9-1997

How the Presence of a Risk Ladder, Time Interval Comparison, and Smoking Comparison Affect Risk Perception

Steve A. Dinzart

AFIT/GSM/LAL/97S-2

HOW THE PRESENCE OF A RISK LADDER, TIME INTERVAL COMPARISON, AND SMOKING COMPARISON AFFECT RISK PERCEPTION

THESIS

Steve Alfonso Dinzart, Captain, USAF

AFIT/GSM/LAL/97S-2

AFIT/GSM/LAL/97S-2

HOW THE PRESENCE OF A RISK LADDER, TIME INTERVAL COMPARISON, AND SMOKING COMPARISON AFFECT RISK PERCEPTION

THESIS

Presented to the Faculty of the Graduate School of

Logistics and Acquisition Management

of the Air Force Institute of Technology

Air University

Air Education and Training Command

in Partial Fulfillment of the Requirements for the

Degree of Master of Science in Systems Management

Steve Alfonso Dinzart, B.S.

Captain, USAF

September 1997

ACKNOWLEDGMENTS

First of all, I want to thank my heavenly Father for giving me the strength and wisdom necessary to complete this Thesis. He is the Creator of all things, and nothing occurs without it being His will and purpose. "Trust in the Lord with all your heart and lean not on your own understanding; In all your ways acknowledge Him and He will make your path straight" (Proverbs 3:5-6). To God be all the glory!

Also, I am especially grateful to Dr. Kim Campbell for her invaluable assistance, guidance, and overall craziness. In addition, I would like to acknowledge Dr. David Christensen and Lt. Col. Steve Lofgren for their help and insightful suggestions.

And last, but not least, I would like to express my deep appreciation to my Mother, Elizabeth, for her patience, love, and unwavering support. Without her constant words of encouragement, this Thesis would not have become a reality. Thank you, Mom, for being a woman who is worthy of honor and praise. *Bendita Seas Madre*!

Steve Alfonso Dinzart

TABLE OF CONTENTS

PAGE

LIST OF FIGURES

LIST OF TABLES

AFIT/GSM/LAL/97S-2

ABSTRACT

The objective of this study is to increase the knowledge available on the relative effectiveness of risk ladders as a presentation format for explaining risk magnitudes to the public. An experiment was conducted to test the hypotheses that an individual's risk perception varies with the presence of a risk ladder, time interval comparison, and smoking comparison. Subjects were AFIT Professional Continuing Education students, asked to assume a particular level of a health hazard in their homes, to read a brochure explaining the hazard, and then to complete a questionnaire. Results demonstrated that subjects exposed to a graphical risk ladder perceived lower levels of risk than subjects not exposed to a risk ladder. Also, the study found that time interval and smoking comparisons did not significantly affect the risk perception of the participants. These findings suggest that the discontinuity between expert views and the public perceptions of health risk can be bridged by effectively utilizing risk ladders when presenting risk magnitudes to the public.

HOW THE PRESENCE OF A RISK LADDER, TIME INTERVAL COMPARISON, AND SMOKING COMPARISON AFFECT RISK PERCEPTION

I. Introduction

General Issue

On 11 February 1992, an F-16 jet fighter took off for a test flight from Twente Air Base in the Netherlands. Soon after, the plane's engine began to malfunction which caused the plane to crash into a residential area housing more than 12,000 people. Although no one was killed, the incident was understandably very traumatic for much of the public. Therefore when the base commander decided to resume flying missions the very next day, a great number of local residents were aggravated and distressed. The city council criticized the Air Force for its lack of consideration toward the residents. Additionally, it was feared that the soil at the crash site had been contaminated by the leaking of poisonous plane fluids and combustion gasses. The city council took action by alerting the public to the risk of food poisoning, and advised destroying all food that might have been in contact with combustion gases. Eventually, the base commander communicated to the public that no real danger of poisoning existed because the dangerous fluids had burned or had been recovered. Unfortunately, the differing perceptions of risk between the public and the Air Force caused the citizens to lose faith in the military and the government (Gutteling and Wiegman, 1996:1-2).

