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## Does apparent motion improve warning label understanding?

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DOES APPARENT MOTION  
IMPROVE WARNING LABEL  
UNDERSTANDING?

A Thesis

Submitted to the Graduate School of Arts and Sciences of the  
UNIVERSITY OF DAYTON

In Partial Fulfillment of the Requirements for

The Degree

Master of Arts in Psychology

by

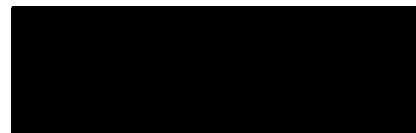
Sara Anne Loomer

UNIVERSITY OF DAYTON

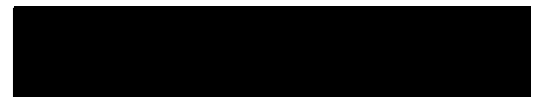
Dayton, Ohio

March 2008

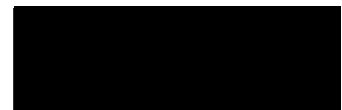
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## ABSTRACT

### DOES APPARENT MOTION IMPROVE WARNING LABEL UNDERSTANDING?

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This thesis studies the effect of apparent motion and sequential drawings on warning label understanding. This research compares the current standard label (traditional label) that contains one static graphic and is accompanied with a textual message to two alternative labels that employ sequential drawings and/or apparent motion.

Thirty participants examined eighteen unique hazards (caution, warning, and danger) using one of three label types: traditional labels, two-panel labels, and lenticular labels. The two-panel label consisted of two pairs of pictures. The first pair of drawings showed the hazard and the correct behavior to avoid the hazard. The second pair of drawings contained a sketch of the hazard and the consequences of not complying with the warning. The lenticular labels used the same graphics from the two-panel label and combined the images to create the perception of motion. Lenticulars are made up of two components, a flat printed image and a lens. The pictures are interlaced by printing very thin alternating lines of each picture. The dependent variable addressed is the difference in understanding between the traditional label, the two-panel label and the lenticular

label. This thesis also examined the ranking of the labels in order of perceived understanding and the level of self-reported likelihood to comply.

Two-panel and lenticular labels were significantly better understood than traditional labels. Additionally the caution hazards were significantly better understood than both warning and danger hazards. Seventy-three percent of participants believed that the two-panel labels provided them with the best understanding of the label. The self-reported likelihood of compliance was high overall, with the best likelihood of compliance coming from the two-panel labels.

These findings suggest that hazard labels should be made more graphical. For companies concerned with ensuring the safety of everyone using their products, using graphical labels may allow their users to understand hazard labels more thoroughly and may improve the probability of their safety.

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## CHAPTER I

### INTRODUCTION

#### History of Warnings

Warnings have been around since humans have first used speech. As written language evolved so did warnings. During the past century, keeping product users safe has been an important consideration for companies, fearing litigation and profit loss. The constant concern for safety has lead to the need for warning related innovation. Due to lawsuits and the widespread concern of labor unrest, the early 1910's was a time of industrial safety activity. In 1912 the first National Conference of Industrial Safety was held. The following year the National Safety Council (NSC) was formed. In 1928 the NSC published the first pamphlet containing guidelines for placement, construction, and maintenance of warnings. This publication became the standard for warning recommendations. The American National Standards Institute (ANSI) was founded in 1918 as the American Engineering Standards Committee. During the 1970's ANSI developed some of the most important warning standards. These standards specify design and content suggestions for signage or labeling that include color, signal word choice, letter style, and size. ANSI standards are considered authoritative and used by government and industry, but they remain voluntary. The International Organization for Standardization (ISO) has also developed standards on warning design and content

although they are not as influential in the United States as ANSI (Egilman & Bohme, 2006).

### Purposes and Functions of Warnings

Warnings inform people of hazards so that the potential consequences may be avoided or minimized. Hazards are defined as sources of potential injury. Warnings serve four main functions or purposes. First, they serve to provide adequate information about hazards so that people can make informed decisions on how to avoid harm. Second, warnings are intended to modify or influence people's behavior in ways that will improve safety by promoting compliance. Third, warnings are intended to reduce or prevent accidents, health problems, personal injury, and/or property damage. Fourth, warnings serve as reminders to people that are already aware of the hazard. The warning can also make people aware of hazard information that may be inactive in long-term memory (Wogalter, 2006).

In keeping people safe there is a hierarchy of hazard control. The first priority of hazard control is to design out or eliminate the hazard. The next priority is to guard against the hazard by attempting to limit contact between people and the hazard. Finally if there is no way to eliminate the hazard there must be a warning. Warnings are not ideal because they are not reliable in preventing contact with the hazard.

When a warning is needed, three issues must be considered. The first is determining what needs to be warned against. The warnings must contain hazard information, instructions to avoid the hazard, and the consequences of not complying with the hazard. What to warn against becomes more important as the severity of the hazard increases, as the likelihood of incidence increases, or when the hazard is not

obvious to laypeople. The second issue to be considered is who to warn. Generally speaking it should be everyone who may be exposed to the hazard. Warnings can vary in the amount of detail they contain; those directed at the general public may contain few details of the hazard, while those directed to a specific audience may contain many details of the hazard. They should take into consideration the lowest ability levels (e.g. those who cannot read) of the target population. The third and final issue is when and where to warn. Warnings should be available whenever and wherever they are needed. They should be located on the product or in an area near the hazardous conditions (Wogalter, 2006).

#### Type of Visual Warnings

A wide variety of warnings are employed to notify people of hazards. They can be in the form of signs, labels, tags, manuals, inserts, audio tapes and videotapes, one-on-one discussions employing the visual, auditory, and tactile sensory systems or a combination of systems. This thesis focuses on visual warnings, specifically warning labels, which generally consist of text and graphics. Warning label design components include signal words, warning text, colors, and symbols. The variation of these combined with label format and placement affects the processing and compliance of the warning information (Lesch, 2006).

#### Warning Label Standards

The ANSI Z535.4 Standard addresses product safety signs and labels. The 2002 update set forth performance requirements for the design, application, use, and placement of safety signs and labels intended to identify potential hazards for persons using, operating, servicing, or in proximity to a wide variety of products. The purposes of this

standard are to establish a uniform and consistent visual layout for safety signs and labels applied to a wide variety of products; to minimize the proliferation of designs for product safety signs and labels; and to establish a national uniform system for the recognition of potential personal injury hazards for product users (ANSI, 2002).

ANSI Z535.4 states there are two main components of a warning label: signal word panel and message panel including the symbol. The signal word is Caution, Warning, or Danger; each word signifies a different hazard level. Caution is specified when injury would be moderate or minor, or would be for accidents that involve only property damage. Warning indicates a potentially hazardous situation that could result in death or serious injury. Danger is indicative of an imminently hazardous situation that can result in death or serious injury if not avoided. Danger is limited to the most extreme situations.

The signal word is presented on a colored panel. Caution is written in black on a yellow background, Warning is written in black on orange background, and Danger is written in white on a red background. The panel also includes the safety alert symbol; the triangle with the exclamation mark.

Deciding which word to use depends on: 1) the severity of the injury, and 2) the likelihood of the injury. Deciding the severity depends on what constitutes a serious injury compared to a moderate or minor injury. If the decision is serious injury or death, then one must decide if the probability of the event occurring is enough to warrant using Danger instead of Warning (Peckham, 2006a).

There has been a substantial research on the colors used to indicate levels of hazards. Dunlap, Granda, and Kustas (1986) and Bresnahan and Bryk (1975) both

support the ANSI recommendation of red for danger, orange for warning, and yellow for caution demonstrating that danger consistently conveys greater danger than warning and caution. However Barzegar and Wogalter (1998) found no difference between caution and warning from participants rating of perceived danger. Despite differences in what the colors convey, symbols, colors, and signal words combine to make warnings more salient than only black and white text (Lesch, 2006).

According to ANSI Z535.4 the message panel should convey the nature or type of hazard, the consequence of the hazard and how to avoid the hazard. This information should be conveyed by use of text, safety symbol, or both. Section 6.5 of ANSI Z535.4 advises being concise when writing a safety message. The standard states that if any of the information can be readily inferred it may be omitted. The 2002 revision also states that a symbol can replace a part of a word message.

There have been multiple studies on the placement and order of the warning information. Some studies have suggested placing warnings before instructions (Wogalter, Godfrey, Fontenelle, Desaulniers, Rothstein, & Laughery, 1987), while others within the instructions (Frantz, 1994). Formatting also has an effect. Some studies have suggested larger text, color highlighting etc. will increase comprehension (Young & Wogalter, 1990). Other studies have demonstrated that the manner in which information is presented (paragraph or bulleted list) can affect encoding and memory (Wogalter & Kalsher, 1994). There is much variability in the design of labels depending on the intended users and type of information being presented. Due to this, ANSI standards are not specific as to the placement and ordering of the hazard information, instead they focus on what type of information must be included.

ISO, in its need to convey information to an international audience, has placed greater emphasis on symbols, than textual message panels, for safety signs and labels. The use of symbols is increasing in the hopes of overcoming language barriers. However many symbols are not intuitively understood and training may be necessary to make symbols more effective (Peckham, 2006b). ISO 3864 describes the different types of signs mandated by ISO. The shapes of the signs inform people about the hazard. A triangle is for warnings, a circle with a red line through it is for prohibition, and a blue circle is a mandatory action sign. The only requirements of what must be conveyed are what the hazard is and how to avoid it. There is no requirement to inform about the consequences of the hazard. Text may be used to supplement safety symbols but additional text is not required. This lack of requirements allows freedom in selecting the format that best suits the intended audience. Currently there is no consensus for either content or format requirements among ANSI or ISO. The lack of agreement between ANSI and ISO standards is problematic, because there is no universal recommendation for government and industry to use (Peckham, 2006b).

#### Issues with Current Label Design

Labels used by industry comply with the requirements discussed above, but, since there is much room for interpretation of the labels, the design will vary among manufacturers. The three main label components of concern are: the use of text, the use of safety symbols, and the overall format of the label.



### *Issues with Text*

There are many design guidelines concerning the textual information on a warning label. The text should be short and use familiar words, be explicit, use concrete rather than abstract wording, use active voice, avoid words with multiple meanings, avoid abbreviations, and use multiple languages when necessary (Wogalter, 2006). Even when designers consider all these points there are still problems with relying on text to convey warnings. The most significant problem with relying on text is the assumption that people who speak a language can also read that language at a level that permits them to adequately understand the warning message. According to the National Assessment of Adult Literacy conducted by the National Center for Education Statistics in 2003, in the United States 11 million adults are nonliterate (cannot understand a written language) in English. Over 30 million are below basic literacy, which indicates the lowest levels of performance such as signing a form, and 63 million read at fourth or fifth grade reading level. Together over 100 million Americans ( 33% of the population) read at or below fifth grade level.

Added to the issue of literacy are immigrants and refugees living and working in countries that do not speak their native language. In the United States, ANSI is the standard adhered to by industries. Translating text to other languages so ANSI standards are met is extremely costly, and often incorrect translations are put on labels. European industries in order to accommodate the number of languages spoken in each country use labels with ISO approved symbols. Due to literacy and translation constraints the reliance on text to inform people of hazards has become increasingly problematic.

Selecting words that are familiar and explicit to the target population is a difficult task. Wogalter and Silver (1995) examined the understandability of warning signal words. Groups of children, elderly, non-native English speakers, and college students rated the understandability and strength (perceived severity) of a list of warning signal words. Overall the groups gave similar ratings to the signal words, but of the 43 words given only 15 met the requirements of being understood by 95% of the fourth-fifth grade children and 80% of the non-native English speakers. The words left blank in the ratings (indicating that they were not understood) varied as a function of letter length and frequency of use in the English language. The number of words left blank was highest for the children group, but decreased for the elderly group indicating that older people had been exposed to a larger variety of signal words. If selecting a signal word that relates the appropriate message to a basic level literate population takes this much consideration then selecting words for the message panel would be a difficult and in-depth procedure.

In addition to word choice, the available space for text is another problem for current warning labels. The label size is often determined by the size of the product or the placement of the label. That predetermined size constrains the space available for text. For hazards that are more obvious and have less severe consequences such as "CAUTION, Slippery Floor" the avoidance and consequences of the hazard are not written in the message panel. These types of hazards are not confined by the space for the warning message. In the case of hazards that are more severe and not as obvious such as "DANGER, Flammable Contents" it is necessary to include explicit avoidance

instruction and consequence identification. These hazards that are the most severe are often the ones that are the most constrained by available space for text (Wogalter, 2006).

### *Issues with Safety Symbols*

The main purpose of symbols is to promote safety-appropriate behavior. Symbols may be used to attract attention by having salient features which stand out from other stimuli in the environment. The symbol must also be legible, even under degraded conditions (distance, size, abrasion and weather exposure). In general symbols should be comprised of large, bold, simple components devoid of irrelevant detail (Wogalter, Silver, Leonard & Zaikina, 2006).

Even when all of these recommendations are considered the most important consideration about symbols remains: Symbols must be understandable. A symbol with multiple interpretations across observers is problematic, as are symbols with rigid literal interpretations. In both of these cases symbols can benefit from context in the setting and placement of the label. Wolff and Wogalter (1998) found that the presence of context (presence of photographs depicting the probable environments where a symbol would be seen) increased symbol comprehension. Wolff and Wogalter suggest that context provides valid cues that limit the range of what the symbol could be representing.

Symbols are the primary media used on warning labels to convey hazards in Europe. In the United States text often accompanies the warning symbol on a label, but with the literacy limitations of users being a problem, symbols are preferred. According to ANSI Z535.3, when symbols are used alone they should have at least 85% correct comprehension scores, with no more than 5% critical confusions (opposite or very wrong answers) with a sample of 50 individuals. Deppa and Kalsher (2006) tested the

comprehension of safety symbols from ANSI Z535.3 and ISO 7010 safety symbols standards. Only 2 of the 12 symbols in one study and 5 of the 14 symbols in the second study met the comprehension acceptance criteria. The poor comprehension of safety symbols highlights the importance of creating understandable symbols for a variety of user populations.

### *Issues with Label Formats*

Labels consist of a signal word panel and a message panel. The message panel is the place for the text message and the safety symbol. General guidelines state that there should be consistent placement with message boxes, priority should be given to the most important warning statements, the message should read from left to right (if consistent with cultural norms), should be left justified (if consistent with cultural norms), and each statement should be on a separate line. The text should be high contrast, legible, and with mixed case lettering in a plain and familiar font (Wogalter, 2006).

