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The Influence of Pictorials on the Comprehension and Recall of Pharmaceutical Safety and Warning Information

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ABSTRACT

Nonverbal symbols such as pictorials are increasingly being recommended and used to convey warnings and other safety-related information. Although fully redundant text and pictorial messages often facilitate performance, it is unknown what may result when textual instructions are accompanied by an incomplete set of pictorials, in which each and every textual item is not supplemented by an accompanying pictorial. To evaluate the practice of communicating information using various pictorial and text formats, fictitious yet realistic-appearing medication instruction sheets were created that presented eight dosing instructions in the following formats: Text alone, pictorials alone, fully redundant text and pictorials, text with four instructions accompanied by pictorials (incomplete pictorials), and no instructions (control). Following exposure to one of the instruction sheets, participants were given a free recall test on the content of the medication information. Results demonstrated that instructions from the fully redundant text and pictorials format were recalled more often than instructions from the other formats. Also, the fully redundant text and pictorials format was given higher ratings than the other formats, whereas the pictorials alone and control formats received the lowest ratings. An age-related decline in recall was observed, with older adults recalling far less information than undergraduates or younger adults.

1. THE INFLUENCE OF PICTORIALS ON THE COMPREHENSION AND RECALL OF PHARMACEUTICAL SAFETY AND WARNING INFORMATION

Pictorials are increasingly being recommended and used to convey warnings and safety-related information (Laux, Mayer, & Thompson, 1989; Young & Wogalter, 1990). Accordingly, most warnings, guidelines, and standards (e.g., American National Standards Institute, 1991; FMC Corp., 1985; Westinghouse Inc., 1981) recommend the use of graphical symbols. The widespread use of pictorials is based on the belief that depicting information in picture form is beneficial. According to Edworthy and Austin (1996) pictorials can: (a) be recognized by those who do not read printed verbal messages, (b) be recognized from a greater distance and with greater discriminability than equivalent printed messages, (c) be recognized more

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quickly and accurately than printed text, (d) withstand environmental degradation, and (e) utilize humans' superior ability to recognize and recall pictured information. Research suggests that pictorials can indeed be a useful way of communicating information (Childers, Heckler, & Houston, 1986; Jaynes & Boles, 1990; Morrell, Park, & Poon, 1990; Young & Wogalter, 1990).

Pictorials are especially beneficial when combined with verbal text messages, thereby enabling dual coding. According to Paivio's (1975) Dual Code Theory, text and pictures result in two different kinds of conceptual representations (or codes). Humans possess a verbal system specialized for processing and storing *semantic* (textual) information and a separate nonverbal system that processes *spatial* and mental imagery (pictures). Presenting information in both a semantic and spatial format allows information to be more easily accessed and stored in both systems, thereby promoting processing efficiency.

Related to Dual Code Theory is Wickens' (1992) concept that presenting the same information in both textual and pictorial formats provides a means of redundant coding, in which different formats emphasize different properties of the information. Depending on the task at hand, either the spatial information depicted in pictorials or the semantic relations found in verbal information may be more relevant. In addition, communicating via pictorial–text combinations facilitates information processing by promoting flexibility, thereby enabling people to capitalize on the information extraction method (spatial pictures or semantic language) they process best. Wickens further believed that pictorials provide an overall context or "frame" within which words can be used to fill in critical details of the pictured concept. Wiseman, MacLeod, and Lootsteen (1985) referred to this as processing elaboration. To Wiseman at al., concept memory is enhanced by the combined processing of words and pictures, and memory quality is improved as the details of pictures and words synthesize.

Although various researchers cite the benefits of combining pictorials with text, empirical evidence has not always supported these claims. For example, a number of studies have shown no facilitative effects of combining pictures with text (e.g., Friedmann, 1988; Otsubo, 1988; Wogalter, Kalsher, & Racicot, 1993). One reason that pictorials have not always been beneficial is that many are not well designed and thus fail to convey adequately their intended message (Collins, Lerner, & Pierman, 1982; Laux et al., 1989; Wolff & Wogalter, 1993). In general, it appears that misinterpreted pictorials tend to represent abstract ideas (e.g., the passage of time), whereas better understood pictorials represent more concrete or visualizable concepts (e.g., no smoking). However, if pictorials are designed well and the concepts to be represented are not overly abstract or complex, research suggests that pictorials can supplement textual information as an aid to comprehension and recall (Dewar, 1994; Morris & Halperin, 1979; Morrow, Leirer, & Sheikh, 1988; Wogalter, Rashid, Clarke, & Kalsher, 1991).