Effective health risk communication, as the above case illustrates, can be a crucial element in successful risk management. It seems likely that the citizen's loss of faith in the Air Force could have been avoided had the respective health risks been more effectively communicated and understood. Accordingly, risk communicators desire to discover the most productive methods of facilitating information flow. The National Research Council (NRC) asserts that to be effective, "a risk message needs to refer both to information about risk and risk reduction and to the psychological or affective factors that influence the intended recipients" (1989:133).

Because risk typically involves safety and health issues, the ultimate goal of risk communication is to provide information in a manner that permits accurate interpretation of hazards and a sensible response. As Kasperson and Palmlund wrote, "the objective is, alternatively, to inform, to incite to action, to reassure, to co-opt, or to overpower" (1989:143). However, risk communication is not an easy task. It typically involves multiple messages containing complex and difficult ideas, which in turn do not facilitate themselves into easy explanations. The manner in which a communicator presents risk information to the public is obviously crucial. Consequently, risk communicators are always in search of better techniques for reassuring the public when hazard levels are low, and alerting them when levels are high.

> The need to become more skilled at explaining serious risks is grounded in public health and similar concerns; lives are at stake when an agency tries to warn people about serious risks. When people persist in worrying disproportionately about minuscule risks, on the other hand, the costs range from unnecessary anxiety to misused environmental protection dollars, from public policy gridlock to reduced agency credibility. (Weinstein et al., 1991:101)

Therefore, it is vital that risk communicators understand what factors influence the public's perception of risk. In turn, this knowledge will promote more appropriate methods of presenting risk information to the public.

<u>Specific Problem</u>

The Air Force has taken great measures to ensure it is responsive to serious public health concerns. In 1994 alone, the Air Force spent over $559 million in environmental cleanup efforts (Thal, 1994; Raymond, 1995). However, in an era of reduced budgets, the Air Force does not want to misuse public funds by spending money on minor or improbable health risks. A solution to this dilemma is for the Air Force to effectively communicate risks to the public. In doing so, the Air Force can expect an increased public confidence in and cooperation with the military in the pursuit of common public health goals.

However, as was alluded to earlier, risk communication is a difficult undertaking. The process involves many inputs and variables that work together to make informing the public about risks very challenging. Communicators have often found that "citizens ignore information designed to alert them to significant hazards; yet, these same citizens may insist that the government take action on risks that are too small to really merit attention" (Weinstein, 1989:11). The process ends up frustrating both the communicator and the public. The NRC offers their explanation for the problem, "risk messages necessarily compress technical information, which can lead to misunderstanding, confusion, and distrust" (1989:3).

Other investigators believe the cause for miscommunication comes from differing perceptions of the significance of various risks between experts and the public (Slovic, 1986; Allen, 1987; Kasperson et al., 1988). Traditionally, risk has been established by experts as the "probability of injury, disease, or death in a specified period of time" (Singer and Endreny, 1993:6). However, Sandman (1987) has redefined risk as the sum of "hazard" plus "outrage," where hazard refers to the traditional quantitative part of risk, and outrage captures the nonscientific factors which affect risk perception. According to Sandman, the experts tend to focus almost exclusively on the hazard aspect of risk, paying little attention to outrage. Conversely, the public has the tendency to pay virtually no attention to the hazard element, instead opting to focus on outrage. Table 1 illustrates how differences in risk perception between experts and the public can lead to different conclusions about the importance of particular health risks.