Design variables for label format have been shown to affect the ability of obtaining users' attention. Adams and Edworthy (1995) demonstrated that text size, followed by border width and white space had the largest effect of perceived urgency. Wogalter and Vigilante (2003) found that knowledge acquisition increased with larger text size for older adults, but there were no effects of white space. For perceived readability both younger and older adults preferred larger text size and more white space. Young and Wogalter (1990) found that conspicuous print (larger text and color highlighting) accompanied by icons produced better comprehension and recall of the verbal messages than messages without icons or with plain print did. While these studies provide recommendations for using larger text and more white space, those

considerations only apply to the people who read at proficient levels. Also larger text requires a larger label that may not be feasible in many cases. The challenge is to create a format that uses other cues besides text size and basic icons to increase salience that will result in better comprehension and memory.

### Additional Issues

While the initial purpose of warnings is to inform people so they recognize potential hazards, there is a secondary purpose: to alter behavior and redirect people from performing risky acts that they might otherwise perform. The complex interaction between label comprehension, and people's beliefs, attitudes, and motivation affects a person's compliance to the warning. Beliefs about the product being safe and product familiarity reduce compliance with the warning (Lesch, 2006). If the warning is noticed, understood, and agrees with a person's attitudes and beliefs, then the perceived cost of compliance (time, effort, etc) is the factor determining compliance. If a person perceives the cost of compliance as being too high (too much effort, money or time) then he/she is less like to comply (Wogalter & Laughery, 1986).

With all of these factors affecting compliance, do warning labels increase safe behavior? Cox, Wogalter, Stokes and Murff (1997) found that overall warnings increase safe behavior in both student and nonstudent participant groups. Wogalter, Kalsher, and Rashid (1999) found that the likelihood of compliance can be increased with a more specific prefix (e.g. US Federal Government Warning) and that more credibility is given to warnings issued by specific governmental regulatory agencies than by using a signal word alone. However, not all additions to labels increase compliance. Often as the amount of time to read and process a warning increases, either on a product or in the

environment, the likelihood of compliance decreases (McCarthy, Ayres, Wood, & Robinson, 1995). Wogalter, Allison, and McKenna (1989) found that a participant's compliance was reduced in a condition where a confederate did not comply with the warning compared to when a confederate did comply. This study supported the effect of social influence on behavior. Wogalter, Magurno, Rashid, and Klein (1998) found that time pressure significantly reduced compliance. These external factors reinforce the need to make labels easier to comprehend.

### Alternative Label Design

The need for an alternative label design is indicated by the numerous problems with current warning labels. The three main problems of dependence on text, ambiguous symbols, and non-salient formatting need to be addressed. With improvements in the warning label it is hoped that the probability of compliance will improve as well. The challenge is to design a label that allows users to identify hazards early enough in the processing stage to allow for behavior modification. Technological advancements have created new opportunities to develop better risk communication and enhance warning effectiveness (Wogalter & Mayhorn, 2005).

Wogalter and Young (1994) evaluated whether or not labels with tags or labels with wings (see Figure 1) facilitate safer behavior than the conventional (control) design. Both new designs afforded more space for text. This warning label was on a small container of glue. Whether or not participants wore gloves as depicted by the warning was measured. Results showed that the tag design produced significantly greater noticing, reading, recall, and compliance. The wings design had slightly greater noticing as well.

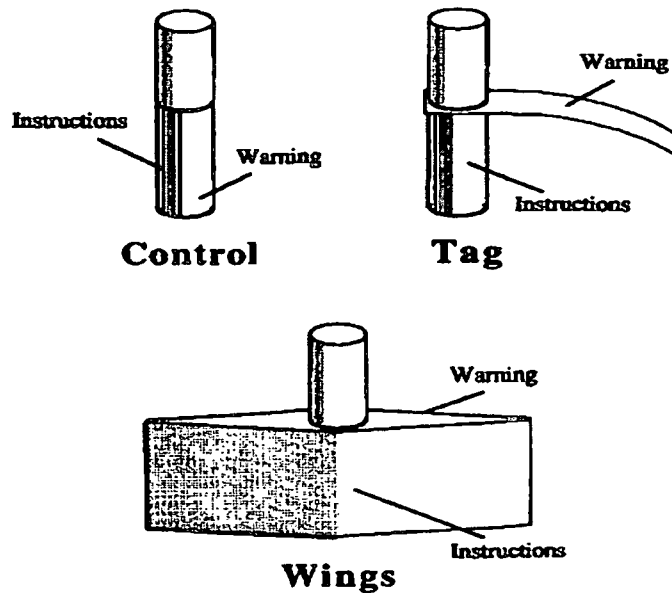


Figure 1. The control and two alternative designs. (From Wogalter and Young, 1994)

Duffy, Kalsher, and Wogalter (1995) explored the effectiveness of interactive product warnings. The interactive labels were considered interactive because the placement of the warning over the outlet cover required the participant to move them in order to use the extension cord. Color and placement of the warning label was varied. Results showed that interactive labels were noticed, recalled, and complied with more than standard labels. Color did not significantly influence effectiveness. Both of these studies show how alternative designs can increase comprehension and compliance. However, neither of these studies addresses the problems with text or symbols; they simply provide label format or placement alternatives.

#### Current Study Alternatives

The current warning label is primarily textual and contains a static symbol. This thesis introduced two alternative warning label designs. They differ from the traditional label in the areas of text, symbols, and design format.

### *Text Alternatives*

As previously discussed, over 100 million Americans read at or below fifth grade level (National Center for Education Statistics, 2003). The dependence on text to convey warning information is inadequate for over one-third of the American population. This population demographically makes up much of the service and industrial factory employment sectors. These workers are the ones who most often use products that have warning labels on them or work in environments where warning signs are most often posted. Additionally, space to clearly describe warnings (especially the more severe and less known to the general public) is often not adequate. Clearly there is a need for a label that eliminates the dependency on text to convey warning information.

Both label designs proposed in this thesis eliminated the use of text in favor of drawings to convey warning information. Paivio, Rogers, and Smythe (1968) found that pictures are more memorable than text. This is due to the dual encoding of both the verbal word and visual image. The drawings evaluated in this thesis may be more memorable than text and produce better understanding.

### *Symbol Alternatives*

The use of symbols can eliminate the dependence on text. The problem of symbols being difficult to understand and comprehend has been described in experimental studies such as Deppa and Kalsher (2006). The use of context has been shown to provide valid cues that limit the range of what the symbol could be representing (Wolff & Wogalter, 1998).

Both label designs proposed in this thesis used sequential drawings to provide more information and context (situation and environment) to the users. The drawings



consisted of a two panel, cartoon-like sketch. Each warning label consisted of two pairs of pictures. The first pair of drawings showed the hazard and the correct behavior to avoid the hazard. The second pair of drawings contained a sketch of the hazard and the consequences of not complying with the warning.

### *Format Alternatives*

The use of technology can create a variety of new label formats. While pictures may be used to attract attention, an effective label will utilize additional ways to capture the user's attention. Once attention is captured more focus on the warning label may occur. The increased focus may allow for more comprehension and better memory retention.

While both label formats used sequential drawings, the second of the two labels proposed in this thesis created the appearance of motion to make the label more salient. The new format used the sequential drawings and incorporated the use of lenticular technology. Lenticulars take multiple static pictures and combine them to create the perception of motion. Lenticulars are made up of two components, a flat printed image and a lens. The pictures are interlaced by printing very thin alternating lines of each picture. The lines are correctly lined up behind the plastic lens, and the lens acts like a prism. The lens refracts the viewer's vision to one set of lines or the other (Saville, 2006). Figure 2 explains the process employed by many of the lenticular printers.

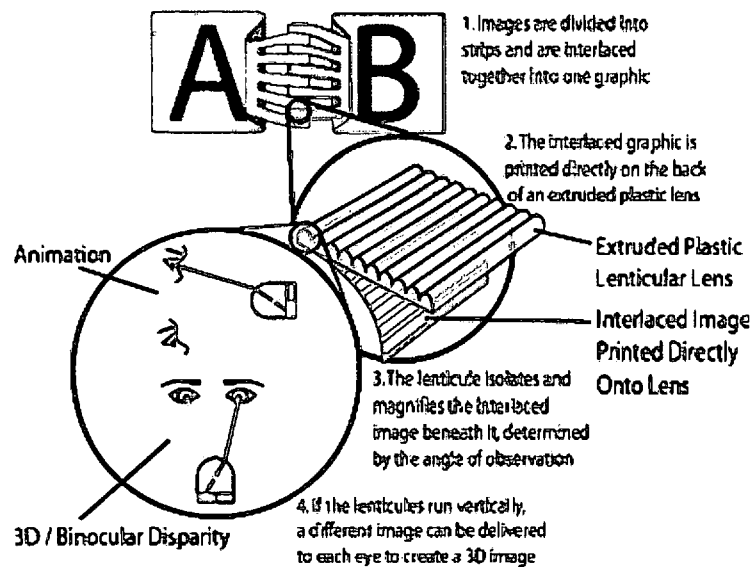


Figure 2. Lenticular Imaging Process (from One2Print)

Lenticular advertising has been used to attract consumer's attention (Murphy, 1997). Volkswagen was one of the first to use lenticular advertisements for mass marketing, by sending out lenticular postcards in Great Britain ("BRIEFS," 2001). Lenticular images have begun to appear in packing to increase consumer interest in items ("Packaging Magazine", 2004). Several companies that produce lenticular displays including Big 3-D and One2print cite a study conducted by Eastman Kodak of 3D lenticular displays in malls. In different areas of the mall there were several 3D lenticular advertisements. Fifty-eight percent of the stores' customers remember seeing the 3D lenticular advertisement when asked compared to 7% for the traditional advertisements. Customers were drawn to the stores that had 3D lenticular advertisements and they had a 34% increase in customer traffic (one2print, 2004). The new label format proposed in

this thesis will use lenticular technology to attempt to attract user's attention to warning labels.

### Statement of Intent

This thesis proposed to test two alternative label designs compared to the traditional, primarily textual and static warning label. One alternative used a two panel drawing which includes more readily accessible information on the ways to avoid the hazard and the consequences of the hazard. The second alternative shows both the way to avoid the hazard and the consequences also, but used lenticular display technology to produce apparent motion. Participants saw all three types of warning labels; the traditional label, the two panel drawing, and the lenticular warning label. Each type of warning label varied in degrees of severity. After viewing each warning label, participants identified the particular hazard, tell how to avoid the hazard, and state the possible consequences of not complying with the warning. The label designs proposed in this thesis attempted to improve the understanding of the hazards. Understanding was measured by the ability of the participant to correctly identify the hazard, the way to avoid the hazard, and the possible consequences for each label.

The new label designs aim to improve understanding. Due to the creation of apparent motion an increased understanding from the lenticular label is predicted. With both labels providing sequential drawings there should be better understanding from both the two-panel labels and lenticular labels than the traditional labels due to the amount of information available to all users.

There may also be an interaction of severity on understanding. Labels whose hazards are less severe may be better understood than those that were more severe,

regardless of type of label, because the hazards for less severe labels are more obvious and commonplace. The effect of severity on understanding may depend on the type of warning label. As the severity of the warning increased, the type of label used may have an increasing effect on understanding. The lenticular label may produce the best understanding for more severe labels.

Two additional questions were asked to the participants: which type of label produces greater understanding and which type of warning label they would be most likely to comply with and why.

## CHAPTER II

### METHOD

#### Participants

Thirty students from the University of Dayton's undergraduate psychology pool participated in the experiment to fulfill a course requirement for their introductory psychology course. Male (N=17) and female (N=13) students participated. They ranged in age from 18-22 years with a mean age of 19 years, and were primarily Caucasian (N=27).

#### Materials and Apparatus

This study used three types of labels: the traditional label, the two-panel label (the label with multiple graphics that demonstrated the consequences and the correct way of avoiding the hazard), and the lenticular label (the label with the same graphics from the two-panel label with apparent motion created by the lenticular printing process). The author hand drew the drawings for both the traditional labels (which were 4 cm by 7.5 cm) and the two-panel labels (which were 7.5 cm by 7.5 cm) on storyboards. Graphic artists then converted the drawings into black and white graphics using the Freehand computer application. A lenticular printer then created the lenticular labels from the two-panel drawings and printed them individually. The printer reduced the original labels from 7.5 cm by 7.5 cm to 7.5 cm by 4 cm. Figures 3 and 4 show samples of both the

traditional label and the two-panel label respectively. The upper colored band on the labels was either yellow (for caution labels), orange (for warning labels) or red (for danger labels) in the actual labels. Complete images of all traditional, two panel, and lenticular labels can be found in Appendix A.

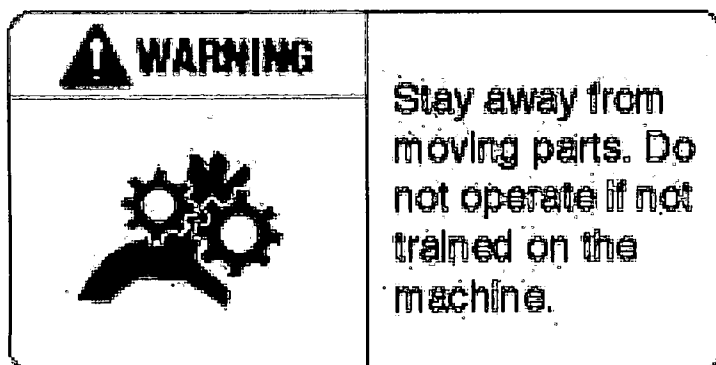


Figure 3. Traditional label used in study (1.4 times larger than actual label used).

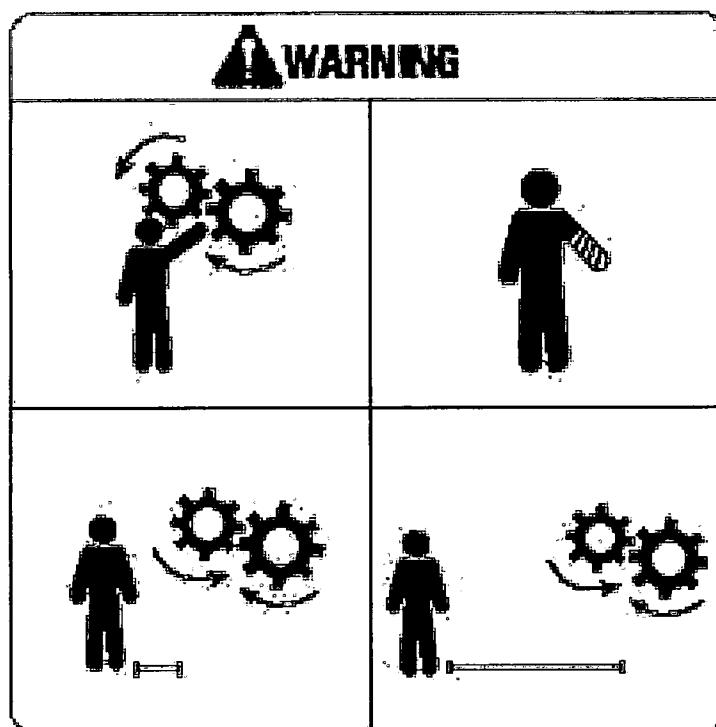


Figure 4. Two-panel label used in study (1.4 times larger than actual label used).