1.1. Pharmaceutical Pictorials

One practical application of using pictorials to augment textual instructions can be found when depicting safety and warning information on pharmaceutical products. Recent research has shown that some kinds of pictorials are successful at effectively communicating important pharmaceutical-related information and warnings (Magurno, Wogalter, Kohake, & Wolff, 1994; Ringseis & Caird, 1995; Wolff & Wogalter, 1993). Furthermore, research has shown that pharmaceutical pictorials are preferred by consumers (Kalsher, Wogalter, & Racicot, 1996; Sojourner & Wogalter, 1996).

Unfortunately, many medication instructions have multiple components, and these components often represent complex concepts. For instance, the medical instruction "take one tablet two hours after meals" is an abstract, multiple component concept. As discussed earlier,

abstract concepts are not easily represented by pictorials that are comprehended at high levels. In fact, the instruction "take one tablet two hours after meals" is currently represented by a commercially available pictorial that Magurno et al. (1994) has shown to be poorly understood. Unfortunately, poorly understood pictorials might be included in medication labeling because in the United States the Food and Drug Administration has regulatory guidelines that focus almost exclusively on the adequacy of textual information, but provide little guidance about pictorial symbols.

1.1.1. Practical implications. Pharmaceutical product manufacturers recognize the need to avoid using poorly comprehended pictorials that do not adequately convey the intended message. As such, the printed material accompanying prescription medications often includes only an incomplete set of pictorials. That is, each and every textual instruction item may not be supplemented by an accompanying pictorial. Text with more concrete concepts may be accompanied by pictorials, whereas the complex and abstract instructions may be represented by text alone.

A potential problem in using an incomplete set of pictorials to accompany textual instructions is that people might overlook (not attend to) those printed instructions that do not have an associated pictorial. Laughery, Young, Vaubel, and Brelsford (1993) found that pictorials can substantially improve noticeability and serve to "reach out and grab people's attention." Similarly, Schmidt and Kysor (1987) described some pictorials as being both attention focusing and attention getting. Given that (a) working memory capacity is limited (Wickens, 1992), (b) people generally only look at warning labels for a limited period of time (Wogalter & Sojourner, in press), and (c) pictorials are noticeable and salient (Young & Wogalter, 1990), then this suggests that people may more readily attend to instructions accompanied by pictorials than those instructions printed as text only.

The research presented here evaluated the practice of providing pharmaceutical safety and warning information via various combinations of text and pictorials.

2. METHOD

2.1. Design

Drug information sheets were created that presented dosing instructions in the following formats: Text alone, pictorials alone, fully redundant text and pictorials, text with one half of the instructions accompanied by pictorials (incomplete pictorials), and no instructions (control). Following exposure to one of the information sheets, participants' comprehension and recall of the medication instructions were assessed, and subjective user preference ratings were collected.

2.1.1. Comprehension and recall. Participant group served as one between-subject variable with the following three levels: (a) undergraduates, (b) adults, and (c) elders. Sheet format served as a second between-subject variable with six levels corresponding to six drug information sheet formats: (a) text alone, (b) pictorials alone, (c) text and pictorials, (d) Incomplete Pictorials 1 (text with one half of the instructions having an associated pictorial), (e) Incomplete Pictorials 2 (text with the other half of the instructions having an associated pictorial), and (f) no instructions (control).

A variable titled *set* served as one within-subjects variable. Four of the eight instructions (Instructions 1, 3, 4, and 7) were randomly assigned to Set A, with the four remaining instructions (Instructions 2, 5, 6, and 8) assigned to Set B. This distinction corresponded to the four instructions accompanied by pictorials in the incomplete pictorials information sheets. Set A contained those instructions accompanied by pictorials in the Incomplete

Pictorials Sheet 1, and Set B contained those instructions accompanied by pictorials in the Incomplete Pictorials Sheet 2. Each text instruction had two parts (a directive and an explanation) which were assessed during recall testing. Thus, question composition served as a second within-subjects variable with the following two levels: (a) directive and (b) explanation. Dependent measures included scores on a test of comprehension and recall.