TABLE 1. **EXPERT VS PUBLIC PERCEPTIONS OF ENVIRONMENTAL RISKS**

(Groth, 1991:250)

	High Hazard	**Low Hazard**
High Outrage	Childhood Lead Poisoning Environmental Tobacco Smoke	Nuclear Waste Disposal Food Irradiation
Low Outrage	Radon Exposure Foodborne Pathogens	Aflatoxins Water Chlorination

Interestingly, many experts are proposing the use of risk comparisons to reduce the discontinuity between expert views and the public perceptions of risk. Lungren states that "an aspect of presenting risk information that concerns most of us who communicate about risk is how to compare risks" (1994:58). Experts agree that risk comparisons are important because they aid in putting difficult and complex pieces of information into a familiar context which can be more easily understood by the public (Brown, 1985; Covello, 1989; Weinstein et al., 1989). Most of the public does not deal with quantitative data on a daily basis, so they do not have a frame of reference for numbers and probabilities (Brown, 1985). However, properly conceived comparisons can provide individuals with a better understanding of technical information, "comparing different risks can help people comprehend the uncommon magnitudes involved and understand the level, or magnitude, of risk associated with a particular hazard" (NRC, 1989:96).

In an attempt to present risk comparisons in a manner that is understandable to the public while still accurate, researchers have investigated a number of presentation formats. These include the placement of a risk on a risk ladder, the portrayal of risk uncertainty by graphical means, and the portrayal of probabilities by matrices of dots (Sandman et al., 1994; Ibrekk and Morgan, 1987; Weinstein et al., 1994). The most often used format is typically a risk ladder, an example of which is provide as Figure 1. Risk ladders are a type of graphical presentation used to display a range of probabilities for a single category of risks (NRC, 1989:96). Although there are many types of risk ladders with varying scales and hazard comparisons, most formats use a vertical ladder to display different exposure levels and corresponding risk estimates. As in the case of Figure 1, exposure levels are usually shown with high levels at the top and low levels at the bottom.

Radon level (fibers/liter)	Extra Cancer Deaths (out of 1000 people)	Comparison to Smoking Risk
2000	400 in 1000	8 packs/day
1000	200 in 1000	
500	100 in 1000	2 packs/day
250	50 in 1000	
120	25 in 1000	10 cigarettes/day
60	12 in 1000	
30	6 in 1000	2 ½ cigarettes/day
15	3 in 1000	
8	1.5 in 1000	½ cigarette/day

FIGURE 1. **EXAMPLE OF A RISK LADDER**

Although risk ladders are currently being used by communicators to explain risk magnitudes, not many of their attributes have been empirically tested. Specifically, the effect of a smoking comparison has not been investigated. Although a smoking comparison has been an attribute present in many risk ladder studies (Weinstein et al., 1989; Weinstein et al., 1991; Baker, 1995), its direct impact has not been empirically tested. Additionally, the attribute of a time interval comparison has not been tested within the constructs of a risk ladder. Weinstein et al. (1996) used time intervals between expected harmful events to communicate risk magnitudes, but a risk ladder was not incorporated into their experimental design.

It should be noted that the use of risk comparisons, regardless of presentation format, are not without problems. It has been well documented that factors such as gender, age, and education affect an individual's risk perception just as much as risk magnitudes (Covello et al., 1988; Ontani et al., 1992; Campbell and Stewart, 1992). However, "there are hardly any data to support claims that one approach works better than another" (Weinstein et al., 1989:11). Accordingly, the objective of this thesis is to contribute to the body of knowledge on risk ladders as a presentation format for explaining risk magnitudes to the public.

RESEARCH QUESTIONS

The following research questions will be addressed in this thesis:

1. Does the presence of a risk ladder affect risk perception?
2. Does the presence of a time interval comparison affect risk perception?
3. Does the presence of a smoking comparison affect risk perception?

SCOPE OF THE STUDY

A great deal of effort has been invested by researchers attempting to discover the factors which impact an individual's perceived risk, however "much less research has attempted to determine how to explain the magnitudes of risks, and thus improve the correlation between risk and response" (Weinstein et al., 1989:1). Specifically, very little research has been conducted to test the effectiveness of presentation formats in conveying risk magnitudes.