Each type of label used 18 distinct hazards, and this led to the creation of 54 new labels. The three severity rankings: caution, warning, and danger each had six hazards. The severity ranking typically given to that hazard in industrial and laboratory settings determined the severity ranking of the label. Table 1 depicts each individual hazard and the severity ranking that was assigned to it.

Table 1. Hazards and their severity ranking for the created labels

<b>CAUTION</b>	<b>WARNING</b>	<b>DANGER</b>
Burn	Choking	Electrocution
Lifting	Collision	Falling Objects
Loud Noise	Crush	Flammable
Slipping	Drowning	Lasers-Eye Damage
Tripping	Falls from Platforms	Poison Gases
Wear Protective Equipment	Rollover	Radiation

### Design

The experiment used a two factor repeated measures design. The first factor, type of warning label, had three levels (traditional, two-panel, and lenticular). The second factor, severity of hazard, had three levels (caution, warning, and danger). As shown in Table 2, each participant viewed two hazards in each condition for a total of 18 hazards. The order of presentation for the type of label used to view the hazards and the severity of the hazard was randomized. There were 729,000 possible viewing combinations of

label type and severity. A complete list of each participant's viewing combinations is in Appendix B.

Table 2: Number of hazards presented in each condition

		Warning Label Type		
		Traditional	Two-Panel	Lenticular
Severity of Warning	Caution	2	2	2
	Warning	2	2	2
	Danger	2	2	2

### Pilot Study

A pilot study developed the research methods used in the study. Ten participants provided base criterion for the presentation style, such as the allowed time to view the labels and the rater's criteria of correct identification. Participants sat in a laboratory room. There were no windows in the laboratory room and the illumination level was 1292 lux. Once seated and given an identification number, participants read the informed consent form (Appendix C) that provided an overview of the experiment. Participants trained by using a sample label booklet containing one label of each panel type (Appendix D). To make label type easily identifiable to participants "single panel labels" identified the traditional labels, two-panel remained "two-panel labels", and "flip labels" identified the lenticular labels. A three ring binder contained the test booklet. The binder contained the labels, free response forms, and follow-up questions. Participants viewed the labels on white paper placed on the right-hand side of the booklet. A response form



and a blank page followed each hazard label in the booklet. The beginning of the booklet had the sample labels. Participants first viewed the traditional label, then the two-panel label, and finally the lenticular label. The participants viewed the labels in that order because it went from the most traditional to the most novel. Participants looked at each label, and became comfortable with the three label types so that they could identify the hazard, the consequences, and the way to avoid the hazard. The experimenter instructed the participants not to focus on the textual component of the single panel label during experimentation. The participants had an unlimited amount of time to familiarize themselves with the style of labels. After viewing each label, participants wrote the following three components of a warning on the free response form (Appendix E): 1. The hazard shown in the label, 2. The possible consequence(s) of not complying with the warning, and 3. The way(s) to avoid the hazard. This marked the end of training. If the participants had any questions during the viewing of the training labels the experimenter answered those questions.

Upon completion of the training, participants received booklets containing all 18 hazards. Participants viewed the labels on white paper placed on the right-hand side of the booklet. An answer response form and then a blank page followed each hazard label in the booklet. The experimenter told the participants to, "Please examine each label in order to identify the hazard, the possible consequences, and the ways to avoid the hazard. When you feel that you have sufficiently examined the label please turn the page." The booklet originally lay flat on the table top. The experimenter noted if the placement of the test booklet changed. The label examination time equaled the time from turning the page to view the label until the turning of the label page. Once the participant turned the

label page, the participant wrote their answers to the three questions about the hazard shown in the label, the possible consequence(s) of not complying with the warning, and the way(s) to avoid the hazard. After viewing each of the 18 individual warning labels, and responding to the three questions, participants answered seven additional follow-up subjective questions (Appendix F). The first asked the participants' opinion as to which type of label they felt produced greater understanding. The second set asked how likely participants' were to comply with each label and why. Lastly, the experimenter debriefed the participants (Appendix G) as to the hypothesis of the study, thanked them for their time, and dismissed them.

#### Rater Scoring of Label Understanding

A three point scale measured participants' understanding for each label. Prior to the pilot study, the investigator established a preliminary list of key words for correct identification of the hazards' three components (see Appendix H). The raters received a key word sheet along with copies of the response pages from each participant. The copies indicated the hazard number that corresponded to the key word sheet. The scorers, blind to the type of label used to view the hazard, awarded one point for each answer that contained words and phrases for the correct identification of the components of a warning. Three points indicated the highest level of understanding, while zero indicated lowest level of understanding. The inter-rater reliability was strong. The reliability between raters 1 and 2 was Spearman  $r = .944$ , the reliability between raters 1 and 3 was Spearman  $r = .956$ , and the reliability between raters 2 and 3 was Spearman  $r = .988$ . After scoring the raters returned and discussed the individual responses. The investigator

modified the final key word sheet to include responses not found on the original key word sheet, but deemed acceptable by all three raters (see Appendix I).

### Experimental Procedure

The actual study followed the same procedure as the pilot study. Participants sat in the laboratory room and received an identification number. Participants read the informed consent form, which provided an overview of the experiment.

Participants then received the sample label booklet used in the pilot study for training. It contained one label of each panel type (Appendix D). To make label type easily identifiable to participants “single panel” identified the traditional labels, the two-panel labels remained “two-panel,” and “flip” identified the lenticular labels. This was the same test booklet used in the pilot study and used a three-ring binder. The binder contained the labels, free response forms, and follow-up questions. The right hand side of the booklet contained the labels on white paper. A response form and a blank page followed each hazard in the booklet. The beginning of the booklet contained the sample labels. Participants first viewed the traditional label, then the two-panel label, and finally the lenticular label. The experimenter introduced the labels in that order because it went from the most traditional to the most novel.

The investigator instructed the participant to leave the booklet lying flat, although some participants moved the pages of the lenticular labels instead of their heads to view the apparent motion. The participants examined the sample labels for unlimited time in order to familiarize themselves with the label types so that they could identify the hazard, the consequences, and the way to avoid the hazard. The experimenter instructed them not to focus on the textual component of the single panel label during

experimentation. After viewing each label, the experimenter instructed the participants to write the following three components of a warning on the free response form (Appendix E): 1. The hazard shown in the label, 2. The possible consequence(s) of not complying with the warning, and 3. The way(s) to avoid the hazard. This marked the end of training. The experimenter answered any questions that the participants had during the viewing of the training labels. A complete set of verbal instructions given during the experiment is provided in Appendix J.

After completing the training booklet participants sequentially viewed each warning label in the test booklet for five seconds with the booklet placed flat on the table. The time to examine the label began when the participant turned to the label page. After five seconds had passed the experimenter asked the participant to turn the page and answer the questions. Of the 18 warning labels viewed, six were at each severity level (Caution, Warning, and Danger). Of the six labels at each severity level participants saw two with lenticular labels, two with the two-panel labels, and two with the traditional labels. After viewing each label, participants identified the following three components of a warning: 1. The hazard shown in the label, 2. The possible consequence(s) of not complying with the warning, and 3. The way(s) to avoid the hazard. Participants wrote their answers on a free response form. After viewing all the individual warning labels, participants answered additional follow-up subjective questions, such as ranking the labels in order of perceived understanding and rating their likelihood of compliance. Lastly, the experimenter debriefed participants as to the hypothesis of the study, thanked them for their time, and dismissed them.

## CHAPTER III

### RESULTS

This study produced both performance and subjective data in order to compare participants' understanding of eighteen unique hazards (at three different severities) conveyed by the three types of labels. Specifically, the dependent variable measured differences in understanding between the traditional label, the two panel label and the lenticular label. This study also examined the ranking of the labels in order of perceived understanding and the level of self-reported likelihood to comply.

#### Scoring

The same three raters who served in the pilot study used a three-point scale to score participants' understanding for each label from the revised key word sheet (Appendix I). Prior to the study the raters trained for scoring using the initial key word sheet. The raters awarded one point for each answer that contained words and/or phrases from the revised key word sheet for the components of a warning label. For each hazard the raters awarded one point for each correct identification of a component of a warning label. Three points indicated the highest level of understanding, while zero indicated the lowest level of understanding.

A bi-serial Spearman correlation measured the agreement between raters for each component. Inter-rater reliability among the three raters was strong. The reliability

between raters 1 and 2 was Spearman  $r = .909$ , the reliability between raters 1 and 3 was Spearman  $r = .884$ , and the reliability between raters 2 and 3 was Spearman  $r = .955$ .

### Participant Understanding

A 3 X 3 (label type x severity) Analysis of Variance on mean understanding scores determined whether the severity of the hazard for the three label types had an effect on participant understanding of the hazard. Mean understanding is comprised of the average score from the three raters for identifying the three components of a warning: 1. The hazard shown in the label, 2. The possible consequence(s) of not complying with the warning, and 3. The way(s) to avoid the hazard.

The new label designs aimed to improve understanding. An interaction between label type and severity was not predicted, but was still a possibility. As shown in Figure 5, the 3 X 3 repeated measures ANOVA failed to reveal a significant interaction effect of label type and severity on participant understanding  $F(4,116) = 2.018$ ,  $MSE = 0.261$ ,  $p = .096$ ,  $p_{rep} = .817$ ,  $\alpha = .05$ . All understanding scores were subsequently evaluated solely for main effects of label type or severity.

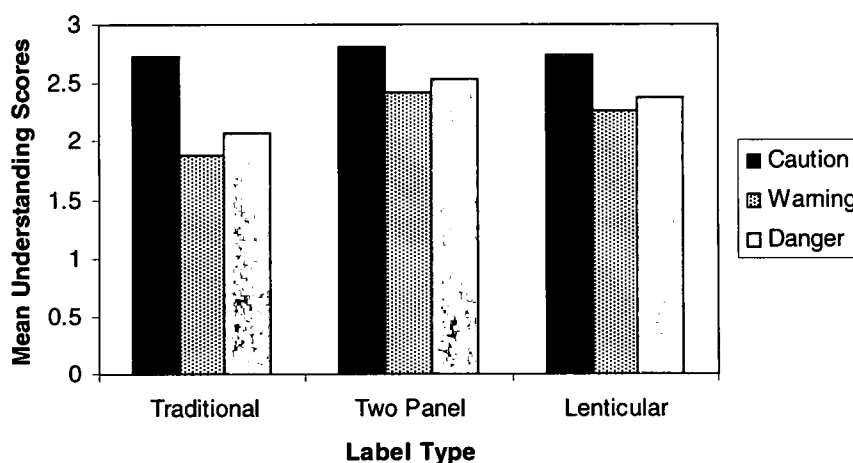


Figure 5: Mean Understanding Scores by Label Type and Severity

The lenticular label's apparent motion and/or its sequential drawings should increase understanding. Since both of the new labels provide sequential drawings, they should increase understanding relative to the traditional labels. The predicted main effect of label type claimed that both lenticular labels ( $M=2.46$ ) and two panel labels ( $M=2.59$ ) would have greater understanding than traditional labels ( $M=2.23$ ). The ANOVA confirmed the prediction for mean understanding scores and found a significant main effect of label type,  $F(2,58)=7.529$ ,  $MSE=0.402$ ,  $p=.001$ ,  $p_{rep}=.990$ . Tukey's (HSD=.227) revealed that both two panel labels and lenticular labels were significantly better understood than traditional labels.

Because less severe labels may be more obvious and commonplace, warning severity should affect understanding. Since caution hazards are more commonplace than warning and danger hazards, caution hazards should have better understanding than both warning hazards and danger hazards. The predicted main effect of severity was that caution hazards ( $M=2.76$ ) would have greater understanding than both warning ( $M=2.18$ ) and danger ( $M=2.33$ ). The prediction for the mean understanding scores was confirmed, and there was a significant main effect of severity,  $F(2,58)=27.598$ ,  $MSE=0.298$ ,  $p=.000$ ,  $p_{rep}=1.0$ . Tukey's (HSD=.196) revealed that caution hazards were significantly better understood than both warning hazards and danger hazards.

### Component Means

The hypothesis of improved understanding with alternative warning labels was exploratory in nature. Because of the dichotomous nature of the variables (where raters either rated correct or incorrect identification) inferential statistics were not used to further examine understanding. Additionally, because of the limited sample size, non-

parametric statistics are unlikely to have sufficient statistical power to detect any difference that might actually be present. Therefore the data below were examined to identify areas for future research.

Additional examination of component means demonstrated how the different label types improved understanding. Raters assigned either 0 or 1 points per component identification of the hazard. The means were based on the average of the three raters' scores. Table 3 shows how each label and severity influenced each of the three components of understanding the label.

Table 3: Proportion of Participants Who Correctly Identified the Component

		Traditional	Two Panel	Lenticular	Marginal Means
Identify	Caution	.88	.89	.88	.88
	Warning	.68	.75	.66	.70
	Danger	.68	.72	.73	.71
	<b>Marginal Means</b>	<b>.75</b>	<b>.79</b>	<b>.76</b>	
Consequences	Caution	1.00	.99	.97	.99
	Warning	.77	.87	.83	.82
	Danger	.79	.98	.85	.87
	<b>Marginal Means</b>	<b>.85</b>	<b>.95</b>	<b>.88</b>	
Avoidance	Caution	.87	.91	.91	.90
	Warning	.42	.80	.77	.66
	Danger	.63	.76	.83	.74
	<b>Marginal Means</b>	<b>.64</b>	<b>.82</b>	<b>.83</b>	



The table shows an overall improvement in identifying the hazard, the consequences of the hazard, and how to avoid the hazard when using the two panel labels over the traditional labels. The above data also suggest that the two panel labels might provide the best identification of the hazard and its consequences. The data additionally suggests that two panel and lenticular labels might provide better identification of how to avoid the hazard. Overall the caution hazards scored the best for identification of all the components. Future research is required to better elucidate this relation between label type and component identification.