2.1.2. Ratings. Participant group served as a between-subject variable with the following three levels: (a) undergraduates, (b) adults, and (c) elders. Sheet format served as a within-subjects variable. The six information presentation methods comprised the six levels of the within-subjects variable. Likert-scale subjective ratings served as dependent variables.

2.2. Participants

A total of 216 individuals participated, with 36 participants randomly assigned to the six sheet format between-subject conditions. One third of the participants were undergraduates (undergraduates, mean age = 19.0 years old), one third were younger adults (adults, mean age = 33.6 years old), and one third were older adults (elders, mean age = 68.0 years old). As remuneration for participating, the younger and older adults received a cash payment, and the undergraduates received course credit.

2.3. Materials

Six drug information sheets for a fictitious medication were created. The information sheets were modeled after those supplied by various pharmaceutical supply companies and drug manufacturers. The drug name was printed at the top of each sheet, followed by a drug purpose statement. Below the drug purpose statement were printed eight medication instructions that specified directions and warnings for drug use. Each instruction contained two parts: An action oriented directive (e.g., "Do not take at bedtime") and a supporting explanation (e.g., "This medication may cause unrest and sleeplessness"). The instructions were obtained from medication literature (e.g., Berkow, 1982; Gahart, 1985) and by interviews with health care professionals (i.e., nurses and pharmacists). The complete set of instructions is shown on the text and pictorials drug information sheet in Figure 1.

In the text and pictorials format, each printed textual instruction was accompanied by an associated pictorial. Text was printed in list format, with pictorials located to the immediate left of the corresponding text (see Figure 1). In the text alone format, only the eight textual instructions were shown and pictorials were omitted. In the pictorials alone format, only the eight pictorials were shown and text was omitted. In the incomplete pictorials formats, two versions of the drug information sheet were created with half of the instructions having an associated pictorial. Incomplete Pictorials 1 included pictorials for the Set A instructions. Incomplete Pictorials 2 included pictorials for the Set B instructions. The no-instruction control format contained only the drug name and purpose and served as a baseline of participants' medication knowledge without benefit of instructions, thereby enabling an assessment of knowledge gained from exposure to the experimental materials.

The drug information sheets were standard 21.6 cm (8.5 in.) × 27.9 cm (11.0 in.) white bond paper with information printed on one side. The drug name was printed in 14-point Times font, and the drug purpose and instructions were printed in 12-point Times font. Pictorials were approximately 1.9 cm × 1.9 cm (.75 in. × .75 in.). The pictorials were taken from a set developed by the United States Pharmacopeial Convention (Rockville, MD) and were previously tested to have comprehension levels of at least 85% (see Magurno et al., 1994).

FLORONEX HCT

Inhibits the parasympathetic nervous system and induces dilation of peripheral blood vessels

Do not take with milk or other dairy products. Dairy products interfere with absorption of this medication.

The shelf life of this medication will be extended if stored at temperatures less than 50 degrees. Store in refrigerator.

Do not take other medicines with this medicine. This medicine reacts negatively with numerous other drugs.

This medication may cause unrest and sleeplessness. Do not take at bedtime.

This medication has been precisely measured, and it is important that each tablet be taken in whole form. Do not break or crush tablets or caplets.

Wash hands. This medication is readily absorbed through the skin, and hands should be washed immediately after taking the medicine.

Take until gone. Even though disease symptoms may disappear in a few days, all of this medication must be taken to avoid disease recurrence.

This medication may cause dehydration. Take with a glass of water.

FIGURE 1: Drug information sheet showing text and pictorials.

