Winter 2016

Do Placement and Repetition of Information in Pictorials Affect Comprehension and Memory of Medication Instructions?

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DO PLACEMENT AND REPETITION OF INFORMATION IN PICTORIALS AFFECT COMPREHENSION AND MEMORY OF MEDICATION INSTRUCTIONS?

by

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(Under the Direction of Karen Z. Naufel)

ABSTRACT

The purpose of this study was to examine how text and picture pairings affected comprehension and memory for medication instructions. Participants viewed instructions on how to prepare a mock oral suspension drug. These instructions either had the picture repeat the information in the text, or complement information in the text. The text instructions were also either integrated into the pictures, or were separated from the pictures. Next, participants were assessed on their comprehension and memory including memory for the order of the steps and their belief in their ability to carry out this task effectively. The results indicated that participants who viewed the complementary format were better at remembering the order of events than those who viewed the repetitious format, perhaps because complementary pictures and text facilitate deeper processing and memory. Incorporating these factors into the creation of medication instructions could increase comprehension and help improve accuracy in medication administration.

INDEX WORDS: Pictorials, Medication instructions, Repetition, Formatting, Comprehension and memory, Self-efficacy

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B.A., Georgia Regents University, 2014

A Thesis Submitted to the Graduate Faculty of Georgia Southern University in Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

STATESBORO, GEORGIA

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Electronic Version Approved:

December 2016

ACKNOWLEDGEMENTS

The completion of my thesis would not have been possible without my mentor, Dr. Karen Naufel, who always provides valuable feedback, guidance, and encouragement. I would also like to thank my committee members, Dr. Lawrence Locker and Dr. Ty Boyer for their insight and expertise. I am grateful for the opportunity to have had such a wonderful thesis committee throughout this journey. Additionally, my research would not have been possible without assistance from Jason Parker, Lindsey Bradley, and Toni Hagin. Lastly, I would like to thank my family and friends for their support, love, and patience throughout my graduate career.

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CHAPTER 1

INTRODUCTION

The United States Pharmacopeia (USP, 1989) defines pharmaceutical pictograms as standardized images that provide instructions, dosage information, and warnings to consumers. Pictorials and text are common in health-related materials such as patient information leaflets, medical procedure guides, medication labels and instructions, and warnings. Labels and instructions can vary from having only text, only pictures, to having a combination of pictures and text to explain health information to patients. Existing literature provides evidence that combining pictures with written text can help integrate information and lead to improved health communication, better comprehension, increased information recall, and increased adherence to the information (Houts, Doak, Doak, & Loscalzo, 2006; Levie & Lentz, 1982). Ultimately, comprehension of health-related materials plays a critical role in health outcomes (Katz, Kripalani, & Weiss, 2006). Accordingly, pictorial instructions can aid in making the procedural information more readily accessible and allow comprehension to be less dependent on the patient's background knowledge (Hardie, Gagnon, & Eckel, 1979).

Although it is important to understand the information conveyed in instructions, it is equally important to be able to follow the instructions and adhere to factors such as dosages, timing, and administration. A combination of pictorial aids and written or oral instructions can enhance patients' understanding of the dosages and procedures of their medications (Katz et al., 2006). However, pictorials in health have not been studied in relation to repetition and placement of pictures and text. Such research is important as it could serve as a step towards better understanding of how pictorial information should be presented in order to maximize medication comprehension and adherence, standardizing health-related materials, and improving patients' health care and health outcomes. The current study examined the extent that different formats of pictures and text aid comprehension and memory for medication instructions.

Picture Superiority Effect

The *picture superiority effect* (Nelson, Reed, & Walling, 1976) suggests that concepts are more likely to be remembered if presented as pictures rather than words (Childers & Houston, 1984). Psychology and marketing research suggests that people prefer information in the form of pictures over text (Sansgiry, Cady, & Sansgiry, 2001). One reason that the picture superiority effect may occur is that pictures lead to deeper processing of information than do words (Weldon, Roediger, & Challis, 1989). The *levels-of-processing approach* posits that information processing can be increased by accessing different ‘levels’ of the cognitive system and pictures engage deeper levels of processing (Craik & Tulving, 1975; McBride & Dosher, 2002). Supporting this notion, Potter and Faulconer (1975) conducted an experiment to assess response times in categorizing objects that are presented as pictures or names. The results indicated that response times for deciding whether an object in a certain category was shorter for drawings than for words. As the authors describe, categorizing an object involves comprehending a conceptual idea of the object instead of its name or appearance. Their study’s analysis of timed responses showed that naming the object in a picture took longer than reading the name of the object aloud.

Another reason that the picture superiority effect may occur is that pictures usually are encoded twice as imaginal and verbal codes, whereas words are only encoded as verbal codes (Weldon et al., 1989). Paivio’s (1986) *dual coding theory* proposes that pictures are often superior to words because pictures are semantically encoded in the image pathway and verbal pathway. As a result, the strength of encoding increases for pictorial information. Supporting this theory, D’Agostino, O’Neill, and Paivio (1977) used pictures, concrete words, and abstract words to assess performance on free recall in tasks that emphasized structural (e.g., Was a word typed in capital letters?), phonemic (e.g., Do words rhyme with each other?), and semantic (e.g., Does a word fit into this sentence?). The results revealed that for phonemic and semantic processing of abstract words and pictures resulted in similar levels of recall and structural-processing had the lowest recall score. For concrete words, there were higher recall scores in semantic processing compared to phonemic processing and structural processing. There was more picture recall than word recall under both structural-processing and phonemic-processing conditions. However, there was no significant difference between the recall of concrete and abstract words. There was also no significant difference for recall of concrete words and pictures. Additionally, the recall score for concrete words and pictures was higher than the abstract-word recall score. For four age groups ranging from grades two to eleven, there was better recall for the pictorial stimuli compared to word stimuli, which demonstrated the picture superiority effect. The rate of picture recall was greater than word recall after structural processing and phonemic processing.