#### Perceived Understanding

To determine perceived understanding, participants indicated which label type they thought they understood best. Two panel and lenticular labels were expected to be equally better understood than traditional labels.

Table 4: Breakdown of perceived understanding among participants

	Lenticular	Two-Panel	Traditional	H <sub>0</sub> : equal expected frequencies
Greatest understanding	10%	73%	17%	$X^2(2) = 21.80, p = .000$
Intermediate understanding	53%	13%	34%	$X^2(2) = 7.20, p = .027$
Least understanding	37%	13%	50%	$X^2(2) = 6.20, p = .045$

These results demonstrate the ability of the participants to correctly match their scored understanding to their perceived understanding. The mean understanding was highest for the two panel label and participants rated the two panel label as the one that

provided them with the best understanding. The mean understanding was the lowest for the traditional label and participants rated the traditional label as the one that provided them with the least understanding.

### Likelihood of Compliance

All the participants indicated their likelihood of compliance using a scale from one to six, with one being “likely to comply” and six being “not likely to comply.” For traditional labels participants’ likelihood of compliance rating ranged from 1 to 5 with a mean rating of 2.90 and a standard deviation of 1.30. For two panel labels participants’ likelihood of compliance rating ranged from 1 to 6 with a mean rating of 2.23 and a standard deviation of 1.36. For lenticular labels participants’ likelihood of compliance rating ranged from 1 to 6 with a mean rating of 3.13 and a standard deviation of 1.43.

Overall compliance ratings were high. Two-panel labels had a significantly better compliance rating  $\chi^2(5) = 19.6, p = .001$  than the traditional labels  $\chi^2(4) = 3.67, p = .543$  and lenticular labels  $\chi^2(5) = 5.20, p = .392$ . The data suggests that participants would be more likely to comply with the two panel label and less likely to comply with both the traditional and lenticular labels.

## CHAPTER IV

### DISCUSSION

The study produced both objective and subjective data to compare the participants' understanding of eighteen unique hazards at three different severities conveyed by the three types of labels. Discussion of the results follows the order of research predictions. Objective data, including participant understanding and component means are discussed first, followed by subjective ratings of perceived understanding and probable compliance.

#### Participant Understanding

Lenticular labels and two panel labels provided drawings that contained additional information, and a better understanding should occur for both the two-panel labels and lenticular labels compared to the traditional labels. Results indicated that this prediction was correct. An effect of severity on understanding was also predicted because the hazards for less severe labels are more obvious and commonplace. Therefore, caution hazards were expected to have better understanding than both warning hazards and danger hazards. Results indicated this prediction was also correct. An interaction of label type and severity was not predicted, but could be explained. The results indicated no such interaction between label type and severity.

A possible explanation of why label type did not have an even stronger effect or why there was no interaction may have been that certain hazards may have been more difficult to identify (see Table 5). As shown below all the caution hazards have mean understanding scores that are close to each other. In comparing the warning hazards both the choking hazard and the collision hazard were less frequently identified than the other warning hazards. If understanding scores had been more similar among individual hazards a stronger significant difference in label type may have occurred and a significant interaction may have been present.

Table 5: Individual hazard means and standard deviations across all three label types  
(comprised of the average scores from the three raters)

<b>Hazards</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Std. Deviation</b>
<b>Caution</b>				
Burn	1.00	3.00	2.87	0.43
Lifting	1.00	3.00	2.70	0.52
Loud Noise	1.00	3.00	2.84	0.49
Slipping	.67	3.00	2.86	0.48
Tripping	2.00	3.00	2.84	0.34
Wear Protective Equipment	1.00	3.00	2.59	0.51
<b>Warning</b>				
Choking	.00	3.00	1.48	1.23
Collision	.00	3.00	1.97	1.13
Crush	1.00	3.00	2.61	0.56
Drowning	.00	3.00	2.37	0.79
Falls	.00	3.00	2.30	0.88
Rollover	.00	3.00	2.32	0.82
<b>Danger</b>				
Electrocution	1.33	3.00	2.74	0.47
Falling Objects	1.00	3.00	2.57	0.65
Flammable	1.00	3.00	2.46	0.71
Lasers	.00	3.00	1.22	1.01
Poison	.33	3.00	2.57	0.77
Radiation	1.00	3.00	2.41	0.78

Participants correctly identified the laser hazard far less frequently than the other danger hazards. Overall, over half the safety symbols met ANSI symbol standards (85% correct comprehension). The hazards that did not meet these requirements were choking, collision, drowning, falls, rollover, flammable area, lasers, and radiation.

### Component Means

The component means data suggested an improvement in identifying how to avoid the hazard when using both the two panel and lenticular labels over the traditional labels. Additionally there was an improvement in identifying the consequences using the two panel and lenticular labels, with the exception of the traditional caution labels. Overall the caution hazards scored the best for identification of all the components.

The improvement in identification of each component based on label type may be even stronger if all the hazards had been more equally identifiable (see Table 5). By having more easily identifiable hazards there may have been stronger label type effects on each component of hazard identification.

### Perceived Understanding

The initial prediction was that participants would believe that they understood lenticular labels best due to the apparent motion and/or the inclusion of consequence information, followed by the two-panel which also included consequence information and then traditional labels. Results were not as expected: 73% of all participants indicated they believed they understood the two panel labels best, 53% of participants believed that they understood the lenticular labels second best, and 50% of participants believed that they understood the traditional labels the least. Overall the subjective data

aligned well with objective data, as the perceived understanding ratings corresponded to the rater mean understanding scores.

One possible reason for this preference is that the lenticular labels take some time to understand by a) taking more time to see images and b) determining where the motion begins and ends. The two-panel label contained the same graphics, but did not require the viewer to position himself/herself in order to view the graphics from the appropriate viewing angle. Additionally, the viewer did not have to distinguish between the first and last scene of the label. Another possible reason for the preference of the two panel and lenticular labels over the traditional labels was the inclusion of graphical representations of consequences and avoidance procedures. Additionally, in the United States, lenticular displays are typically used for advertising and in children's products and some people may have interpreted them as such, and not as a serious warning.

#### Likelihood of Compliance

Participants indicated compliance on a scale of one to six, with one being "likely to comply" and six being "not likely to comply." Overall likelihood of compliance ratings were high, possibly due to the laboratory environment or due to the population being more conservative on average. Two panel labels produced the best compliance score, traditional labels followed, and lenticular labels were last. Over half the participants (approximately 18 participants) gave meaningful free response data that gave insight into their reasons for probable compliance.

The compliance ratings were highest for the two panel labels and correspond to the mean understanding scores and the perceived understanding ratings. When asked why they would comply with the two-panel label, participants stated that the two-panel

labels had clear graphics, included consequences and what not to do in the graphics, and were quickly and easily understood.

The compliance ratings for lenticular labels do not correspond with previous objective measures. For both the mean understanding and the perceived understanding lenticular labels scored second best. For compliance ratings, lenticular labels rated last. When asked why they would comply with a lenticular label, participants replied that the graphics included consequences and what not to do. However, the participants also stated that lenticular labels were time consuming to view and understand, they were unable to differentiate the beginning and end points of the hazard label, the pictures were less clear, and the labels hurt their eyes. A more complete description of the reasons for compliance and non-compliance is contained in Appendix K.

### Limitations

The hazards used in this study came from a variety of settings such as industrial equipment, medical equipment, outdoor settings and household items. Additional research in these domains would be necessary before implementing a non traditional label (either two panel or lenticular) to warn people of hazards.

In this study the lenticular labels had limitations due to material constraints. One limitation of these labels is the number of transitions or flips (flips are the number of graphical overlays used to create the apparent motion) used in the lenticular label. It is possible that with more transitions the apparent motion that lenticulars create would be more continuous and create less confusion as to the beginning and end movement. Some participants found the motion to be helpful, but most, since there were only two graphical transitions, found them hard to understand due to the difficulty in differentiating between

the beginning action and the final action. The lenticular labels also could have had numbers to prescribe what the first frame was and what the second frame was. This may have helped in eliminating some of the confusion of where the image began and ended.

An additional limitation of the lenticular label was its size. The two panel label was sized 7.5 cm by 7.5 cm. When the lenticular was created the label combined the same size graphic into 7.5cm by 4.0cm labels. The limited space in which to see the transitions may have made the graphics less salient. Studies have demonstrated that larger graphics accompanied with larger text produces the best comprehension (Wogalter and Young, 1990). While the graphic "content" in the stimuli utilized in this was the same size, white space, which improves readability and clarity, was not. Indeed, when the two panel labels were combined to produce the lenticular displays the white space was reduced by approximately half.

The study itself has limitations as well. There was limited training and exposure to the lenticular label type. This study was performed in a laboratory setting. The test labels were seen in a binder, and were not embedded in a particular context. Wolff and Wogalter (1998) found that the presence of context increased symbol comprehension. It is assumed that context would help eliminate some confusion in identifying what the graphics were attempting to convey. Also, findings in this study can only be generalized to college-aged populations. The pilot and study participants were college-aged, and since age brings experience and exposure to a variety of hazards, the results can only apply to college-aged persons. Additional research is needed to determine whether similar results would be obtained for other age groups.



### Future Research

One major area of future exploration concerns the improvement of the graphics used to convey each hazard. In this research, the experimenter used current hazard graphics and combined them with additional context cues. Some hazards were not as easily identified as others. Future research should examine the best graphic available to identify each hazard scenario. It would be interesting to determine if better graphics would have made the effect sizes larger or if an interaction would have resulted.

Another question concerns the actual presentation of the hazard label. Results indicated that multiple graphics led to better understanding than one static graphic. There was still text present on traditional labels, and even though the participants were asked not to read them, it may have had an effect on traditional label understanding. Removal of text on traditional labels in future studies may strengthen the need for multiple graphic labels.

Future research should examine what is the best label type to use. Two-panel labels were best in this experiment, but with improvements or changes in the labels that may not always be the case. Lenticular labels might be made more understandable by making more transitions (flips) in order to mark a clear beginning and end to the motion.

In some cases the size of the two panel label used in this experiment is not feasible for smaller products needing warning labels. Further research could determine the effect of a size difference. The lenticular labels may be made larger or the two panel label smaller. Size variations of the label types should be explored to gather more conclusive information.

Future research may also wish to consider the effect of a real world setting. By using a real world setting (placing labels on the items intended to warn against) you may receive more accurate identifications. For example in this particular study the laser hazard scored lower than other danger hazards. Many participants believed the laser symbol to be a sun, identifying the hazard as “don’t look directly at the sun.” If a label was placed on a piece of laser equipment or on a doorway to a lab room then there may have been less confusion as to what the label was depicting. Additionally, further research should consider using other populations besides college students to assure that future results are generalizable.

### Conclusion

This thesis introduced many of the problems encountered by using traditional hazard labels. The research in this thesis provides clear evidence of the benefits of using graphical labels with multiple graphics containing consequences and avoidance procedures. Participants’ mean understanding scores were significantly better using graphical labels with multiple graphics than the traditional label. Subjective data provided further evidence of the benefits of using graphical labels with multiple graphics. Specifically, more participants perceived better understanding from the graphical labels with multiple graphics, and in the case of the two panel label felt that they would be more likely to comply with the hazard label. In sum, both the two panel labels and the lenticular labels, as compared to the traditional labels allowed participants to better understand what the hazard was, the consequences the hazard prevents, and how to avoid the hazard.

From a practical standpoint, this evidence indicates that hazard labels should be made more graphical. There are still many unanswered research questions, but with further research the best label type to use will be determined. For companies concerned with ensuring the safety of their products users, using graphical labels may allow their users to better understand hazard labels and thus improve their safety.

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## APPENDIX A

## Images of Each Hazard Label Used

Figure A 1: Burn Hazard

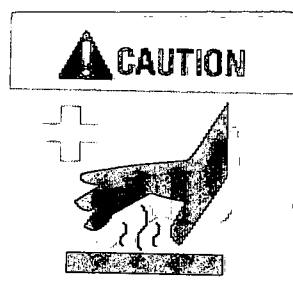
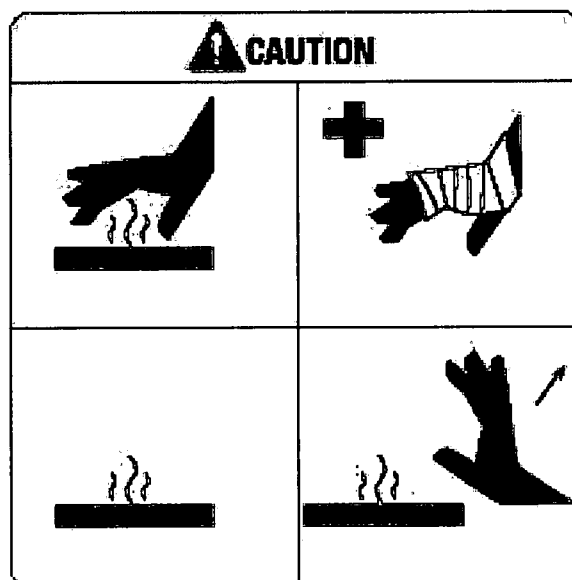
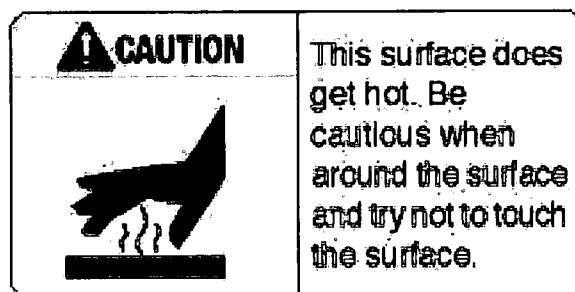




Figure A 2: Lifting Hazard

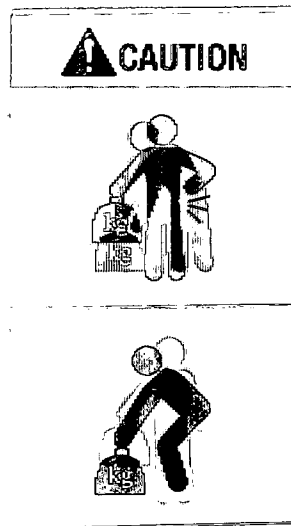
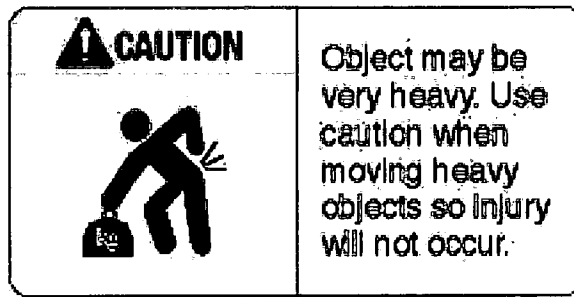