2.4. Procedure

To enhance realism, participants were asked to assume they were obtaining a prescription for an unfamiliar medication used to treat a personal medical condition. After being given a medication bottle having basic information found on all prescription drug labels (e.g., drug name, quantity, refill information, patient's name and address), participants were given a drug information sheet corresponding to one of the six (randomly assigned) experimental formats and were told to examine the information for 60 sec. The time limit was established during preliminary pilot trials. After 60 sec had elapsed, the sheets were collected, and participants completed a questionnaire. The questionnaire was used to collect participants' demographic information and opinions regarding prescription medications. It also served as a filler task, creating a nonrehearsal distracter which prevented the information on the drug information sheet from being retained in working memory.

Upon completion of the questionnaire, a free recall test was administered that asked participants to write down on lined paper the medication instructions that were relevant to their "prescribed" medication. When the test was completed, the entire set of six drug information sheets was arranged (in random order) on a table in front of the participants. Participants then reviewed all of the information sheets and completed a ratings form that asked the question: "How effective was the drug information sheet at helping you understand and remember the medication instructions?" A 5-point Likert scale was used with the following numerical and verbal response anchors: 1 = *not at all effective*, 2 = *somewhat effective*, 3 = *effective*, 4 = *very effective*, and 5 = *extremely effective*. A rating was assigned to each of the drug information sheets. The ratings form was printed in 12-point Times font, using standard 21.6 cm (8.5 in.) × 27.9 cm (11.0 in.) white bond paper.

3. RESULTS

As mentioned previously, each of the drug information sheet instructions were comprised of two distinct parts: A directive and an explanation. Accordingly, scoring of the comprehension and recall test was based on a maximum of 2 points per instruction. Responses that included both the directive and explanation were awarded 2 points, and responses that contained either the directive or the explanation were awarded 1 point. Nonresponses, or those that were incorrect, were given 0 points. The scoring criteria were lenient in that responses did not have to specifically match the exact wording found on the drug information sheet. Instead, a response was counted correct if synonymous with the instruction provided, thereby indicating participants' basic understanding and recall of the medication instruction.

To ensure validity of the test scoring procedure, a training session was undertaken by two judges who established common scoring criteria and procedures. The judges scored the tests without knowing the conditions from which they were taken (i.e., blind). Interrater reliability was found to be 90.8%. The data reported here are based on judge's scoring procedure.

Test score means for participant group and sheet format are contained in Table 1.

3.1. Incomplete Pictorials Combined

3.1.1. Main effects. A 3 (Participant Group: undergraduates, adults, elders) × 5 (Sheet Format: text alone, pictorials alone, text and pictorials, incomplete pictorials, control) between-subject analysis of variance (ANOVA) was performed. Note that in this analysis, the Incomplete Pictorials Sheets 1 and 2 were combined into one overall incomplete pictorials condition. The ANOVA showed a significant main effect of participant group, $F(2, 201) = 50.88$, $p < .0001$, with Tukey's Honestly Significant Difference (HSD) test ($p < .05$) showing that all groups

were significantly different from each other. Scores were highest for the undergraduates (M = 7.24), followed by the adults (M = 6.31), with the elders (M = 3.57) performing poorest.

The ANOVA also showed a significant main effect of sheet format, $F(4, 201) = 116.16$, $p < .0001$, with text and pictorials performing highest (M = 9.14), followed in descending performance order by text alone (M = 7.94), incomplete pictorials (M = 7.38), pictorials alone (M = 4.03), and control (M = 0.00). Tukey's HSD test ($p < .05$) confirmed that all sheet formats were significantly different from one another, except for text alone and incomplete pictorials, which did not differ.

3.1.2. Interaction. The ANOVA also showed a significant two-factor interaction of participant group and sheet format, $F(8, 201) = 4.74$, $p < .0001$. Inspection of the means in Table 1 shows that for every sheet format except pictorials alone and control, the undergraduates recalled the most information, followed by the adults, with recall by the elders being poorest. In the pictorials alone condition, the undergraduates and adults did not differ, and in the control condition, none of the groups differed. This pattern was supported by Tukey's HSD test ($p < .05$).

3.2. Directive Versus Explanation

3.2.1. Main effects. To determine if differential recall for the two instructional components (directive or explanation) existed, a 3 (Participant Group: undergraduates, adults, elders) × 5 (Sheet Format: text alone, pictorials alone, text and pictorials, incomplete pictorials, control) × 2 (Question Composition: directive, explanation) mixed-model ANOVA was performed. In addition to the participant group and sheet format effects discussed previously, the ANOVA also showed a main effect of question composition, $F(1, 201) = 435.82$, $p < .0001$, with directives (M = 4.04) recalled more often than explanations (M = 1.66).