The picture-superiority effect has been studied in various cognitive assessments and health contexts. Whitehouse, Maybery, and Durkin (2006) examined the picture superiority effect by administering an explicit memory task to a group of participants with ages ranging from middle childhood to adolescence. Lists of pictures and words appeared on a computer screen and participants had to remember items from the stimulus list. The results revealed an advantage for pictures and suggested that the amount of picture superiority effect increased with age. It provides support for the idea that picture superiority occurs because pictorial information is encoded through two different routes and dual coding occurs. Creating a dual representation of a stimulus through image and verbal pathways occurs more as internalization of speech and verbal ability increase with age (Whitehouse et al., 2006).

In terms of evidence of the picture superiority effect in health, Houts et al. (2006) reviewed several studies that provide evidence of the effectiveness of pictures related to a number of factors including improving health communication, attention, comprehension, recall, and adherence to instructions. Their review revealed that pictures corresponding to written text facilitate better attention and memory of health education information, in comparison to text alone. Pictures are also related to better comprehension when they illustrate relationships between concepts, leading to better adherence to health instructions, and increased target behaviors. Although pictures can be helpful in comprehension, verbal instructions are also important as they can explain what is illustrated in the pictures (Houts et al., 2006). For instance, in order to understand a set of pictures that depict steps for medication administration, one must have prior knowledge of what syringes and mixing cups are used for. Current research suggests that not only do pictures facilitate cognitive processing (e.g., picture superiority effect), but also that benefits of dual-coding in the form of the combinations of pictures and text are beneficial for the comprehension of information. However, there are differing means by which pictures and text can be combined to convey information and the goal of the current study is to further examine the extent to which differing combinations may have an effect on health-related comprehension and behavior.

Integrated vs. Separated Pictures and Text

When readers encounter a complex multimedia message, they must read the text and look at the picture in order to process both components, give meaning to the information, and mentally integrate the contents (Holsanova, Holmberg, & Holmqvist, 2009). The process involves the *spatial contiguity principle*, which posits that people can better comprehend multimedia messages when pictures and words are formatted closer rather than further apart from each other (Mayer, 2005). In an integrated format, pictures are formatted closely to corresponding information in the text. In a separated format, the pictorial and main texts are formatted more distant from one another (Holsanova et al., 2009). For instance, some formats present the text at the top of the page and then a row of pictures on the bottom of the page. Processing a multimedia message can require more cognitive resources if pictures and text are placed further apart. Consequently, physically integrating the text and illustrations can reduce extraneous cognitive load and help schema construction (Sweller, Van Merriënboer, & Paas, 1998). Sweller (1988) refers to this phenomenon as the *split attention effect*, which takes place when there are numerous sources of information that make sense in conjunction but not in isolation. Integrating components reduces the amount of cognitive effort required to process the information (Sweller, 1994). Sweller and his colleagues conducted several experiments that demonstrated quicker learning of information in instructions when integrated formats are used instead of split-source formats. In one experiment, Chandler and Sweller (1991) presented students in an industrial training setting with instructional electrical engineering materials that were either integrated or conventional. Students were assessed with a procedural task in which electrical equipment or new wiring was installed. The installation testing assessed participants' speed and accuracy in the installation procedure. The integrated materials contained the same information as the conventional materials, differing only in the format of presentation. Chandler and Sweller (1991) predicted that the integrated instructions would be superior to conventional instructions, and the results supported the prediction that participants in the integrated condition would score higher in speed and accuracy of the procedural task than participants in the conventional condition. Chandler and Sweller (1991) explained these results by noting that the integrated instructions decrease the amount of cognitive resources required to process the materials for understanding, which allows more resources to be allocated to learning and recalling the installation testing material.

Similarly, people were more likely to simultaneously maintain corresponding words and text in working memory if they are presented near each other as opposed to being distant from each other (Mayer, 2001). Mayer explained this finding by stating that the amount of required cognitive resources is reduced when people do not have to look for information on a page or screen. As a result, there is more space in working memory for learning to occur. When the provided information is insufficient, people may not interpret pictorials in ways intended by the authors, and therefore close proximity of pictures and text can better promote integration and understanding.

Again confirming the spatial contiguity principle, Holsanova et al. (2009) examined separated versus integrated formats in a study involving authentic-looking newspapers and eye-tracking. In the separated graphic, the text and corresponding pictorial are formatted far apart from each other. In the integrated format, the pictorial was formatted close to segments of the text where the corresponding information is located. Reading behavior was measured by the order of reading, how much time it took to read, and text-graphic integration. They hypothesized that when there is less space between the text and picture, it will be easier for readers to find corresponding information. The arrangement would allow readers to integrate text and pictures, pay better attention, and process the information on a deeper level. Holsanova and colleagues (2009) predicted that there would be more integration of pictures and text for the *integrated* format than the *separated* format. The results showed that in the *separated* format, readers viewed the text and pictures as two separate parts and did not integrate them. In the *integrated* format that had less space between the pictures and text, readers were more likely to integrate the information because the pictures were next to the corresponding text information. The results confirmed the spatial contiguity principle and the prediction that the integrated format would yield better integration than the separated format. In other words, there was better integration of information that was presented in pictures and text that are placed close in proximity.

Johnson and Mayer (2012) investigated spatial contiguity in multimedia presentations about how car brakes work and recorded eye movements of participants. In one condition, participants viewed instructions that contained captioned illustrations that were placed near text. In the other condition, the text and illustrations were presented on separate pages. The results showed that when the captioned illustrations were placed near the text, there were about 75% more correct answers on problem-solving questions compared to when the text and illustrations were presented on separate pages (Johnson & Mayer, 2012). Additionally, Johnson and Mayer had predicted that the integrated-with-labels group would make more integrative transitions than the separated group, meaning eye movements from the text to diagram or the diagram to the text. The results indicated that the integrated-with-labels group made significantly more integrative transitions than the separated group. In another study, Harter and Ku (2008) examined the spatial contiguity principle in the context of computer instructions of mathematics word problems. They wanted to investigate the effect of spatial contiguity on the performance and attitude of sixth-grade students. Students were randomly assigned to a spatially contiguous or non-spatially contiguous condition based on their ability level determined by their performance on a pretest. The results showed that there was significantly greater improvement between the pretest to posttest for student in the spatially contiguous condition compared to the higher-ability students.

