As expected, with few processing questions, pictures were better remembered following deep processing than after shallow processing (e.g., Intraub & Nicklos, 1985). The expected interaction between LoP condition and format, whereby the difference between pictures and the other formats would be greater when a shallow task was used, was obtained.

While the present findings support the attention allocation model of format effects and Nelson's sensory-semantic model of picture superiority, there is a need to see if similar findings occur when test format is changed. A number of recent studies suggest that printed words are coded orthographically as well as semantically and phonologically (e.g., Cleary & Greene, 2002; Gallo, McDermott, Percer, & Roediger, 2001). Perhaps the improved recall of printed words in the present experiment is due, in part, to orthographic coding for printed words and use of a visual recognition test of memory. Experiment 2 is designed to test this hypothesis by eliminating any advantage attributable to orthographic coding for printed words.

Experiment 2

The intentional and the control conditions from Experiment 1 were run with the same procedure except that an auditory recall task replaced the written recognition test. Twenty seven participants, drawn from the same subject pool as E1, were in the intentional study condition and 32 were in the control. The materials and procedure were the same as the previous experiment except that participants were asked to verbally recall as many of the presented words as they could. Minimum recall time was 5 minutes.

Table 2: Mean (SD) proportion of items recalled.

Condition	Mean	SD
Intentional--Deep		
Picture	.40	.15
Spoken Word	.21	.13
Printed Word	.22	.15
Intentional--Shallow		
Picture	.15	.13
Spoken Word	.08	.07
Printed Word	.12	.09
Control		
Picture	.37	.17
Spoken Word	.24	.12
Printed Word	.22	.16

Results and Discussion

Table 2 presents the mean recall. Significantly more items presented as pictures (.27) were recalled than items presented as spoken (.14) or printed (.18) words, $F (2, 50) = 12.43$, $p < .01$, $\eta^2 = .33$. Deep processing led to higher recall (.28) than shallow processing (.12), $F (1, 25) = 87.79$, $p < .01$, $\eta^2 = .77$, and processing level interacted with format condition, $F (2, 50) = 6.80$, $p < .01$, $\eta^2 = .21$. The picture advantage was more evident with deeply processed items than with shallow items. However, consistent with the results of Experiment 1, there were no differences between long-term memory for spoken and printed words. For the control group, there was only a significant effect of format, $F (2, 62) = 30.58$, $p < .01$, $\eta^2 = .50$. Pictures (.37) were recalled at a higher rate than spoken (.24) or printed words (.22).

When a LoP task is required and conscious attention is thereby directed to semantic processing irrespective of presentation format, then memory differences between the verbal formats disappear. The only lingering format effects are associated with pictures. The previously obtained reduction (i.e., Experiment 1) cannot be attributed to a test format that offers some advantage to printed words. In the present experiment any advantage resulting from such coding was eliminated by the use of an auditory recall task. Pictures were again remembered better than words even though the levels of processing were equivalent.

Experiment 3

In Experiment 3 we again used the levels of processing task but this time the questions required only deep processing and half of the old items presented in the recognition test were in a changed presentation format. We were interested in whether participants would be able to recognize an item as being presented in the study phase even when it appeared in a changed format at test. Participants were not informed about the memory test and they were not informed about the change in presentation format. Since the LoP instructions ask participants to focus on processing the items semantically, there is no need to retain any information about presentation format.

The present study also examines the richness of the visual and semantic codes for pictures compared to verbal items. If the long-term visual representation of pictures is richer than that for verbal items, as suggested by Larkin and Simon (1987), then one would expect to find picture superiority when study and test format are the same. This superiority should be absent when study and test formats differ since, in that case, only semantic information can be used.

Method

The participants were 27 students drawn from the same subject pool as the previous experiments. The study materials were the same 60 items used in Experiments 1 and 2 and the item list was comprised of 20 pictures, 20 spoken words and 20 printed words. Three versions of the stimulus list were developed to counterbalance item format across participants.

The recognition memory test consisted of 120 items—60 old and 60 new items. Half of the old items in each of the format conditions were presented in the same format at study and test, and the remaining half of the items appeared in a different format. When an item appeared in a different format an effort was made to change the format an equal number of times into each of the two remaining formats so that across all of the old items that appeared with a different format there were an equal number of pictures, spoken words and printed words.

The new items were matched in concept frequency with the old items and selected from the same item pool. The test items were presented in a different random order for each of the participants. Recognition test items appeared one at a time on the screen and participants used the number keypad to respond to the question “Was this item presented in the study list?” For the spoken items, the sound file played while the response scale was shown on the screen.

All participants were run individually in 20 minute sessions. They studied each of the items under incidental learning instructions. Following the levels of processing task, participants were asked to engage in the filler task of counting backwards. After that they took the computerized recognition test with 120 items.

Results and Discussion

Mean proportion of yes responses to the recognition test are presented in Figure 1. To correct for guessing, mean recognition scores were calculated by subtracting the proportion of false alarms from the proportion of hits. A repeated measures analysis was conducted separately on the recognition scores and the confidence scale data. Since the results of both analyses were the same, only the recognition analysis is reported.