Figure A 3: Loud Noise Hazard

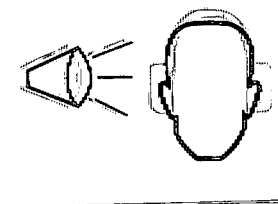
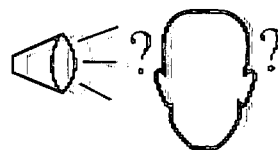
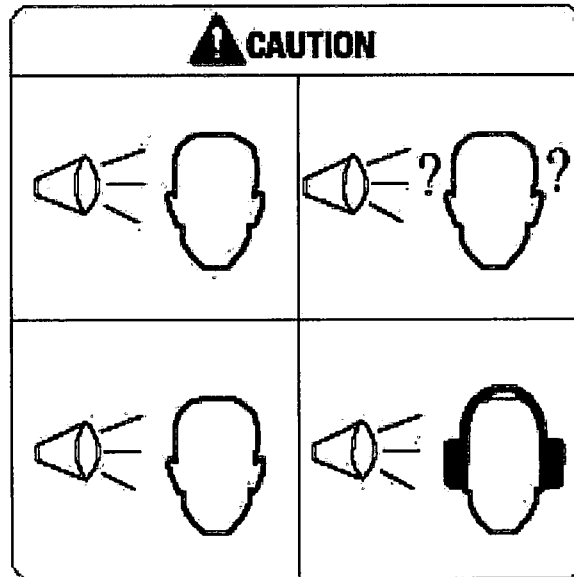
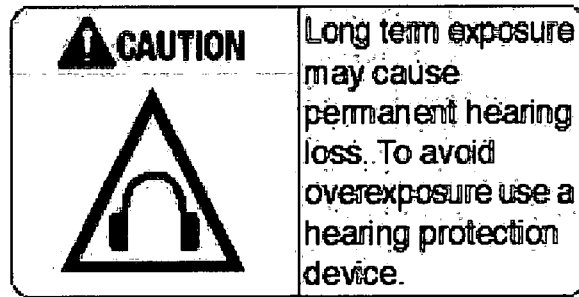


Figure A 4: Slipping Hazard

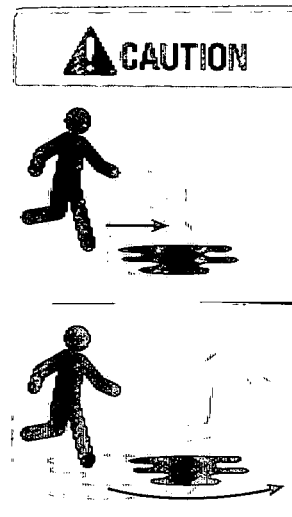
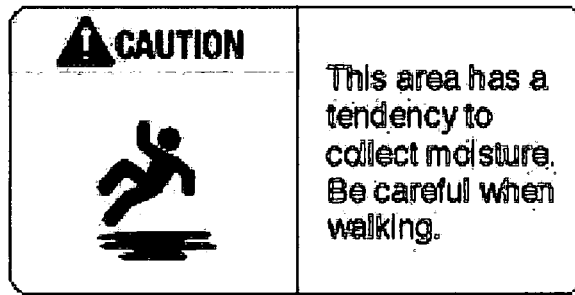


Figure A 5: Tripping Hazard

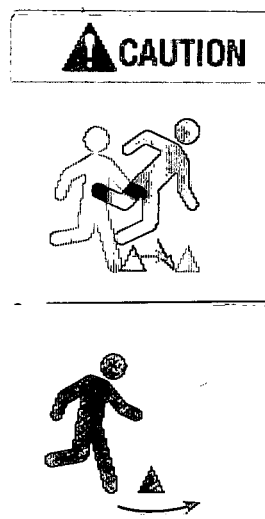
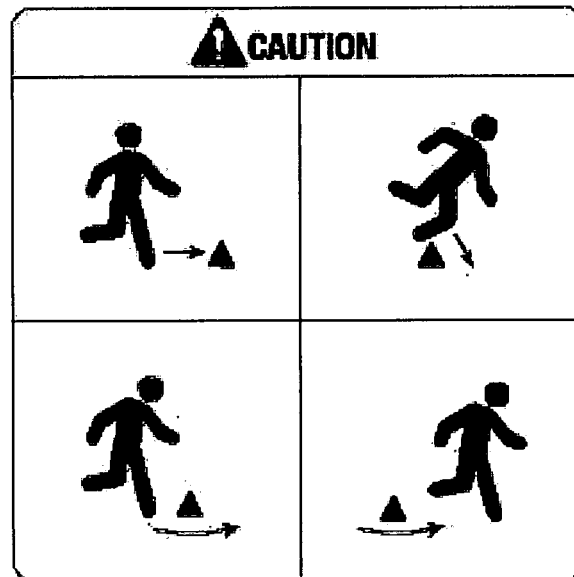
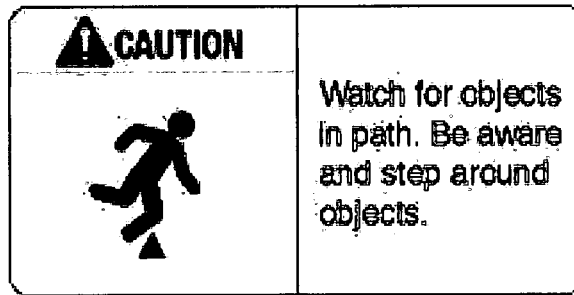


Figure A 6: Wear Protective Equipment Hazard

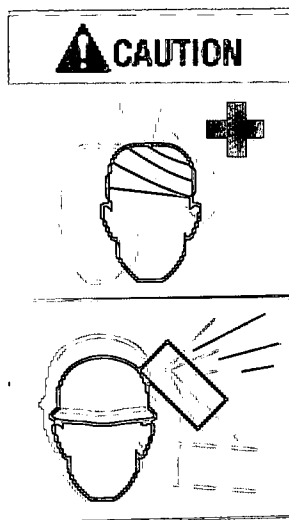
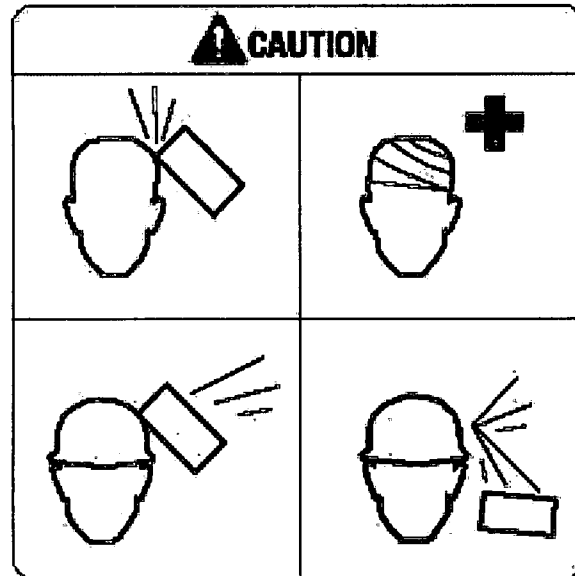
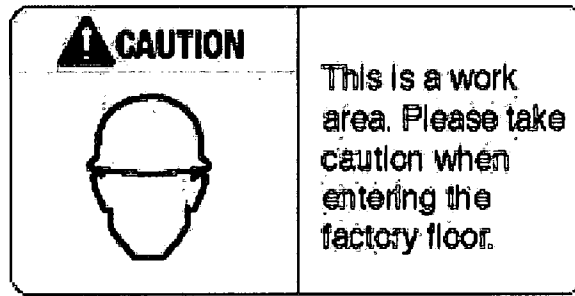


Figure A 7: Choking Hazard

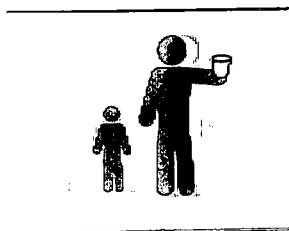
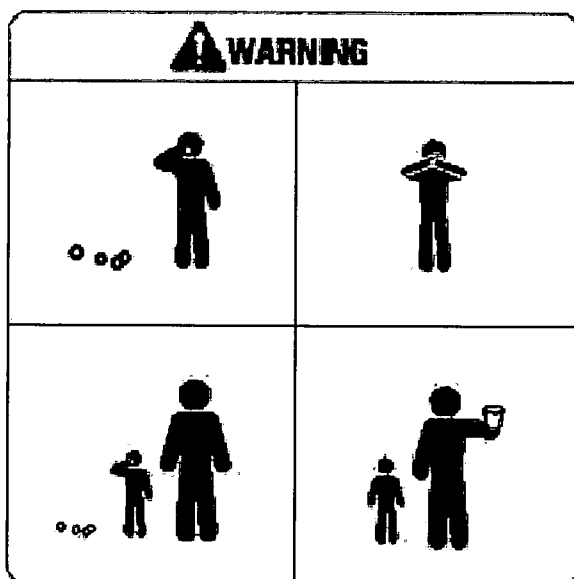
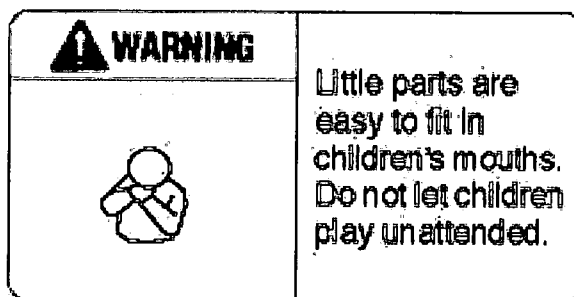


Figure A 8: Collision Hazard

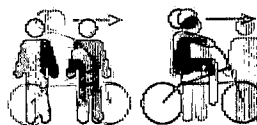
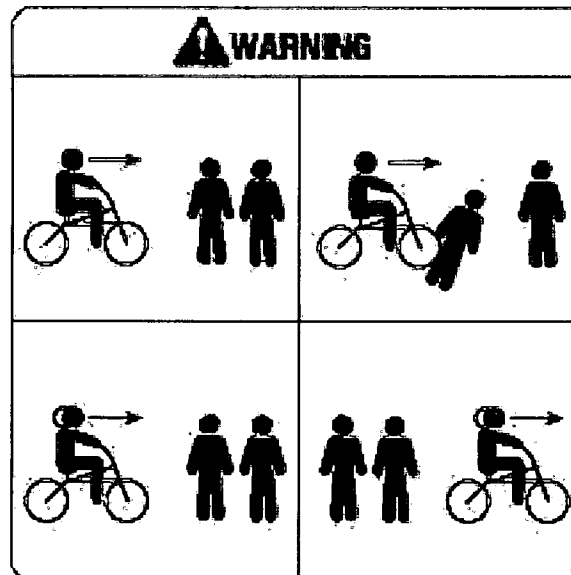
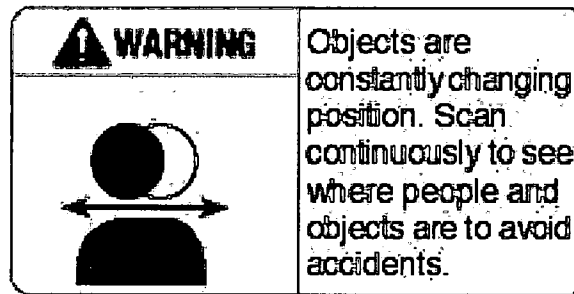


Figure A 9: Crush Hazard

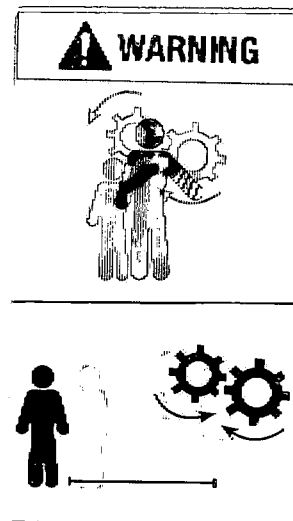
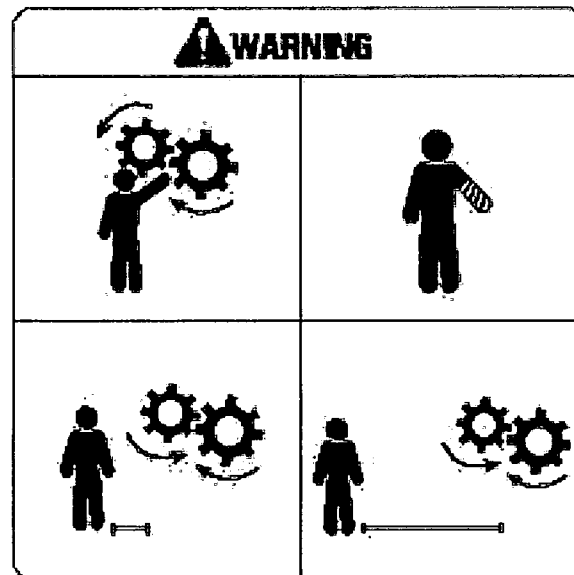
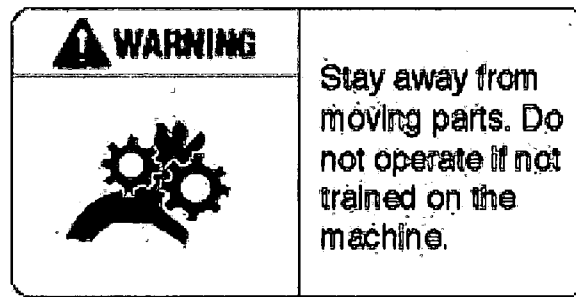