Responses from the focus group interviews suggested that the spatially contiguous instructions facilitated better comprehension than the non-spatially contiguous instructions. Both Johnson and Mayer (2012) and Harter and Ku (2008) found when pictures and text are placed close together, it results in better comprehension. Like Holsanova et al. (2009), these studies employed methods in which the information in the text repeated information contained in the picture.

To summarize, integrated versus separated pictures and text have been studied in the context of newspapers, car brake instructions, and mathematic instructions but there is no existing literature pertaining to health-related materials. It is important to note that the spatial contiguity principle has been examined in the context of learning and reading (Moreno & Mayer, 1999; Harter & Ku, 2008; Holsanova et al., 2009), and thus the pictures reiterated what the text said. However, studies did not investigate the extent that integration continues to facilitate comprehension if the instructions and pictures are redundant (e.g., of the same information) or complementary (e.g., information is split between pictures and text).

Repetitious vs. Complementary Pictures and Text

In the context of pictures and text, repetition in forms of multimedia repeats similar information across formats. This kind of repetition is often seen in images with text captions that provide a brief summary of portions of the image or long descriptions that are overtly repetitious (Brunyé, Taylor, & Rapp, 2008). In repetitious formats, the information provided in the text is also conveyed in the picture. In contrast, complementary forms of multimedia provide different information across formats (Brunyé et al., 2008). For example, the text provides part of the information and the picture provides the rest of it. Essentially, all of the information cannot be derived from just a single format of picture or text.

Various theories support the idea that repetition in multimedia presentations is superior over complementary information. The *levels-of-processing approach* (Craik & Lockhart, 1972) posits that a stimulus is processed at multiple levels simultaneously and deeper processing facilitates better memory of the information. The levels-of-processing approach suggests that repetition will aid recall if the second presentation causes the learner to process the material at a different semantic or sensory level. For instance, stimuli that contain pictures or relate to current knowledge goes through deeper processing because people remember information that is meaningful to them. Meaningful information requires more processing than stimuli that is not meaningful (Craik & Lockhart, 1972). The approach posits that when something is coded at a certain level in the cognitive system, recall is based on that same level later on (Roediger, Gallo, & Geraci, 2002). In other words, information is more likely to be remembered if it was deeply processed while learning. Adding text-redundant illustrations may promote text processing at a different level, and repetition of information can provide a second learning opportunity and reduce forgetting because of deeper processing (Levie & Lentz, 1982). The combination of a picture and text allow the information to be processed twice, which may facilitate comprehension and memory (Glenberg & Langston, 1992). As noted above, according to Paivio's (1986) *dual coding theory*, there is a cognitive subsystem that specializes in processing nonverbal stimuli and another that specializes in language. Processing text and pictures leads to two types of representations that may allow separate access to information in memory and may benefit retention of the information conveyed. Research suggests that people typically attend to the overall picture and there is a lack of attention and encoding of most of the detailed features (Friedman, 1979). It is also possible that people only closely attend to parts of pictures that are mentioned in the text (Levie & Lentz, 1982). If this is the case, it could indicate that text repetition of information conveyed in a picture facilitate better comprehension and information recall because of the emphasis on certain details. Levie and Lentz (1982) state that pictures may aid comprehension by forming a context for the interpretation of text information and by increasing the depth of semantic processing. Additionally, they state that pictures may benefit retention because repetition of information conveyed in accompanying text facilitates deeper processing.

Brunyé and colleagues (2008) compared repetitious with complementary multimedia presentations. In Experiment 1, students were presented sequences for assembling toys and then they had to recall if those steps were presented in the correct order. They also participated in an information recall task in which they assembled toys. Consistent with the authors' predictions, the results showed that participants in the repetitious multimedia condition performed better than the complementary multimedia condition on some of the measures. Repetitious multimedia features pictures and text that both provide similar information while complementary multimedia features pictures and text that each provide different information. Their results revealed that repetitious multimedia had higher scores than complementary multimedia on free recall, order verification accuracy, and order verification response times. In other words, participants who viewed repetitious multimedia were able to remember the correct sequence orders and respond quicker than participants who viewed complementary multimedia. In Experiment 2, participants viewed repetitious instructions or instructions that were interleaved, meaning that the sequence alternated from pictures to text. The results revealed that participants who viewed repetitious multimedia scored higher accuracy on assembling toys than participants who viewed the interleaved multimedia. Their studies suggest that multimedia containing both pictures and text are more efficacious for learning and remembering compared to only pictures or only text.

Additionally, repetitious multimedia aids recall of information and sequences. Although Brunyé et al. (2008) investigated repetitious and complementary multimedia in their first study, their research did not include the effects of formatting the text to be close to the picture or far apart.

In contrast, there is also research that indicates that complementary multimedia formats are more efficacious for comprehension and memory. Sweller's (1988) cognitive load theory states that repetition could hinder learning. Although some research suggests that repetition provides a second learning opportunity, there is research that states that repetition could cause increased cognitive load for working memory and reduced integration of information into long-term memory (Levie & Lentz, 1982; Sweller, 1988). For instance, Kalyuga, Chandler, and Sweller (1999) examined split-attention and repetition in instructional materials. They found that when text was presented in both auditory and visual formats, the redundancy created extra cognitive load that impeded learning. This counter-hypothesis indicates that complementary multimedia formats promote integration of information because part of the information is derived from the picture and the other part is derived from the text. It is possible that participants in the repetitious multimedia conditions will score better on the comprehension and memory test and sequence order verification test, and it is also possible that participants in the complementary multimedia conditions will score better. Based on theoretical evidence, there appears to be evidence that there are advantages to both repetitious multimedia and complementary multimedia that may contribute to performance on the measures.

Statement of Problem

Existing research that addresses the effects of repetition in pictures and text has been in contexts such as object assembly. Some research shows that repetitious multimedia generally results in better free recall and accuracy as well as response times in order verification (Brunyé et al., 2008) while other research suggests that complementary multimedia results in better comprehension and recall (Sweller, 1988). Research also suggests that there is better recall for pictures integrated with the text than separated (Johnson & Mayer, 2012). However, there is an existing gap in the literature that no studies have investigated the effect of repetitious versus complementary information in the context of integrated versus separated text and pictorial information.