3.2.2. Interaction. The ANOVA also showed a significant two-factor interaction of sheet format and question composition, $F(4, 201) = 31.51$, $p < .0001$. This interaction can be seen by inspecting the pattern of means shown in Table 2. Although there was a substantial decline in recall for the instruction explanation compared to the instruction directive for all sheet conditions (except the control condition, in which there was zero recall for directive and explanation), the decline was more pronounced in the pictorials alone condition, in which the explanation mean score dropped nearly to zero. This pattern was supported by Tukey's HSD test ($p < .05$).

3.3. Set

3.3.1. Main effects. As previously discussed, the variable set was used to delineate those instructions within an incomplete pictorial sheet that were or were not accompanied by pictorials. A 3 (Participant Group: undergraduates, adults, elders) × 6 (Sheet Format: text

TABLE 1
Recall Means for Participant Group and Sheet Format

Condition	*Undergraduates*	*Adults*	*Elders*	*Total*
Text alone	10.8	8.7	4.3	7.9
Pictorial alone	4.8	4.9	2.4	4.0
Text and pictorial	11.1	9.8	6.5	9.1
Incomplete pictorial 1	9.5	7.3	4.1	7.0
Incomplete pictorial 2	9.3	8.9	5.1	7.8
Control	0.0	0.0	0.0	0.0

TABLE 2
Recall Means for Question Composition and Sheet Format

Condition	*Directive*	*Explanation*
Text alone	5.2	2.7
Pictorial alone	3.9	0.1
Text and pictorial	5.9	3.2
Incomplete pictorial	5.1	2.3

alone, pictorials alone, text and pictorials, Incomplete Pictorials 1, Incomplete Pictorials 2, control) × 2 (set: A, B) mixed-model ANOVA was performed. In addition to the main effects of participant group and sheet format discussed previously, the ANOVA also showed a main effect of set, $F(1, 198) = 7.05$, $p < .01$, with test scores higher for Set A ($M = 3.16$) than Set B ($M = 2.81$). Set means scores by sheet format are listed in Table 3.

3.3.2. Interactions. Although no significant interactions were present, a trend in these data are worth noting. Set A instructions were recalled more often than Set B instructions for every sheet format except Incomplete Pictorials 2, in which Set B instructions (text accompanied by a pictorial) were recalled more often than Set A instructions (text unaccompanied by a pictorial).

3.4. Individual Instructions

A repeated measures ANOVA was performed using the recall scores associated with the eight individual drug information sheet instructions. The ANOVA showed a significant difference in recall among the instructions, $F(7, 1505) = 15.91$, $p < .0001$. Table 4 shows the mean recall scores for each instruction concept listed in descending order. Post hoc analysis of the means using Tukey's HSD ($p < .05$) showed that the three best recalled instructions were significantly higher than the other instructions. There were no differences among the remaining instructions except that the lowest (refrigerate) was significantly lower than all of the others except for the second lowest (don't take with other medications).

3.5. Ratings

Mean ratings for participant group (undergraduates, adults, elders) and sheet format (text alone, pictorials alone, text and pictorials, Incomplete Pictorials 1, Incomplete Pictorials 2, control) are listed in descending order in Table 5.

3.5.1. Main effects. A 3 (participant group: Undergraduates, adults, elders) × 6 (sheet format: Text alone, pictorials alone, text and pictorials, Incomplete Pictorials 1, Incomplete Pictorials 2, control) mixed-model ANOVA was performed. The ANOVA showed a significant main effect of participant group, $F(2, 213) = 4.82$, $p < .01$, with Tukey's HSD test ($p < .05$) confirming that the undergraduates provided higher ratings ($M = 2.97$) than either the adults ($M = 2.79$) or the elders ($M = 2.83$), with no difference between the adults and elders. The ANOVA also showed a significant main effect of sheet format, $F(5, 1065) = 790.55$, $p < .0001$, with text and pictorials rated the highest ($M = 4.73$), followed in descending order by Incomplete Pictorials 1 ($M = 3.23$), Incomplete Pictorials 2 ($M = 3.22$), text alone ($M = 3.08$), pictorials alone ($M = 1.89$), and control ($M = 1.04$). Post hoc analysis using Tukey's HSD test ($p < .05$) showed all formats to be significantly different from one another except between text alone and Incomplete Pictorials 1 and 2.