Figure A 10: Drowning Hazard

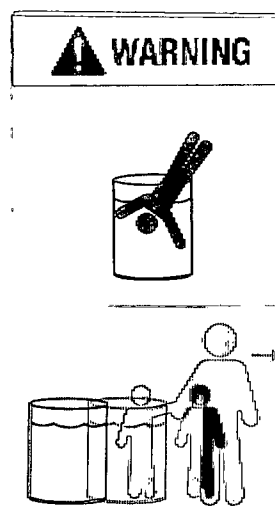
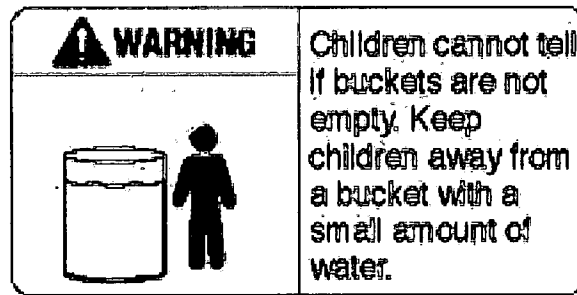


Figure A 11: Fall Hazard

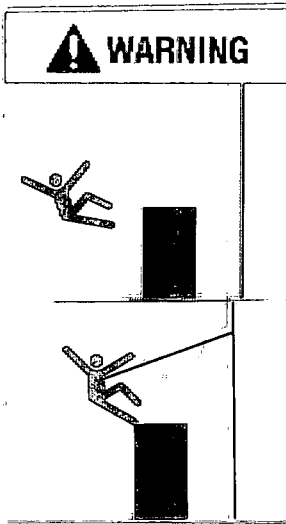
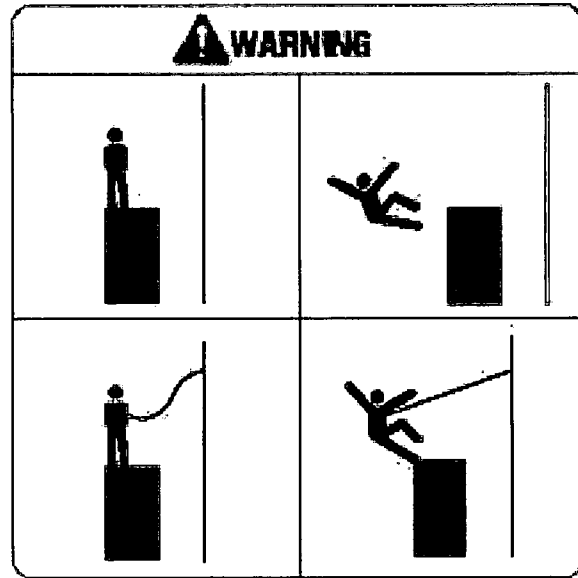


Figure A 12: Roll-over Hazard

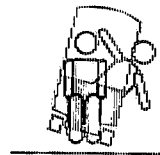
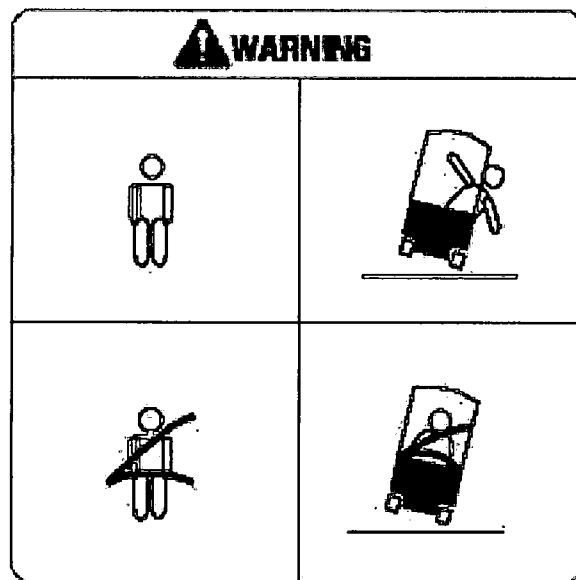
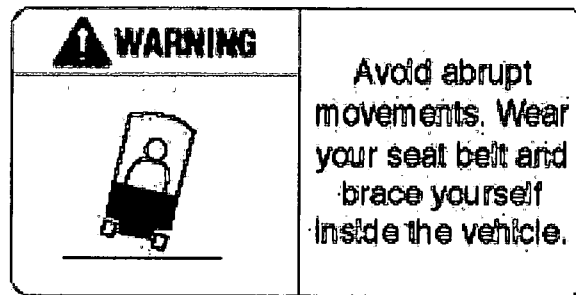


Figure A 13: Electrocution Hazard

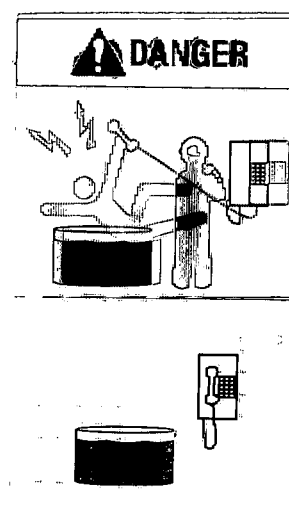
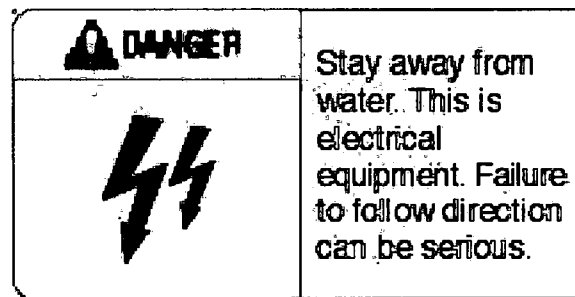


Figure A 14: Falling Objects Hazard

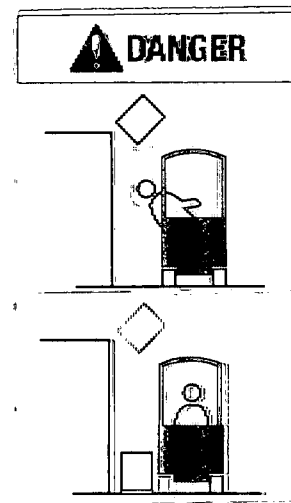
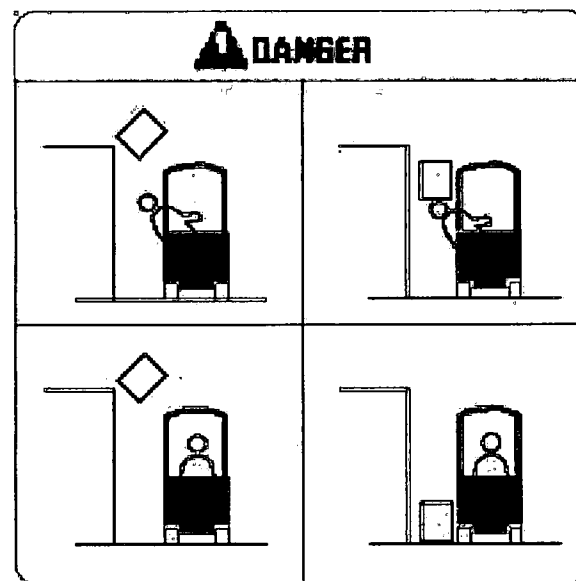
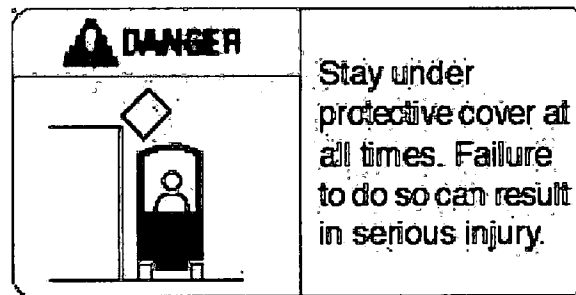


Figure A 15: Flammable Hazard

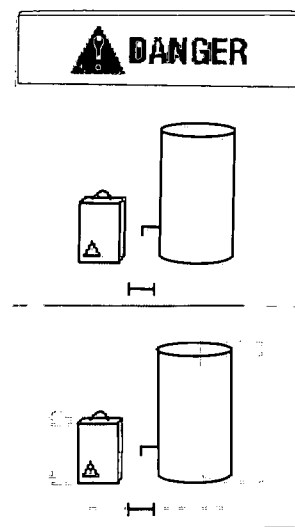
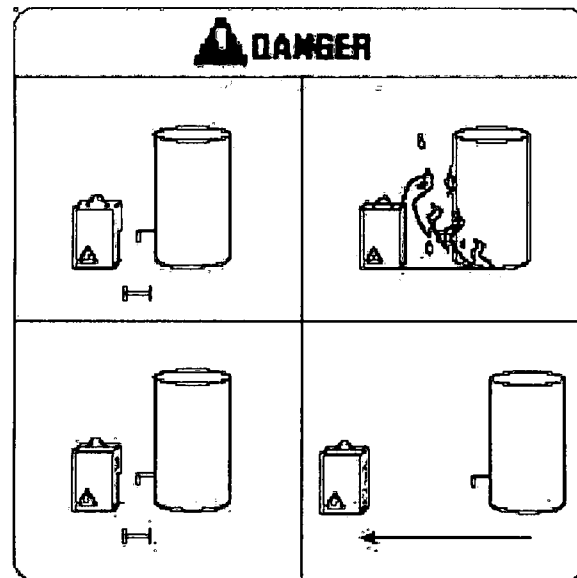
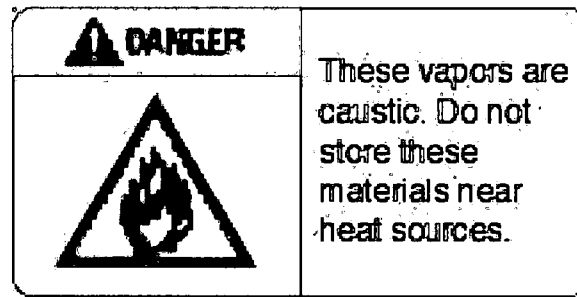


Figure A 16: Lasers- Eye Damage Hazard

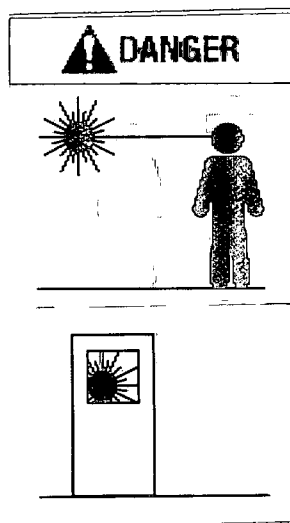
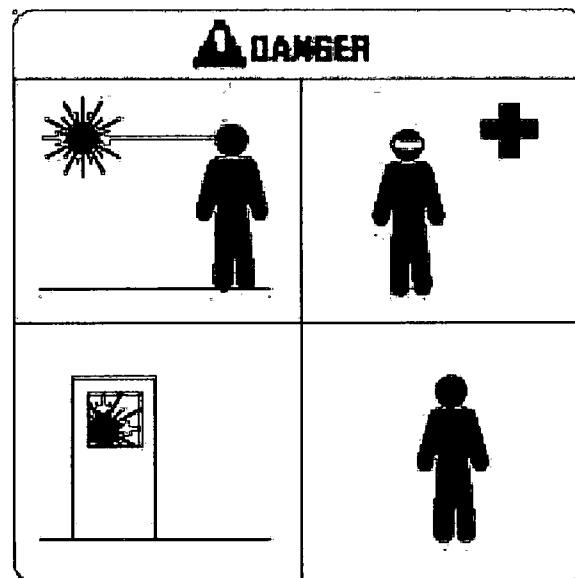
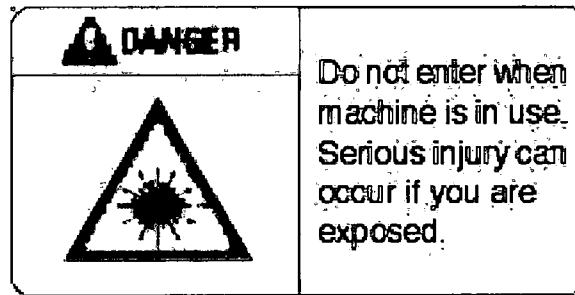


Figure A 17: Poison Hazard

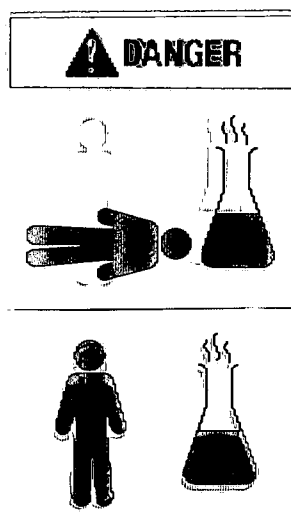
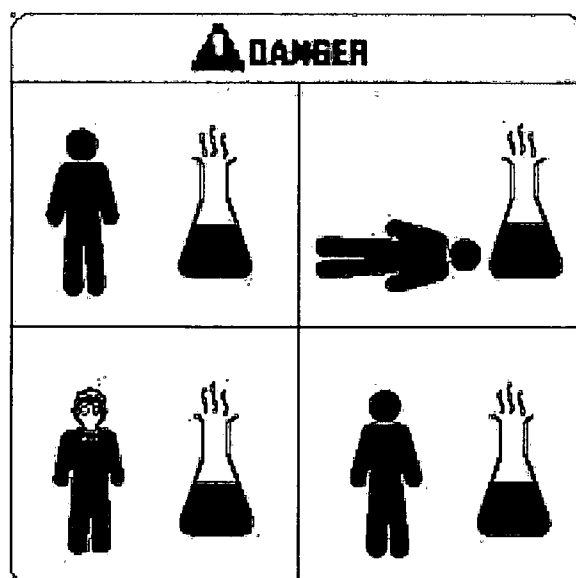
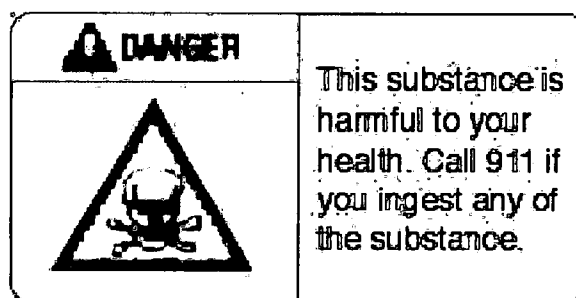
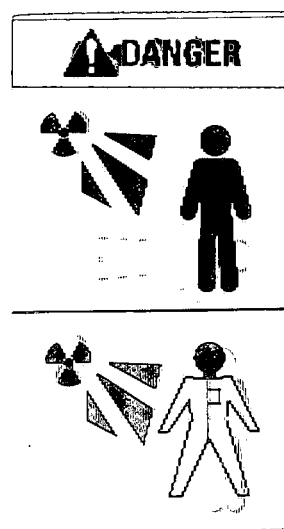
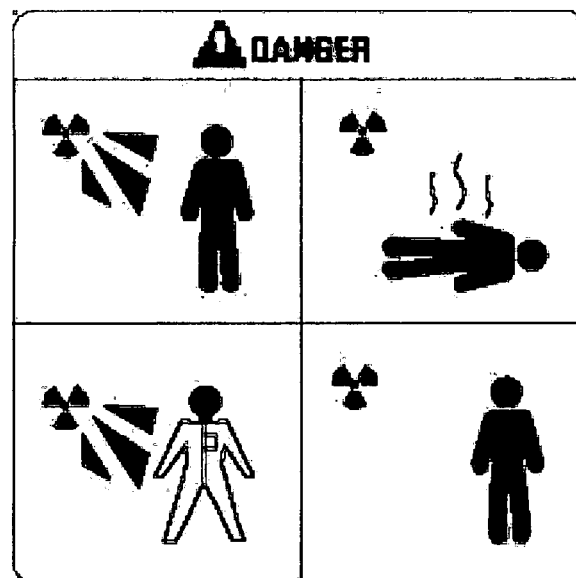
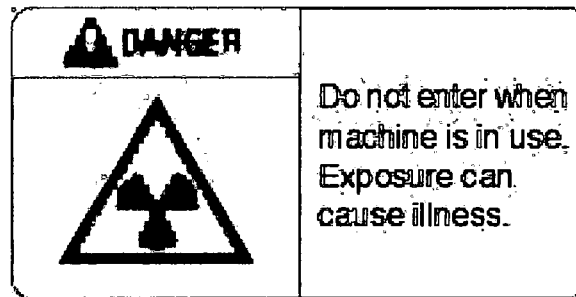