The levels-of-processing approach (Craik & Lockhart, 1972), Levie and Lentz's (1982), and dual coding theory (Paivio, 1986) suggest that repetition of information can aid in remembering information. On the contrary, Sweller's (1988) cognitive load theory posits that complementary multimedia formats yield better comprehension and memory than repetitious multimedia. Therefore, this study tested the extent that repetitious versus complementary information in pictures paired with texts plays a role in comprehension and memory, sequence order verification, and self-efficacy. Additionally, research suggests that integrated versus separated formatting in instructions play a role in how information is processed and remembered. The spatial contiguity principle and split attention effect suggest that physical integration of components can reduce the amount of cognitive effort needed to combine separate types of information (Mayer, 2005; Sweller et al., 1988; Sweller, 1994). Therefore, research is needed to identify the extent that repetition and formatting facilitate or hinder memory.

In this study, participants viewed a set of instructions on how to prepare a mock oral suspension drug that involves a series of eight steps. There were four different sets of medication instructions that varied in whether the information in the pictures and text were close together vs. far apart and whether the information in the pictures repeated or complemented the information in the text. After viewing these instruction sets, they completed measures about comprehension and memory for the instructions and their belief in their ability to carry out instructions. The following outcomes were predicted:

Some research suggests that repetitious multimedia promotes better comprehension and recall than complementary multimedia (Brunyé et al., 2008). However, other research suggests that complementary multimedia is more efficacious for comprehension and recall so a set of competing hypotheses were developed (Sweller, 1988). Based on this research, the following competing hypotheses were formed:

Hypothesis 1a: Participants in the repetitious multimedia conditions will score higher than those in complementary multimedia conditions on the comprehension and memory test, sequence order verification test, and self-efficacy.

Hypothesis 1b: Participants in the complementary multimedia conditions will score higher than those in repetitious multimedia conditions on the comprehension and memory test, sequence order verification test, and self-efficacy.

However, the degree to which repetition and complementary may work depends on the extent that the pictures and texts are integrated versus separated. If the format is integrated, complementary may be more efficacious than separated. That is, when pictures and text are placed close in proximity to each other, complementary information can reduce cognitive load required for processing and memory while repetitious information can require more cognitive load (Sweller, 1988). If the format is separated, repetition would be more efficacious than complementary. This is because the pictures and text placed further apart from each other would provide similar information (Brunyé et al., 2008). Based on this research, the following hypothesis was also formed:

Hypothesis 2: Effects of repetition would be moderated by a separated format and effects of complementary information would be moderated by the extent that text and pictures were integrated.

CHAPTER 2

METHOD

Participants

Two hundred and sixty-eight students at a southeastern university participated in this study. The participants were undergraduate Introduction to Psychology students and they were at least 18 years of age. 46.3% of participants were women (*N*=124) and 53.4% were men (*N*=143). 64.2% of participants indicated they were Caucasian (*N*=172), 27.2% of participants were African-American (*N*=73), 2.6% were Hispanic or Latino American (*N*=7), 2.6% responded with "other" for their race (*N*=7), 1.1% were American Indian or Alaskan Native (*N*=3), 1.1% chose not to respond to the race prompt (*N*=3), 0.7% were Native Hawaiian or Pacific Islander (*N*=2), and 0.4% were Asian-American (*N*=1).

For the survey question, "Have you ever used a syringe to administer medication to yourself or another person or animal before?" 55.6% (*N*=149) of participants answered "yes." One participant chose not to respond to the question. 28.7% (*N*=77) of participants answered "yes" to the survey question, "Have you ever administered a complex medication to yourself or another person or animal before?" For this question, two participants chose not to respond. In sum, over half of the participants had previous experience using a syringe to administer medication and a smaller percentage indicated having administered a complex medication.

Participants were recruited through the Psychology Department Research Pool as a requirement for an introductory-level psychology course. Research procedures ensured that all participants were treated in accordance with the “Ethical Principles of Psychologists and Code of Conduct” (American Psychological Association, 2002). All of the participants gave informed consent prior to beginning the study, and completed the study in person in a research lab.

Design, Materials, and Measures

Participants all viewed a set of mock oral suspension instructions for a fictional drug ZYTREX . The text and pictorial instructions for ZYTREX are heavily based on the real oral suspension medication, ISENTRESS® (raltegravir), a treatment for human immunodeficiency virus (HIV) that is produced by Merck & Co., Inc. The Instructions for Use medication insert for ISENTRESS® are used for the pilot study and actual study, and the pictures and instructions are altered in order to accommodate the academic lab setting, as opposed to a clinical setting. The instructions feature ZYTREX, a mock oral suspension medication includes medication packets, mixing cups, and a syringe.

The study is a 2 (Multimedia Type: repetitious versus complementary) X 2 (Presentation Type: integrated versus separated) between-subjects experimental design. Repetitious information means that the information in pictures and text both provide the same, repeated information. For instance, the text would state “Swirl the mixing cup to mix using a gentle circular motion for 30-60 seconds (see figure G)” and there would be a picture showing a hand swirling a mixing cup in a circular motion accompanied by a clock icon with the caption “30-60 seconds” (Merck & Co., Inc., 2013). Complementary information means that half of the information comes from the picture and the other half comes from the text. For instance, the text would state “Swirl the mixing cup to mix using a gentle circular motion as indicated in the figure below” and there would be a picture showing a hand swirling a mixing cup in a circular motion accompanied by a clock icon with the caption “30-60 seconds.” An integrated format refers to when a picture and text are placed in close proximity. A separated format refers to when a picture and text are placed far apart from one another. In total, there were 8 steps that were entirely repetitious and integrated, repetitious and separated, complementary and integrated, or complementary and separated.