3.5.2. Interaction. The ANOVA also showed a significant two-factor interaction of participant group and sheet format, $F(10, 1065) = 5.07$, $p < .05$. The pattern of means shows a consistent ratings pattern shared by all participant groups, with the exception of text alone, in which elders provided ratings that were significantly higher than the other groups, and pictorials alone, in which the pattern reversed and elders provided significantly lower ratings than the other two groups. This pattern was supported by Tukey's HSD test ($p < .05$).

4. DISCUSSION

4.1. Comprehension and Recall

4.1.1. Fully redundant text and pictorials. The research literature suggests that the combination of redundant spatial and semantic information produces superior processing efficiency from the formation of multiple codes in memory (Booher, 1975; Edworthy &

TABLE 3
Recall Means for Set and Sheet Format

Condition	*Set A*	*Set B*
Text alone	4.5	3.4
Pictorial alone	2.2	1.8
Text and pictorial	4.7	4.4
Incomplete pictorial 1	3.8	3.2
Incomplete pictorial 2	3.7	4.1
Control	0.0	0.0

TABLE 4
Free Recall Means for Each Instruction

Concept (Short Description)	*Mean Recall*
Take with water	.99
Don't take at bedtime	.91
Take until gone	.89
Don't take with milk	.74
Wash hands	.67
Don't break tablets	.65
Don't take with other medications	.63
Refrigerate	.50

TABLE 5
Mean Ratings for Sheet Format and Participant Group

Condition	*Undergraduates*	*Adults*	*Elders*	*Total*
Text and pictorial	4.9	4.7	4.6	4.7
Incomplete pictorial 1	3.4	3.1	3.2	3.2
Incomplete pictorial 2	3.4	3.0	3.2	3.2
Text alone	3.1	2.8	3.3	3.1
Pictorial alone	2.0	2.1	1.6	1.9
Control	1.0	1.1	1.1	1.0

Austin, 1996; Levin & Lesgold, 1978). Such superiority was evident in this study, in which recall of pharmaceutical information was facilitated by the use of fully redundant text and pictorials. Across a wide variety of ages and participant backgrounds, information presented in both a spatial and semantic form was consistently recalled more often than other combinations of information. Paivio's (1975) Dual Code Theory and Wickens' (1992) Redundant Code Theory thus appear to apply to the presentation of medication dosing information and warnings.

4.1.2. Incomplete dual coding. Conclusions drawn from instances of incomplete dual coding are not so clear. For example, it was expected that those instructions that did not have pictorials would fail to capture attention (see Laughery et al., 1993; Schmidt & Kysor, 1987) and would be less efficiently processed (see Glenberg & Langston, 1992; Wiseman et al., 1985) than instructions on the same information sheet that were accompanied by pictorials. However, when examining the effect of set, there were no differences between the incomplete pictorials sheet instructions accompanied by pictorials and the instructions on the same sheets that were unaccompanied by pictorials. In addition, there were no differences in textual set instructions from the incomplete pictorials sheets and the same textual set instructions from the text alone sheet. Furthermore, overall test scores from the incomplete pictorials sheets were just as high as scores from the text alone sheet. As a consequence, it appears as if an instruction sheet that contained text and some number of pictorials was just as effective as an instruction sheet presented entirely as text.

4.1.3. Single coding. Recall of the text alone instructions was not as high as the fully redundant text and pictorials instructions. This result supports Paivio's (1975) Dual Code theory that use of a single semantic code is not as efficient as the use of a redundant dual code. Although the text alone instructions were not recalled any better than the incomplete pictorials instructions, the use of text alone was still advantageous over the use of pictorials alone and no instructions.