Figure A 18: Radiation Hazard



## APPENDIX B

## Participant Viewing Combinations

Participant 1	Traditional	Two-Panel	Lenticular
Caution	Tripping	Burn	Loud Noise
	Lifting	Slipping	Protective Equip
Warning	Collision	Crush	Choking
	Drowning	Falls	Rollover
Danger	Electrocution	Poison	Lasers
	Flammable	Falling Objects	Radiation

Participant 2	Traditional	Two-Panel	Lenticular
Caution	Burn	Loud Noise	Tripping
	Lifting	Slipping	Protective Equip
Warning	Collision	Crush	Drowning
	Choking	Falls	Rollover
Danger	Electrocution	Poison	Lasers
	Falling Objects	Radiation	Flammable

Participant 3	Traditional	Two-Panel	Lenticular
Caution	Burn	Loud Noise	Tripping
	Protective Equip	Lifting	Slipping
Warning	Collision	Crush	Drowning
	Falls	Rollover	Choking
Danger	Lasers	Electrocution	Poison
	Flammable	Falling Objects	Radiation

Participant 4	Traditional	Two-Panel	Lenticular
Caution	Burn	Slipping	Protective Equip
	Loud Noise	Tripping	Lifting
Warning	Collision	Crush	Falls
	Drowning	Rollover	Choking
Danger	Poison	Lasers	Electrocution
	Flammable	Falling Objects	Radiation

Participant 5	Traditional	Two-Panel	Lenticular
Caution	Lifting	Slipping	Loud Noise
	Protective Equip	Tripping	Burn
Warning	Crush	Drowning	Falls
	Rollover	Choking	Collision
Danger	Radiation	Lasers	Electrocution
	Flammable	Falling Objects	Poison

Participant 6	Traditional	Two-Panel	Lenticular
Caution	Lifting	Slipping	Protective Equip
	Loud Noise	Tripping	Burn
Warning	Crush	Drowning	Rollover
	Falls	Choking	Collision
Danger	Lasers	Electrocution	Poison
	Radiation	Falling Objects	Flammable

Participant 7	Traditional	Two-Panel	Lenticular
Caution	Loud Noise	Slipping	Burn
	Tripping	Protective Equip	Lifting
Warning	Crush	Rollover	Falls
	Drowning	Choking	Collision
Danger	Lasers	Flammable	Poison
	Electrocution	Falling Objects	Radiation

Participant 8	Traditional	Two-Panel	Lenticular
Caution	Loud Noise	Tripping	Protective Equip
	Slipping	Burn	Lifting
Warning	Drowning	Falls	Collision
	Choking	Rollover	Crush
Danger	Lasers	Electrocution	Falling Objects
	Flammable	Poison	Radiation

Participant 9	Traditional	Two-Panel	Lenticular
Caution	Lifting	Tripping	Burn
	Slipping	Protective Equip	Loud Noise
Warning	Crush	Falls	Rollover
	Choking	Collision	Drowning
Danger	Flammable	Poison	Lasers
	Falling Objects	Radiation	Electrocution

Participant 10	Traditional	Two-Panel	Lenticular
Caution	Burn	Protective Equip	Lifting
	Tripping	Slipping	Loud Noise
Warning	Collision	Falls	Rollover
	Choking	Drowning	Crush
Danger	Radiation	Poison	Lasers
	Falling Objects	Electrocution	Flammable

Participant 11	Traditional	Two-Panel	Lenticular
Caution	Slipping	Loud Noise	Lifting
	Tripping	Burn	Protective Equip
Warning	Falls	Drowning	Choking
	Collision	Crush	Rollover
Danger	Electrocution	Flammable	Lasers
	Falling Objects	Radiation	Poison

Participant 12	Traditional	Two-Panel	Lenticular
Caution	Slipping	Protective Equip	Tripping
	Lifting	Burn	Loud Noise
Warning	Falls	Rollover	Collision
	Choking	Crush	Drowning
Danger	Electrocution	Poison	Radiation
	Lasers	Flammable	Falling Objects

Participant 13	Traditional	Two-Panel	Lenticular
Caution	Loud Noise	Burn	Tripping
	Protective Equip	Lifting	Slipping
Warning	Falls	Rollover	Choking
	Collision	Crush	Drowning
Danger	Electrocution	Poison	Lasers
	Radiation	Flammable	Falling Objects

Participant 14	Traditional	Two-Panel	Lenticular
Caution	Tripping	Burn	Loud Noise
	Protective Equip	Lifting	Slipping
Warning	Collision	Choking	Rollover
	Crush	Drowning	Falls
Danger	Electrocution	Poison	Lasers
	Radiation	Flammable	Falling Objects

Participant 15	Traditional	Two-Panel	Lenticular
Caution	Tripping	Burn	Loud Noise
	Protective Equip	Lifting	Slipping
Warning	Rollover	Choking	Collision
	Crush	Drowning	Falls
Danger	Lasers	Poison	Electrocution
	Flammable	Falling Objects	Radiation

Participant 16	Traditional	Two-Panel	Lenticular
Caution	Protective Equip	Lifting	Slipping
	Burn	Loud Noise	Tripping
Warning	Choking	Collision	Rollover
	Crush	Drowning	Falls
Danger	Electrocution	Poison	Lasers
	Flammable	Falling Objects	Radiation

Participant 17	Traditional	Two-Panel	Lenticular
Caution	Slipping	Protective Equip	Lifting
	Burn	Loud Noise	Tripping
Warning	Collision	Crush	Choking
	Rollover	Drowning	Falls
Danger	Electrocution	Poison	Lasers
	Falling Objects	Radiation	Flammable

Participant 18	Traditional	Two-Panel	Lenticular
Caution	Protective Equip	Lifting	Slipping
	Tripping	Burn	Loud Noise
Warning	Choking	Collision	Crush
	Drowning	Falls	Rollover
Danger	Lasers	Electrocution	Poison
	Falling Objects	Radiation	Flammable

Participant 19	Traditional	Two-Panel	Lenticular
Caution	Tripping	Loud Noise	Burn
	Lifting	Slipping	Protective Equip
Warning	Choking	Collision	Crush
	Rollover	Falls	Drowning
Danger	Poison	Lasers	Electrocution
	Falling Objects	Radiation	Flammable

Participant 20	Traditional	Two-Panel	Lenticular
Caution	Burn	Loud Noise	Tripping
	Protective Equip	Slipping	Lifting
Warning	Drowning	Falls	Rollover
	Collision	Crush	Choking
Danger	Electrocution	Lasers	Poison
	Falling Objects	Radiation	Flammable

Participant 21	Traditional	Two-Panel	Lenticular
Caution	Burn	Loud Noise	Tripping
	Lifting	Slipping	Protective Equip
Warning	Rollover	Falls	Drowning
	Collision	Crush	Choking
Danger	Poison	Lasers	Electrocution
	Falling Objects	Flammable	Radiation

Participant 22	Traditional	Two-Panel	Lenticular
Caution	Loud Noise	Slipping	Lifting
	Tripping	Protective Equip	Burn
Warning	Drowning	Collision	Rollover
	Falls	Crush	Choking
Danger	Poison	Radiation	Electrocution
	Lasers	Flammable	Falling Objects

Participant 23	Traditional	Two-Panel	Lenticular
Caution	Loud Noise	Tripping	Protective Equip
	Slipping	Lifting	Burn
Warning	Collision	Crush	Rollover
	Falls	Choking	Drowning
Danger	Poison	Lasers	Flammable
	Radiation	Electrocution	Falling Objects

Participant 24	Traditional	Two-Panel	Lenticular
Caution	Burn	Tripping	Lifting
	Slipping	Protective Equip	Loud Noise
Warning	Drowning	Crush	Choking
	Falls	Rollover	Collision
Danger	Radiation	Lasers	Electrocution
	Flammable	Falling Objects	Poison

Participant 25	Traditional	Two-Panel	Lenticular
Caution	Burn	Lifting	Slipping
	Protective Equip	Tripping	Loud Noise
Warning	Rollover	Crush	Choking
	Falls	Collision	Drowning
Danger	Falling Objects	Lasers	Electrocution
	Flammable	Poison	Radiation

Participant 26	Traditional	Two-Panel	Lenticular
Caution	Tripping	Loud Noise	Slipping
	Protective Equip	Burn	Lifting
Warning	Falls	Collision	Drowning
	Crush	Choking	Rollover
Danger	Poison	Radiation	Electrocution
	Flammable	Falling Objects	Lasers

Participant 27	Traditional	Two-Panel	Lenticular
Caution	Tripping	Lifting	Protective Equip
	Slipping	Burn	Loud Noise
Warning	Falls	Rollover	Crush
	Drowning	Choking	Collision
Danger	Lasers	Electrocution	Falling Objects
	Poison	Radiation	Flammable

Participant 28	Traditional	Two-Panel	Lenticular
Caution	Tripping	Slipping	Protective Equip
	Burn	Loud Noise	Lifting
Warning	Collision	Rollover	Drowning
	Crush	Choking	Falls
Danger	Flammable	Electrocution	Poison
	Falling Objects	Radiation	Lasers

Participant 29	Traditional	Two-Panel	Lenticular
Caution	Lifting	Burn	Protective Equip
	Slipping	Loud Noise	Tripping
Warning	Crush	Rollover	Collision
	Choking	Drowning	Falls
Danger	Lasers	Falling Objects	Poison
	Electrocution	Radiation	Flammable

Participant 30	Traditional	Two-Panel	Lenticular
Caution	Lifting	Slipping	Loud Noise
	Burn	Protective Equip	Tripping
Warning	Crush	Choking	Drowning
	Rollover	Collision	Falls
Danger	Lasers	Electrocution	Flammable
	Radiation	Poison	Falling Objects

## APPENDIX C

## Informed Consent

## Informed Consent to Participate in a Research Project

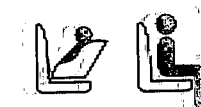
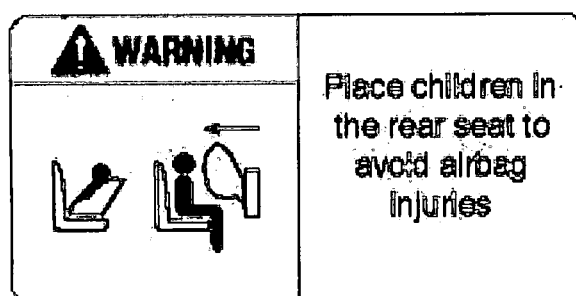
Project Title:	<b>Warning Labels</b>
Investigator(s):	Sara Loomer and Greg Elvers, PhD (faculty sponsor)
Description of Study:	Participants will examine a series of warning labels, identify three components of a warning label and answer follow-up questions.
Adverse Effects and Risks:	No adverse effects have occurred in similar research. Participation involves looking at warning labels depicting a range of hazards. The physical components of the study are not stressful. There are no known physical or mental risks. If you are having difficulty seeing the warning label, please inform the investigator or experimenter.
Duration of Study:	The study will take approximately 1 hour to complete.
Confidentiality of Data:	Your name will be kept separate from the data. Both your name and the data will be kept in a locked filing cabinet. Only the investigators named above will have access to the locked filing cabinet. Your name will not be revealed in any document resulting from this study. Only the experimenters will be aware of your identity.
Contact Person:	Students may contact Sara Loomer, SJ 313, (937) 229-2175, loomersa@notes.udayton.edu or Greg Elvers, SJ 312, (937) 229-2171, greg.elvers@notes.udayton.edu if you have questions or problems after the study. If you have questions about your rights as a research participant you may also contact the acting chair of the Research Review and Ethics Committee, Roger Reeb, PhD in SJ 306, (937) 229-2395, Roger.Reeb@notes.udayton.edu.
Consent to Participate:	I have voluntarily decided to participate in this study. The investigator named above has adequately answered any and all questions I have about this study, the procedures involved, and my participation. I understand that the experimenter will be available to answer any questions about research procedures throughout this study. I also understand that I may voluntarily terminate my participation in this study at any time and still receive full credit. I also understand that the investigator named above may terminate my participation in this study if s/he feels this to be in my best interest. In addition, I certify that I am 18 (eighteen) years of age or older.