The comprehensibility of the pictorial instructions alone was assessed in the pilot study. In this study, 30 participants viewed the pictorial steps without word instructions. Twenty completed the multiple choice test in which they selected from a list of choices to indicate what the step depicted. Ten participants completed the fill-in-the-blank test that contained the same pictures and they were asked to write down their interpretation for each step. Drawing from the results, three steps had the highest frequency in number of incorrect responses, which may have resulted from lack of labels in the drawings for liquids to identify the substance and quantity. Subsequently, the instructions were edited accordingly.

Comprehension/Memory Test

The self-designed Comprehension/Memory multiple choice test (refer to Appendix A) contained eight questions and assessed participants' understanding of the medication instructions and their memory of the correct dosages, frequency of administration, and steps for administration. An example of a question is "How much liquid medication is in 1 dose?" and the multiple choice answers included the options: A) 1mL, B) 3mL, C) 5mL, and D) 6mL.

Sequence Order Verification Test

The Sequence Order Verification Test for this study was adapted from Brunyé et al. (2008; Appendix B). The test contained eight questions that tested participants' temporal knowledge by presenting a series of eight pairs, with two pictures per pair that were in either correct or reverse order, going from left to right. Text was omitted. Participants determined whether the steps were presented in the correct temporal sequence. As in the Brunyé et al. (2008) study, correct temporal order did not require contiguous steps (i.e., a trial showing steps 2 and 4 are in correct temporal order even though step 3 is missing in the sequence).

Self-efficacy Questionnaire

The Self-efficacy Questionnaire (refer to Appendix C) was a self-designed series of six questions that examined the participants' self-reports of their perceived accuracy on the Comprehension/Memory Test and Sequence Order Verification Test, and their perceived confidence in a situation where they would be administering the medication in real life. An example of a question is: "If this were actual medication, I would feel confident that I had taken the right dosage." The question responses were rated on a five-point Likert scale (1=Strongly Disagree to 5=Strongly Agree). The scale showed sufficient consistency (Cronbach's α=.82).

Timing

The total amount of time spent on viewing each of the eight steps of the medication instructions was measured using the timing function on Qualtrics. The amount of time spent viewing one step was measured from when participants clicked the "next" button on the computer to view the step to when participants clicked the following "next" button to proceed onto the next step. The amount of time spent viewing each of the eight steps was averaged for each of the participants, producing a mean value for each of them. Time was measured in order to examine whether there was a connection between the amount of time spent viewing the medication instructions and how participants scored on the comprehension and memory test, sequence order verification test, and self-efficacy questionnaire.

Demographics Questionnaire

The demographics questionnaire (refer to Appendix D) contained five questions about the participant's gender, race, year level of education, and whether they have had previous experience in administering medication. The questions about previous experience were "Have you ever used a syringe to administer medication to yourself or another person or animal before?" (Yes or no response options) and "Have you ever administered a complex medication to yourself or another person or animal before?" (Yes or no response options). These questions were added to examine the extent that previous experience with medicine predicted performance on the current study's measures.

Procedure

The study was conducted in a lab setting in which a maximum of four per time slot. All materials and measures were computerized. After sitting at the computer, participants read and signed the Informed Consent that explained their rights as a participant. The research assistant instructed participants to put forth their best effort as if they were following the medication instructions to administer medication to themselves because improper administration could result in serious consequences. Next, participants read medication instructions about preparing a dosage for oral suspension administration. Participants were randomly assigned to view one of the four instruction conditions that they viewed at their own pace. Following, participants completed the comprehension/memory test, the sequence order verification test, self-efficacy questionnaire, and the demographics questionnaire.

CHAPTER 3

RESULTS

Descriptive Statistics

Three dependent variables were calculated for this study: comprehension and memory, sequence order verification, and self-efficacy. The Comprehension/Memory Test scores ranged from 3 to 8 (possible range 0-8; $N = 264$; $M = 6.75$, $SD = 1.04$, $SE = 0.06$). Higher scores indicate better comprehension and memory of information in the medication instructions. The Sequence Order Verification Test scores ranged from 1 to 8 (possible range 0-8; $N = 260$; $M = 6.33$, $SD = 1.24$, $SE = 0.08$). Higher scores denote better temporal knowledge of the sequence of medication instruction steps. The Self-efficacy Questionnaire scores ranged from 10 to 30 (possible range: 0-30; $N = 265$; $M = 23.27$, $SD = 3.64$, $SE = 0.22$). Higher scores convey better performance on the Comprehension/Memory Test, better performance on the Sequence Order Verification Test, and more confidence in a situation where the participant would be administering the medication in real life. Each of the measures has varying sample sizes because of participants who skipped or chose not to complete questions in the measures.

Missing Data

Total mean scores on each measure were generated if every question for that measure was completed. If the participant skipped a question or left it blank, it was considered a non-response. In those cases, the entire response was excluded from analyses. Specifically, four participants' responses on the comprehension and memory measure were excluded (repetitious-integrated, $n = 1$; complementary-integrated, $n = 1$; complementary-separated, $n = 2$). Eight participants' responses on the sequence order verification measure were excluded (repetitious-integrated, $n = 3$; complementary-integrated, $n = 5$. There were more participants in the complementary-integrated condition who skipped a question compared to the other conditions but not to a significant degree. Fourteen skipped the question “Have you ever used a syringe to administer medication to yourself or another person or animal before?” and 14 skipped the question “Have you ever administered a complex medication to yourself or another person or animal before?” In short, 14 participants skipped one or more questions. These participants were excluded from the analyses described below.

Identifying Possible Covariates

To determine if previous experience with medication was a possible covariate, independent sample *t*-tests were used if there were differences between those participants that had experience using syringes to administer medication and previous experience administering complex medications versus those that did not have experience on the three outcome measures. Only participants who completed the comprehension and memory, sequence order verification, and self-efficacy measures in their entirety were included in the analyses. The results revealed that those with previous experience using syringes to administer medication scored higher on the comprehension measure (N=140, M = 6.96, SD = 0.94, SE = 0.08) compared to those without previous experience (N=114, M = 6.50, SD = 1.12, SE =0.10); $t(252) = 3.53$, $p = 0.001$. There was no significant result in the relationship between previous experience using syringes to administer medication with sequence order verification; $t(252) = 0.99$, $p = 0.31$. There were also no significant result between previous experience using syringes to administer medication with self-efficacy; $t(252) =1.99$, $p = 0.05$. Additionally, there were no significant results in the relationship between previous experience administering a complex medication with comprehension; $t(252) = 0.97$, p=0.34, sequence order verification; $t(252) = 0.06$, $p = 0.95$, or self-efficacy; $t(252)=1.33$, $p = 0.18$. Previous experience using syringes was entered as a covariate in the primary analyses.