The pictorials alone format was consistently associated with low recall, with scores only higher than that of the control format. Numerous researchers (e.g., Collins et al., 1982; Dewar, 1994) believe that pictorials should rarely be used as a sole communication source. Even when pictorials were chosen that had acceptable rates of comprehension (American National Standards Institute's 85% comprehension criteria), when used alone the pictorials did not convey the level of detail needed for proper comprehension of the pharmaceutical information.

4.1.4. Control. The use of the no instruction format demonstrated participants' baseline medication instruction knowledge without benefit of any instructions other than those printed on the medication bottle label. The lack of any correct responses associated with the control format serves as proof that participants exposed to the other formats were not simply recalling common medication instructions from previous experience, but rather were remembering instructions that were presented on the drug information sheets. It appears that some information in addition to that which is simply provided on a drug bottle label can stimulate memory for important dosing instructions and should routinely be provided to consumers.

4.1.5. Age. Due to the applied nature of this research, a diverse participant group was selected, and an age-related loss in recall was exhibited. Undergraduates consistently had the highest recall scores, followed by the adults, with the elderly participants exhibiting the poorest recall. In fact, the older adults only recalled approximately 50% of the information recalled by the undergraduates. Because older adults tend to take more medications relative

to other population groups, the conclusion that they had difficulty comprehending and remembering common medication instructions is critically important. This finding is consistent with previous research (e.g., Morrell et al., 1990; Morrow et al., 1988; Park & Halter, in press) showing that older adults have greater difficulty remembering medication information and adhering to dosing schedules. Clearly this is the target population that must be addressed when developing methods of improving memory for pharmaceutical instructions.

4.1.6. Instruction composition. The instruction directive was recalled significantly more often than the instruction explanation across all conditions (except the control). This finding was expected for the pictorials alone format because the pictorials did not specifically address the level of detail required to fully understand the explanation portion of an instruction. For example, the picture of a medicine being stored in the refrigerator did not convey "why" the medicine should be stored there, and the proper reason had to be inferred. However, when text information was provided, the reason why—that refrigeration extends the shelf life of the medicine—required only proper recall, not inference. Indeed, for the participants who viewed the pictorials alone format, recall performance for the explanation portion of the instructions fell almost to zero, demonstrating participants' inability (or unwillingness) to make the proper inferences into why an instruction was given.

The more interesting finding involving directives versus explanations is that even the participants exposed to the information sheets other than the pictorials alone format recalled the explanations at a much lower rate than the directives. Speculation into the reason for this finding takes several forms. First, the directives may simply be easier to retrieve than the explanations, because the directives are more concrete and action oriented than the more abstract explanations. Second, the participants may have actively chosen to concentrate on the directives at the expense of the explanations because the participants believed the directives were more critical, that is, what the individual should or should not do. As such, the instruction explanation might have been seen as supplementary information, or information that was merely "nice to know." Finally, the use of a written test could have influenced how participants' responded. For example, the requirement to write an answer could have affected the amount of detail provided by the participants in giving their responses. This test, which is not closely monitored while participants are writing their answers, allows the production of short, sometimes incomplete, responses that may not reflect what the participants know and can recall. An interview-type assessment in which participants' respond orally, with the interviewer following up with subsequent probe questions, might elicit a set of more complete answers that better reflects what participants actually know.

In either case, the fact that instruction directives were recalled at a much higher rate than instruction explanations is an important finding and one that might be critical when designing future medication instructional materials. It is interesting to note that there is a growing trend in the warnings literature to include more elaborate explicit explanations (e.g., more detailed consequences statements) in warnings for the purpose of motivating people to comply (Wogalter & Laughery, 1996).

4.2. Ratings

The fully dual-coded text and pictorials information sheet received the highest ratings, demonstrating the Kalsher et al. (1996) finding of subjective preference for combined text–pictorial information. Participants appeared to appreciate the redundant presentation technique and may have believed that text and associated pictorials would effectively facilitate understanding and recall of the medication instructions. In this regard, Paivio's

(1975) Dual Code Theory and Wickens' (1982) Redundant Code Theory seem to apply to subjective beliefs as well as objective measures.