There were significant main effects of presentation format $F\ (2.52) = 6.89$, $p < .01$, $\eta^2 = .21$; and same/different test item, $F\ (1.26) = 32.12$, $p < .01$, $\eta^2 = .55$. The analyses also showed significant interaction effects of presentation format and test conditions, $F\ (2,52) = 8.25$, $p < .01$, $\eta^2 = .24$. The type of test item showed the strongest effect. When corrected for guessing, recognition of old items presented in the same format at study and test (.73) were significantly higher than recognition of old items presented in a different format (.46). And the old items with the changed format were recognized more often than new items (.09; this is, of course, a false alarm rate). Follow-up within subject contrasts (at $p < .05$ level of significance) showed that format differences within each of these item types were very different. As can be seen in Figure 1, format effects are totally absent when the test format is different from the study format. When, however, study and test formats are the same a distinct advantage for pictures over the two verbal formats is evident. The recognition rate is highest with pictures in the same format compared to other conditions.

Since this study was primarily interested in responses to the old items presented in different formats, we calculated mean recognition and confidence scale data for each of the 6 possible study-test change conditions. When the 9 conditions were analyzed with a single factor repeated measures design, significant differences were found among the conditions, $F\ (8,208) = 14.84$, $p < .01$. Recognition memory and confidence scale data showed that changes between spoken and printed words were not as recognizable as changes to or from pictures. Recognition scores fell around 11% (from .67 to .56) when verbal formats were switched. However, when the change involved pictures the fall in recognition was 30% (from .73 to .43). Follow-up within subject contrasts (at $p < .05$ level of significance) showed that these drops in recognition were significantly different from each other and from the recognition rate for the old items presented in the same format.

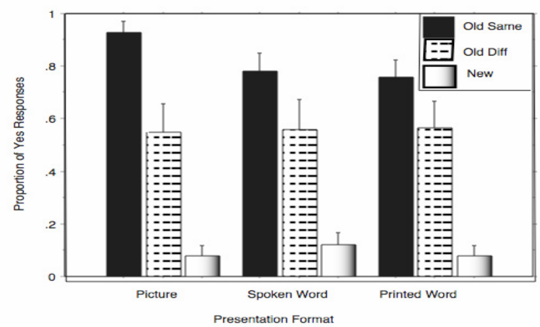

Figure 1. Mean proportion of yes responses for the format by test item interaction. The error bars represent 95% confidence intervals.

Discussion

These findings show that presentation formats are not irrelevant for recognition from long-term memory. Recognition memory and confidence scores were significantly higher when old items appeared in the same format in the study and test phases. On average, recognition dropped 27% when old items appeared in a different format. Since an incidental leaning task was used, these format results suggest some automatic coding of format for spoken and printed words and not just for pictures (Intraub & Nicklos, 1985).

The fact that recognition memory and confidence scores were higher for old items presented in picture format provides support for those who believe that pictures are more richly coded (e.g., Larkin & Simon, 1987). Moreover, it made a difference whether the change in format at test involved a switch between the two verbal formats or between picture and verbal formats. Changes to or from pictures were more noticeable than changes between the spoken and printed words.

General Discussion

When taken together these findings show that varying the manner of encoding by using LoP tasks and instructions for incidental/intentional learning can have significant effects on the pictorial advantage and the advantage of spoken over written words. The pictorial advantage was consistently obtained in all three experiments while the advantage of spoken over written words was eliminated when participants were asked to process the stimulus items semantically and no memory test was expected. Additionally, the effects were obtained when both visual and auditory recognition and recall were used.

These findings contribute theoretically by providing support for sensory semantic models to explain picture processing and the attention allocation hypothesis for verbal material. In contrast to our earlier prediction, however, both theories are necessary to explain presentation format effects on memory. The attentional allocation hypothesis is not sufficient by itself to explain the picture advantage in long term memory. On a more practical level these findings help to identify some principles to guide efficient processing of and memory for stimulus information.

When a LoP approach was used to control the level of processing required, we found evidence for a strong although not exclusive role of attention to conscious processing underlying effects of presentation format. In Experiment 1 when participants were required to semantically process the stimulus items with no expectation of a memory test (incidental study), long-term recognition was comparable in spite of presentation format differences in study items. A general principle is then that focused processing can diminish format effects and when that processing is semantic, format effects can be eliminated.

An effect of presentation format is found when participants are aware that a memory test will follow. The awareness of a memory test improves recognition for items presented as pictures compared to both spoken and printed words. The picture advantage can be explained by the sensory-semantic model of picture memory (Nelson, 1979; Nelson et al, 1977) because pictures are not just well attended but also have a more direct link with semantic processing and a richer encoding (Larkin & Simon, 1987). A second general principle is that pictures are remembered better when individuals expect a memory test and/or are occupied by a shallow processing task.

The effect of presentation format on long-term memory was particularly evident in the findings from Experiment 3 when we compared recognition for items presented in same/different formats during study and test phases of the experiment. Recognition of items presented in the same format was better than items presented in a changed format. This finding provides some evidence that information about presentation format is retained together with semantic information and that this automatic retention of format occurs for spoken and printed words in addition to pictures (Intraub & Nicklos, 1985). A third general principle is that performance is best when study and test formats match.

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