Primary Analyses

I hypothesized that either repetitious or complementary pictures and text would score higher on the comprehension and memory test, sequence order verification test, and self-efficacy, integrated pictures and text would score higher than separated on the measures, and there may be an interaction in the multimedia type independent variable (repetitious versus complementary) and in the presentation type independent variable (integrated versus separated). The data were analyzed using a factorial MANCOVA to determine the effect of multimedia type (repetitious versus complementary) and presentation type (integrated versus separated) on comprehension and memory, sequence order verification, and self-efficacy. The covariates were two demographics questions regarding past experience administering medication with a syringe and past experience administering a complex medication. A factorial MANCOVA was used because measuring multiple dependent variables instead of one helps show how repetition and formatting affect how participants understand information in medication instructions. If separate ANCOVAs are conducted on multiple dependent variables, the distributions for the groups may overlap and a mean difference may not be found (Stevens, 2001; Tabachnick & Fidell, 2007). Furthermore, if multiple dependent variables are in an analysis, they will be correlated to a certain degree. MANCOVAs take into consideration the intercorrelations between the dependent variables. When a MANCOVA is performed on multiple dependent variables, differences may emerge and there may be a significant difference between the groups, while avoiding an inflated Type I error rate that can result from using several univariate analyses. Using a MANCOVA maintains the desired error rate (.05 level in this study: Harris, 1998).

A 2 (multimedia type: repetitious vs. complementary) x 2(presentation type: separated vs. integrated) MANCOVA was conducted with previous experience with syringes as a covariate, and comprehension and memory, sequence order verification, and self-efficacy as dependent variables. The covariate was a significant predictor, Wilk's λ = 0.95, *F*(3, 247) = 4.08, *p* = 0, η_ρ^2 = 0.05.The previously mentioned *t*-tests show the direction of the relationship.

Additionally, the results of the MANCOVA revealed that multimedia type significantly affected the outcome variables, Wilk's λ = 0.96, *F*(3, 247) = 3.77, *p* = 0.01, η_ρ^2 = 0.04. There was no significant effect of presentation type, Wilk's λ = .99, *F*(3, 247) = 0.32, *p* = 0.81, η_ρ^2 = 0, or interaction effect, Wilk's λ = 0.99, *F*(3, 247) = 0.65, *p* = 0.59, η_ρ^2 = 0. Follow-up ANCOVAs with multimedia type as the factor were examined. Effects of multimedia type were not found on comprehension, *F*(1, 249) = 1.16, *p* = .28, η_ρ^2 = 0, or self-efficacy, *F*(1, 249) = 0.62, *p* = 0.43, η_ρ^2 = 0[1]. Those who saw the complementary format scored higher on the sequence order verification than those who saw the repetitious format, *F*(1, 249) = 6.72, *p* = 0.01, η_ρ^2 = 0.03. Figure 1 presents the adjusted group means for total scores on sequence order verification task adjusted for the covariate (*M* = 1.45).

Additional Analyses

A 2 (multimedia type: repetitious vs. complementary) x 2 (presentation type: separated vs. integrated) ANOVA was used to analyze differences among groups on time viewing the medication instructions. The results indicated that there was a significant effect of presentation type on time spent viewing the medication instructions, *F*(1, 250) = 5.24, *p* = 0.02. Cohen's effect size value (*d* = 0.02) suggested there was a small effect size. There was no significant effect of multimedia type, *F*(1, 250) = 0.44, *p* = 0.51, or interaction effect, *F*(1, 250) = 0.41, *p* = 0.52. Those who saw the separated format spent more time viewing the medication instructions

(*M* = 84.33; *SD* = 25.41) than those who saw the integrated format (*M* = 77.66; *SD* = 20.40), $F(1, 250) = 5.24$, $p = 0.02$. These results suggest that the proximity in which pictures and text are formatted do have an effect on the amount of time spent viewing the steps of the medication instructions. Specifically, the results suggest that participants who saw the separated format spent more time viewing the medication instructions than did those who saw the integrated format.

CHAPTER 4

DISCUSSION

The present study examined the effect of multimedia type and presentation type on comprehension and memory, sequence order verification, and self-efficacy. Because of discrepancies in the literature, competing hypotheses were developed. The first hypothesis stated that participants in the repetitious multimedia conditions would score higher than those in complementary multimedia conditions on the comprehension and memory test, sequence order verification test, and self-efficacy while the competing hypothesis stated that participants in the complementary multimedia conditions would score higher than those in the repetitious multimedia conditions.

Consistent with the latter hypothesis, the results suggest that the complementary format is beneficial in terms of a sequence order verification task. This finding is consistent with the theory of cognitive load theory (Sweller, 1988). Repetition can create extraneous cognitive load because of information overload and as a result, it can interfere with learning (Van Merriënboer & Sweller, 2010). The resources required to process redundant information can take away from resources allocated to retain and retrieve the information (Kalyuga et al., 1999). However, complementary formats help reduce extraneous cognitive load, thus freeing resources to efficiently process and retain information.

Additionally, participants in complementary conditions may have performed better than those in the repetitious conditions because the information in pictures and text had to be mentally integrated, thus facilitating deeper processing and better memory of the step sequencing. Mentally integrating complementary information can help reduce working memory load and preserve the information that goes into long-term memory (Sweller, 1988). As a result, the complementary format may have allowed participants to remember the sequencing of the medication instructions better than did participants who saw the repetitious formatting. Perhaps paying attention to the details of both pictures and text instead of solely reading the text and glancing past the pictures led to deeper processing. The deeper processing and memory of the details may have then contributed to better performance on the sequence order verification task that presented participants with only pictures and no accompanying text.