Signature of Student	Student's Name (printed)	Date
Signature of Witness		Date



## APPENDIX D

## Sample Training Labels

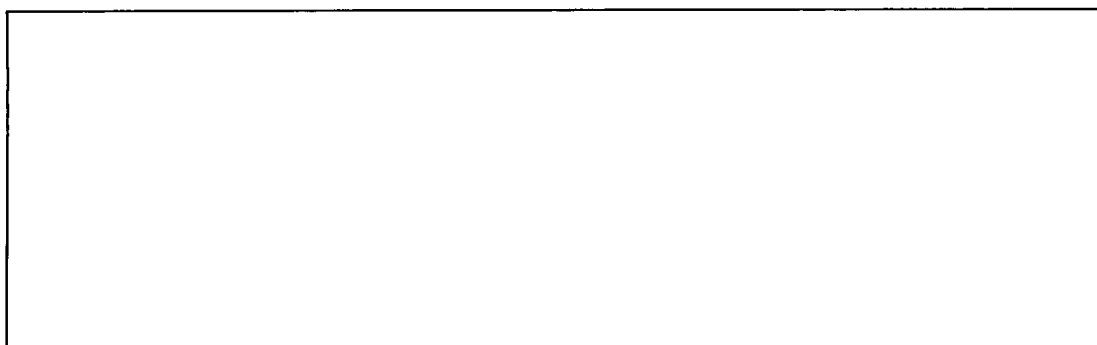


## APPENDIX E

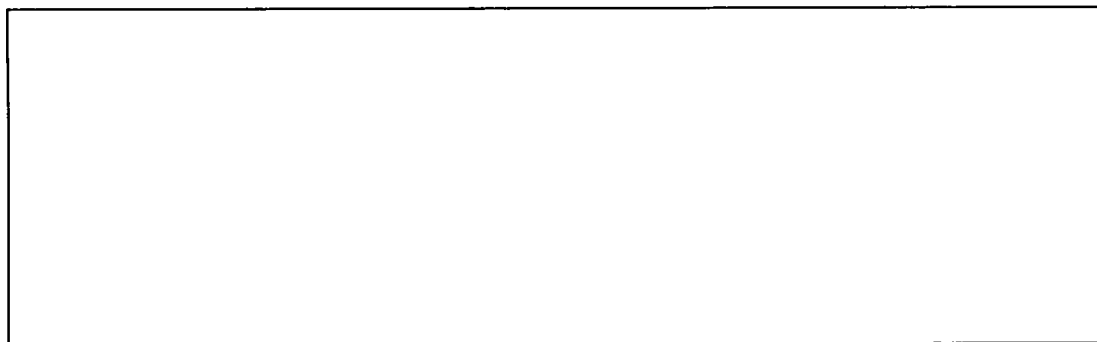
## Free Response Answer Form

For the label you just viewed...

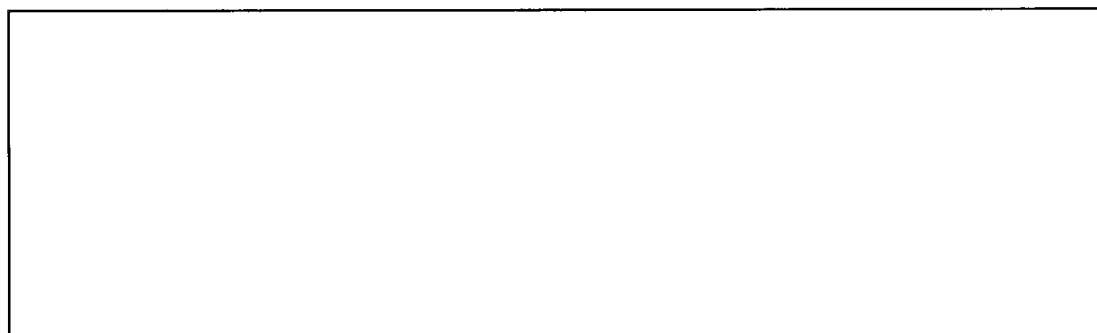
Identify the hazard depicted in the warning label.



Identify the possible consequences of not complying with the warning label.



Identify the ways to avoid the hazard.



## APPENDIX F

## Follow-Up Questions

1. Rank from 1 to 3 which type of label you felt produced the greatest overall **understanding**, with 1 being the greatest understanding and 3 being the least understanding.

\_\_\_\_ single-panel

\_\_\_\_ two-panel

\_\_\_\_ flip

2. For the **single-panel** warning label how likely would you be to **comply** with the warning?

Likely to comply

Not likely to comply

1

2

3

4

5

6

3. Why?

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4. For the **two-panel** warning label how likely would you be to **comply** with the warning?

Likely to comply

Not likely to comply

1

2

3

4

5

6

5. Why?

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6. For the **flip** warning label how likely would you be to **comply** with the warning?

Likely to comply

Not likely to comply

1

2

3

4

5

6

7. Why?

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## APPENDIX G

### Debriefing Form

#### **Information about the Study**

##### **Objective:**

During the past century, keeping product users safe has been a top consideration of companies often due to fear of litigation and profit loss. The constant concern for safety has driven the need for warning related innovation over the years. The objective of our research is to improve understanding with alternative label designs.

##### **Hypothesis:**

We hypothesized that the flip (more technically known as the lenticular label design), which uses advanced printing techniques to create apparent motion, will produce greater understanding of the hazard depicted in each label. In addition, we expect that you will understand the two-panel label, the label with two pictures in sequence, better than the traditional, single-panel warning label. Also, there may be an effect of severity on understanding. Labels that convey a less severe hazard may be understood better than labels that convey more severe hazards because the hazards for less severe labels are more obvious and common. The effect of severity on understanding may depend on the type of warning label. As the severity of the warning increases, the type of label used may have an increasing effect on understanding. We are testing our hypothesis by conducting this study to compare the new label designs to the traditional label. All participants evaluated all three types of labels. We expect our results to indicate the benefit of the flip label design.

##### **Your Contribution:**

Your data will be analyzed to determine if understanding is improved by use of the alternative label design. The manipulated independent variables in this study are the type of label used (flip, two-panel, or single-panel) and the severity of the warning. Your understanding of the warning label and probability of compliance are the dependent variables that were tested.

##### **Benefits:**

Improving warning label understanding is significant because while such labels are now everywhere, many people cannot understand the warning and subsequently take measures to avoid the hazard resulting in terrible consequences such as bodily injury or death.

More understandable warning labels will keep product users safer, and have the potential to save companies money by avoiding litigation and profit loss.

**Assurance of Privacy:**

We are studying warning label understanding and are not evaluating you personally in any way. Your responses will be kept completely confidential and your responses will only be identified by a participant number in the data set with other participant numbers. Your name will not be revealed in any document resulting from this study.

**Please note:**

- **We ask you to kindly refrain from discussing this study with others in order to help us avoid biasing future participants.**
- If you have any questions please do not hesitate to contact any of the individuals listed on this page.
- For further information about this area of Warning Label research, you may consult the text cited on this page.

**Contact Information**

Students may contact Sara Loomer, SJ 313, (937) 229-2175, loomersa@notes.udayton.edu or Greg Elvers, SJ 312, (937) 229-2171, greg.elvers@notes.udayton.edu if you have questions or problems after the study. If you have questions about your rights as a research participant you may also contact the acting chair of the Research Review and Ethics Committee, Roger Reeb, PhD in SJ 306, (937) 229-2395, Roger.Reeb@notes.udayton.edu.

Thank you for your participation. I will update your research credit on the online system.

**References**

- American National Standards Institute (ANSI, 2002). *Accredited Standards Committee on Safety Signs and Colors*. Z535.1-5. Arlington, VA: National Electrical Manufacturers Association.
- One2Print (2004). Lenticular: How it works. Retrieved February 8, 2007, from [http://www.one2print.com/content/html/copy\\_print/lenticular.htm](http://www.one2print.com/content/html/copy_print/lenticular.htm).
- Wogalter, M.S. (Ed.). (2006). *Handbook of Warnings* (pp. 11-20). Mahwah, NJ: Erlbaum.

## APPENDIX H

## Preliminary Key Words for Identification of Warning Label Components

	<b>Hazard</b>	<b>Possible Consequences</b>	<b>How to Avoid</b>
C1	Burn or Scalding	Burns, tissue damage	Do not touch
C2	Lifting or Back Strain	Back pain, stiffness, muscle strains and injury	Lift with entire body, bend knees, follow materials handling recommendation
C3	Loud Noise, Hearing Damage	Hearing damage, headaches	Use hearing protection devices, turn down volume
C4	Slipping, Wet floor	Bruises, sprains, broken bones	Use caution when walking, avoid wet areas
C5	Tripping, falling	Bruises, sprains, broken bones	Use caution when walking, avoid hazards in sight
C6	Wear protective equipment, Hard hat area, etc.	Bumps, Bruises, Cuts, etc	Use protective equipment
W1	Choking, Swallowing small objects	Unconsciousness, Death	Do not leave children unattended
W2	Collisions, Hitting people	Bruises, sprains, broken bones, extreme cases of paralysis and death	Look both ways, scan continuously, be attentive
W3	Crushing, Cutting of appendages	Bruises, sprains, broken bones, loss of appendage	Stay away from moving parts, use protective equipment, make sure machine is off/not operating
W4	Drowning	Choking, unconsciousness, even death	Do not leave child unattended, empty all buckets



	<b>Hazard</b>	<b>Possible Consequences</b>	<b>How to Avoid</b>
W5	Falls from heights	Bruises, sprains, broken bones, even paralysis or death	Use a lanyard, attach your protective equipment to stationary object
W6	Rollovers, Falling out of vehicles, Being crushed by vehicle	Bruises, broken bones, loss of appendages even paralysis or death	Use a seatbelt, Brace yourself in vehicle, Stay in vehicle
D1	Electrocution, Electric Shock	Burns, death	Keep electrical objects away from water
D2	Falling Objects, being crushed by objects	Broken bones, loss of appendages, death	Stay under guards, wear protective equipment
D3	Flammable Materials	Fire, Burns, death	Keep flammable materials away from heat sources
D4	Lasers, eye damage	Eye damage, blindness	Do not go in when laser is in use, use protective eye wear
D5	Poison if inhaled	Illness, Unconsciousness, Death	Do not get near hazardous chemicals, use protective equipment
D6	Radiation, Poisoning	Illness, Cancers, Death	Wear protective equipment, limit exposure

## APPENDIX I

## Final Key Words for Identification of Warning Label Components

	<b>Hazard</b>	<b>Possible Consequences</b>	<b>How to Avoid</b>
C1	Burning or scalding, hot surfaces	Burns, tissue damage, blisters	Do not touch
C2	Lifting heavy objects or Back Strain	Back pain, stiffness, muscle strains and injury	Lift with entire body, bend knees, follow materials handling recommendation, use lifting devices
C3	Loud Noise, Hearing Damage	Hearing damage, headaches, Hurting your ears, talking loud	Use hearing protection devices, wear headphones or earplugs, turn down volume
C4	Slipping, Wet floor, spills on floor	Slip and fall, bruises, sprains, broken bones	Use caution when walking, avoid wet areas, walk around spills
C5	Tripping, falling, objects in walking path	Tripping, Bruises, sprains, broken bones	Use caution when walking, walk around objects, avoid hazards in sight
C6	Dangerous area, wear protective equipment, Hard hat area, etc.	Bumps, concussion, bruises, cuts, etc	Use protective equipment, wear hard hat
W1	Small objects around children, Choking, Swallowing small objects	Choking, Unconsciousness, Death	Do not leave children unattended, pick up things kids would put in their mouth
W2	Collisions, Hitting people, moving objects, blind spot, pedestrian area	Hitting pedestrians, bruises, sprains, broken bones, extreme cases of paralysis and death	Look both ways, scan continuously, be attentive, avoid crowded areas

	<b>Hazard</b>	<b>Possible Consequences</b>	<b>How to Avoid</b>
W3	Crushing, Cutting of appendages, moving parts	Bruises, sprains, broken bones, loss of appendage	Stay away from moving parts, use protective equipment, make sure machine is off/not operating
W4	Unattended tub of water or liquid, drowning	Choking, drowning, unconsciousness, even death	Do not leave child unattended, empty all buckets
W5	Falls from heights, extreme heights	Bruises, sprains, broken bones, even paralysis or death	Use a lanyard, use safety belt/cord, attach your protective equipment to stationary object
W6	Rollovers, tipping with sharp turns, falling out of vehicles, being crushed by vehicle	Bruises, broken bones, concussion, loss of appendages even paralysis or death	Use a seatbelt, Brace yourself in vehicle, Stay in vehicle
D1	Electrocution, Electric Shock, electrical object too close to water	Electrocution, shock, burns, death	Keep electrical objects away from water, move electrical objects away from water, do not touch live objects in water
D2	Falling Objects, being crushed by objects	Broken bones, head injury, loss of appendages, decapitation, death	Stay under guards, keep body inside vehicle, wear protective equipment
D3	Flammable Materials, fire hazard	Fire, burns, injure lungs, death	Keep flammable materials away from heat sources, use caution when handling
D4	Lasers, laser machine, harmful light	Eye damage, blindness	Do not go in when laser is in use, use protective eye wear, keep door shut to outside people, don't look at laser
D5	Poison if inhaled, hazardous chemical vapors or liquids, dangerous fumes	Illness, injury to eyes/lungs, unconsciousness, death	Do not get near hazardous chemicals, use protective equipment, gas masks, do not drink or eat
D6	Radiation, Poisoning	Illness, unconsciousness, cancers, death	Wear protective equipment, radiation suit, limit or avoid exposure

## APPENDIX J

### Participant Instructions

- You will first be given a sample booklet that contains one of each type of label
  - Single-panel
  - Two-panel
  - Flip
- Remember to keep the booklet lying flat on the table
- During the experiment you will be viewing each warning for 5 seconds. Please examine them as thoroughly as the time allows, when I announce time is up please turn the page
- For the training labels you will have unlimited time to examine the labels
- If you are shown a label with textual explanation please do not focus especially on the text.
- After viewing the labels you will be asked to identify the following three components on a separate answer sheet.
  - Identify the hazard depicted in the warning label.
  - Identify the way(s) to avoid the hazard.
  - Identify the possible consequences of not complying with the warning label.
- Upon completion of the sample booklet, we will proceed with test booklet
- At the end of the test booklet you will be asked to answer some follow-up questions
- Remember an experimenter will be present to observe during the entire study.

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## APPENDIX K

## Compliance Matrix

	<b>Reasons Likely to Comply</b>	<b>Reasons Unlikely to Comply</b>
<b>Traditional</b>	Familiar (N=8)	Does not include consequences (N=12)
	Easy to understand (N=4)	Does not include how to avoid (N=12)
	Quick to understand (N=1)	
<b>Two-panel</b>	Clear graphics (N=15)	Pictures were confusing (N=1)
	Included consequences in graphic (N=12)	
	Included what not to do in graphic (N=12)	
	Quick to understand (N=10)	
	Easy to understand (N=8)	
<b>Lenticular</b>	Included consequences in graphic (N=12)	Confusing; could not tell start from finish (N=11)
	Included what not to do in graphic (N=12)	Time consuming (N=10)
		Made pictures less clear (N=8)
		Hurt eyes (N=4)