Consistent with previous research (e.g., Sojourner & Wogalter, 1996), the incomplete pictorials sheets were rated the next highest in terms of subjective preference. Of some surprise was the fact that the incomplete pictorials sheets received the same ratings as the sheet using text alone. Apparently participants believed that communicating with only a partial set of pictorials to accompany textual information was just as effective as communicating with text used alone. Because the ratings effectively mirrored the results found during comprehension and recall testing, a case can therefore be made for the interchangeable nature of either incomplete pictorials or text alone. Not only were there no differences in recall between the two formats, participants also perceived there would be no difference between them.

As for the pictorials alone and control formats, ratings mirrored recall performance. When pictorials were used alone, participants deemed them as being only somewhat effective. Once again, consistent with the recommendations made in the literature (e.g., Collins et al., 1982; Dewar, 1994), pharmaceutical pictorials should probably not be used as a sole communication method. As for the no instruction format, participants believed that a simple drug name and purpose statement were not at all effective at aiding comprehension and recall. When compared to the ratings assigned to the other drug information sheets, it appears that participants believed medication information supplied in any format is superior to no information at all. This result is consistent with Morris and Halperin's (1979) finding that people desire to be supplied with elaborative supplemental written medication information.

4.2.1. Age. Although the same general pattern of ratings across all conditions were provided by all age groups, the older participants did have distinctly different opinions regarding the single-coded instructions. The older adults rated the text alone sheet higher than did the other two participant groups, but rated the pictorials alone sheet lower than the other participant groups. This finding might be expected for two reasons when one considers the experience base enjoyed by the older participants. First, older adults have greater experience taking medications and thus have greater familiarity with drug information communication methods (e.g., drug information sheets). However, it is also true that the communication methods frequently do not employ pictorials, relying instead on printed verbal messages. Consequently, it is not surprising that older adults might provide a higher rating for textual instructions, because they repeatedly see textual medication information on a day-to-day basis. Secondly, much like the assumption that older adults have had greater experiences with medication information, it might also be assumed that older adults have had less experience with pictorials in general. In fact, although many of the undergraduate and young adult participants anecdotally reported seeing similar pictorials to the ones used here on various warnings, signs, and computer applications, rarely did older adults report the same types of experiences. Because pictorials have proliferated in recent years, especially in the area of safety signage and computer applications, it once again is not surprising that younger adults, having more experience with their application, would rate pictorials as being more effective. This belief may merely reflect a greater unfamiliarity among the older adult population with pictorials in general.

4.3. Conclusion and Implications

Fully redundant medication instructions that present dual-coded information in both a semantic and spatial format far surpassed the other presentation methods in both objective

recall and subjective scoring. As Wickens (1992) stated: "the performance advantage attributed to the redundancy of information stands as one of the more firmly validated concepts in the engineering psychology of instructions" (p. 193). Clearly this performance advantage applies to medication instructions, and the use of fully redundant pictorials and text should be undertaken in the future whenever possible.

The benefit of using an incomplete set of pictorials was inconclusive with respect to the more common single-coded text instruction. Although one might have expected that any use of pictorials would facilitate performance by adding redundancy, the results indicate that text alone was just as effective in terms of recall and ratings as text with an incomplete set of pictorials.

Consistent with recommended guidelines, pictorials should rarely be used alone, that is, as a substitute for textual instructions. The amount of information that can reliably be gleaned from a pictorial is probably limited, and although their use may still be beneficial when compared to no instructions at all, pictorials should only be used to augment text.

It was noted that participants exposed to the no instruction format scored zero on the recall test. This is persuasive evidence that consumers need supplemental medication instructions to aid comprehension and recall of dosing information. In this regard, it is encouraging to note that most states require patient counseling or medication information leaflets be provided consumers when requested. The problem may then become one of inducing consumers to request (and read) this supplementary information.

A final comment on older adults as participants is warranted. Older adults are an important target population for research on medication recall and adherence because not only do they tend to take more medications than other groups, but they are also experiencing the physical and cognitive declines that accompany the aging process. As a group, older adults in this study behaved much like the other participants, with the main difference being that the older adults recalled far less information. This fact points to the critical need to improve methods of disseminating medical information in a manner that promotes proper recall and safe behavior for elders.

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