Relatedly, participants receiving complementary instructions could have performed better than those receiving repetitious instructions because of the nature of the sequence order verification task. The sequence order verification task contained no text and only pictures from the medication instructions. Perhaps those in the repetitious conditions did not need to attend to the picture because they could derive information from just the text. The same information is conveyed through both pictures and text, making it redundant. Meanwhile, those in the complementary conditions had to refer to both pictures and text because the information is split between the two sources. It is important to understand whether complementary or repetitious information is better because when it comes to any kind of instructions, the reader must be able to easily comprehend the information to perform the task correctly, and text instructions may not be readily available. For instance, the content and formatting of medication instructions should be informative yet succinct so that people can easily comprehend how medication should be administered.

Though complementary information did have an effect, this effect was not moderated by the extent that pictures and text were integrated. The results are in contrast with what Sweller's (1988) cognitive load theory and Mayer's (2005) spatial contiguity principle had predicted. Based on the two theories, participants who saw integrated formats of pictures and text should have required less cognitive effort and thus, scored higher on comprehension and memory compared to those who saw separated formats. Perhaps the null results in this study could have been related to familiarity to the task. In Chandler and Sweller's (1991) study, participants were all electrical engineering students or apprentices while the current study had both participants who had experience administering medication and those who did not have experience.

The results of the current study unexpectedly showed that presentation type (separated versus integrated) did not significantly affect comprehension or self-efficacy measures. One possible reason for this null effect is that the content of instructions matters more than formatting when it comes to reading health information as opposed to other types of information. Indeed, the other studies examining integration and separation have examined integration in newspapers (e.g., Holsanova et al., 2009), but no studies have investigated integrated and separated formatting in health information like medication instructions or using online instruments. The results of the study showed that the effect of presentation type was null but perhaps the self-designed measures were not measuring sensitively enough to see any significant results. Calibrating the measures so that they are more in line with Chandler and Sweller (1991) and Brunyé et al. (2008) may provide more accuracy. Additionally, the differences between integrated and separated conditions may have been too subtle to significantly affect participants' performance on the measures. It is possible that the pictures and text were not placed far enough from each other in the separated conditions to elicit any noticeable differences in the integrated condition. The results however, did reveal that those who saw the separated format spent more time viewing the medication instructions than those who saw the integrated format, which suggests that there was in fact enough contrast between the integrated and separated formats when timing is taken into consideration.

Though separation versus integration did not affect memory scores in this study, their effect on the amount of time spent viewing medication instructions provides potential applications for viewing health information. There are real-life situations where information in pictures and text are placed far apart in proximity, such as in newspaper articles that require readers to flip to another page to view a diagram. In the health domain, there are instructions for metered-dose inhalers that dispense medicine for individuals with asthma and they are usually in an integrated or separated format (Asthma Society of Canada, 2016). In situations where it is crucial to act quickly (like taking an inhaler), it would be best to integrate the text with the picture and utilize complementary information. Another limitation is the fact that neither multimedia type nor presentation type affected the comprehension and memory test. Perhaps the self-designed test was not difficult enough or there were too few questions and it resulted in insufficient variability to detect differences among participants' scores. On average, participants scored 6.75 out of 8.00 on the comprehension and memory test, suggesting potential ceiling effects. Taking this into consideration, any future follow-up studies may need a revised version of the comprehension and memory tests that would be more valid and comprehensive.

Future Directions

In the future, there could be also be more variation among the conditions to make sure that they clearly portray the repetitious versus complementary formats and integrated versus separated formats. For instance, the content in pictures and text could contain more differences for repetitious versus complementary. Also, there could be a bigger contrast in how the pictures and text are presented on the computer screen so that the separated format would have more space in between the pictures and text. The differences in the presentation formats (integrated versus separated) in the current study may have been too subtle for significant results to emerge on some measures. A potential follow-up study could entail a procedural task in which participants would view a set of medication instructions, carry out a mock procedural task of administering medication with a syringe, and then completing memory measures. Overall, the data provided insight in how formatting instructions may affect outcomes in the context of medication instructions. Specifically, complementary instructions may be better understood and remembered than repetitious instructions. Proceeding with follow-up studies in the future could provide more valuable information that could contribute to better comprehension, medication adherence, and less medication errors.

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Footnotes

[1] A MANOVA was also performed without the covariate. Specifically, a 2 (multimedia type: repetitious vs. complementary) x 2(presentation type: separated vs. integrated) MANOVA with comprehension, sequence order verification, and self-efficacy as dependent variables was conducted. The results revealed that multimedia type significantly affected the outcome variables, Wilk's $\lambda = 0.96$, $F(3, 248) = 3.89$, $p = 0.01$, $\eta_\rho^2 = 0.05$. There was no significant effect of presentation type, Wilk's $\lambda = 0.99$, $F(3, 248) = 0.27$, $p = 0.85$, $\eta_\rho^2 = 0$, or interaction effects, Wilk's $\lambda = 0.99$, $F(3, 248) = 0.76$, $p = 0.52$, $\eta_\rho^2 = 0$. The follow-up ANOVAs with multimedia type as the factor were examined. Those who saw the complementary format scored higher on the sequence order verification task ($M = 6.53$; $SD = 1.04$) than those who saw the repetitious format ($M = 6.14$; $SD = 1.38$), $F(3, 248) = 6.44$, $p = 0.01$, $\eta_\rho^2 = 0.03$. Effects of multimedia type were not found on comprehension, $F(3, 248) = 1.49$, $p = 0.22$, $\eta_\rho^2 = 0$, or self-efficacy, $F(3, 248) = 0.77$, $p = 0.38$, $\eta_\rho^2 = 0$. These results follow the same pattern as the MANCOVA.

APPENDIX A

COMPREHENSION AND MEMORY TEST

Please answer the following questions based on the set of medication instructions you viewed at the beginning of the experiment.

1) **How much liquid medication is in 1 dose?**
    a. 1mL
    b. 3mL
    c. 5mL
    d. 6mL

2) **How many steps are there in the set of medication instructions?**
    a. 6
    b. 8
    c. 10
    d. 12

3) **How many mixing cups does the oral suspension kit contain?**
    a. 1
    b. 2
    c. 3
    d. 4

4) **How many syringes does the oral suspension kit contain?**
    a. 1
    b. 2
    c. 3
    d. 4

5) **Which substance is drawn into the dosing syringe in Step 1?**
    a. Mixed oral suspension solution
    b. Water
    c. Powder medication

6) What is the duration of time in which the mixing cup should be mixed in a circular motion?

a. 10 seconds
b. 20 seconds
c. 30-60 seconds
d. 70-90 seconds

7) How should the medical solution be mixed?

a. In a circular motion
b. Shaken up and down quickly
c. Turned upside down and then right side up repeatedly
d. Turned upside down and then right side up once

8) How should the lid be placed on the cup?

a. It should be twisted
b. It should be snapped
c. It should be tapped

APPENDIX B

SEQUENCE ORDER VERIFICATION TEST

In the following test, you will be presented with a series of eight pairs of steps from the instructions. Each pair will consist of two pictures from the instructions. Reading from left to right, they will be in either correct or incorrect (reverse) order and a pair can be considered correct order even if they are not consecutive (i.e., a pair showing Steps 2 and 4 would be considered in correct order, despite the fact that Step 3 is missing in the sequence). Please select "Yes" or "No" in each question to indicate whether the pair is in correct order.

1) [Key: Correct] – Step 3 and Step 4

Is the following pair in correct order?

A. Yes
B. No

Image of Step 3 | **Image of Step 4**

2) [Key: Correct] – Step 6 and Step 7

Is the following pair in correct order?

A. Yes
B. No

Image of Step 6 | **Image of Step 7**

3) [Key: Incorrect] – Step 5 and Step 4

Is the following pair in correct order?

A. Yes
B. No

Image of Step 5

Image of Step 4

4) [Key: Correct] – Step 6 and Step 8

Is the following pair in correct order?

A. Yes
B. No

Image of Step 6

Image of Step 8

5) [Key: Correct] – Step 2 and Step 4

Is the following pair in correct order?

A. Yes
B. No

Image of Step 2 **Image of Step 4**

6) [Key: Incorrect] – Step 7 and Step 6

Is the following pair in correct order?

A. Yes
B. No

Image of Step 7 **Image of Step 6**

7) [Key: Correct] – Step 1 and Step 2

Is the following pair in correct order?

A. Yes
B. No

Image of Step 1 **Image of Step 2**

8) [Key: Incorrect] – Step 8 and Step 6

Is the following pair in correct order?

A. Yes
B. No

Image of Step 8 **Image of Step 6**

APPENDIX C

SELF-EFFICACY QUESTIONNAIRE

Please respond with your level of agreement with the following statements:

1) **I was able to remember the steps of the medication instructions correctly.**
    a. Strongly disagree
    b. Disagree
    c. Neither agree nor disagree
    d. Agree
    e. Strongly agree

2) **I was able to remember details like the number of milliliters in a dose.**
    a. Strongly disagree
    b. Disagree
    c. Neither agree nor disagree
    d. Agree
    e. Strongly agree

3) **I was able to remember how each of the materials (e.g., syringe, mixing cup, and medication packet) are used.**
    a. Strongly disagree
    b. Disagree
    c. Neither agree nor disagree
    d. Agree
    e. Strongly agree

4) **If this were actual medication, I would feel confident that I administered the right dosage.**
    a. Strongly disagree
    b. Disagree
    c. Neither agree nor disagree
    d. Agree
    e. Strongly agree

5) **I thought it was easy to understand the details of the instructions.**
    a. Strongly disagree
    b. Disagree
    c. Neither agree nor disagree
    d. Agree
    e. Strongly agree

6) **I thought it was easy to remember the order of the instructions.**
   a. Strongly disagree
   b. Disagree
   c. Neither agree nor disagree
   d. Agree
   e. Strongly agree

APPENDIX D

DEMOGRAPHICS QUESTIONNAIRE

1) **Please indicate your gender:**
   a. Female
   b. Male
   c. Other (please specify: ____________
   d. Prefer not to answer

2) **Please indicate your race (check all that apply):**
   a. American Indian or Alaskan Native
   b. Asian or Asian-American
   c. Black or African American
   d. Native Hawaiian or Pacific Islander
   e. White
   f. Other (please specify): ____________________
   g. Prefer not to answer

3) **What is your year in school?**
   a. First Year Student (0-30 credits)
   b. Sophomore (31-60 credits)
   c. Junior (61-90 credits)
   d. Senior (91+ credits)
   e. Graduate student
   f. Prefer not to answer

4) **Have you ever used a syringe to administer medication to yourself or another person or animal before?**
   a. Yes
   b. No
5) **Have you ever administered a complex medication to yourself or another person or animal before?**
   a. Yes
   b. No

APPENDIX E

EXPERIMENT SCRIPT

[Participant enters room and Research Assistant directs him/her to computer]

Research Assistant:

"Hi, my name is **_____** and I am a research assistant for this study. Thank you for choosing to participate. On the computer screen is the informed consent form that describes the purpose of the study and what you will be doing. Please carefully read over this form from top to bottom, and click the box that indicates that you are aware of your rights and agree to participate in this experiment. After clicking 'yes,' click the arrow on the bottom of the right of the screen to move onto the next page."

[After all participants have clicked through informed consent forms]

Research Assistant:

"You will be viewing a set of medication instructions on the computer and then you will be quizzed on how well you understand and can remember the details of the procedure. Please put forth your best effort as if you were following the medication instructions to administer medication to yourself."

"The procedure of viewing the instructions and doing the tests that follow are self-paced, so you may use as much time as needed. Please note that you will only be able to view the medication instructions once at the beginning and cannot refer back to them."

"Now, carefully read the instructions to view the medication instructions and quizzes. Please let me know if you have any questions. You may begin."

[Participant completes study]

Research Assistant: "Thank you for your participation and your contribution to our research!"

[Research Assistant walks Participant out of the lab]

Figure 1

Adjusted Group Means (Standard Error Bars) on Sequence Order Verification Test according to Multimedia Type