Considering that risk ladders can be customized by the risk communicator in any number of ways, there are also a corresponding countless number of attributes which could be studied. Consequently, this study will limit its research to the presence of only three attributes: a risk ladder, a time interval comparison, and a smoking comparison.

THESIS OVERVIEW

This thesis is organized in a traditional format. This chapter introduced the purpose of the study, the scope of the problem and some necessary background. The next chapter briefly illustrates how this thesis fits into related research. The methodology, results, and conclusions are presented in subsequent chapters. In addition to this discussion, appendices containing illustrative and supporting data are provided along with a comprehensive bibliography.

II. Literature Review

Introduction

This chapter is divided into four sections. The first section discusses the necessity for research in the area of risk ladder attributes, while the second section reviews relevant risk magnitude research. The third section details the research available on risk ladders, and the final section establishes how this study will contribute to the current knowledge on risk ladders.

Research Need

People have always had to contend with risks and risk assessments in their struggle to survive (Krimsky and Plough, 1988). We can only assume that Christopher Columbus assessed the risk of crossing an unknown ocean before he set sail. Similarly, people today are confronted with assessing the risks associated with pesticides, water pollution, air pollution, and a host of other hazards. As a result, the need for effective communication of risk magnitudes has never been greater.

The NRC asserts that "comparing different risks can help people comprehend the uncommon magnitudes involved and understand the level, or magnitude, of risk associated with a particular hazard" (1989:96). Furthermore, Covello et al. (1988) believe that because of the inherent strength in risk comparisons, a critical need exists to better understand the factors which influence their effectiveness. Additionally, they declare that research is needed to address several different questions, including: "What means of display are most effective for risk comparisons?" and "How can basic risk assessment terms, such as 'parts per billion,' be more effectively presented and explained through comparisons?" (Covello et al., 1988:37).

Moreover, Sandman et al. add that "although investigators have identified many factors other than risk magnitudes that seem to influence how the public responds to particular risks, much less research has sought the best ways of explaining risk magnitudes" (1994:35). In support of risk comparisons, the NRC assessed that

> Risk messages commonly convey quantitative information this is unfamiliar and difficult to comprehend. These magnitudes and risk estimates are not easily understood without benchmarks or points of reference, and providing careful comparisons can help people understand this information. (NRC, 1989:96)

Furthermore, the committee felt that risk ladders, in particular, were a capable method for helping the public understand risk magnitudes. However, they were quick to also assert that many of the risk ladder's attributes have yet to be tested, and that "each practical use of the risk comparison should be carefully pre-tested if possible" (NRC, 1989:97).

RISK MAGNITUDE RESEARCH

An extensive search of existing literature was performed to gain information about communicating risk magnitudes. Books and journals from the disciplines of psychology, communication, and public health were the main areas of focus. Specifically, it was hoped that sources could be found which would provide information about effective formats or techniques for communicating risks to the public. The search revealed that very few studies have examined methods for explaining risk magnitudes.

However, one study organized by Weinstein et al. (1996) was found to be very insightful. The research team conducting a test using time intervals between expected harmful events to communicate risk magnitudes. Perception of the risk from a hypothetical occurrence of cancer-causing arsenic in drinking water supplies was examined. The risk was described as either 1 in 1000 or 1 in 100,000, and as present in a town of 2000 people or a city of 200,000 people. With these parameters, the time intervals ranged from 1 expected death in 3500 years (town), to 1 death every 4 months (city). The results indicated that the addition of time intervals significantly decreased perceived risk in the town scenario, but did not affect the city scenario.

Hopeful of discovering research applicable to risk ladders, the search switched its focus to the study of graphic communication. It seems many researchers have focused on the area of improving the appearance of graphs (American National Standards Institute, 1979; Enrick, 1980; Szoka et al., 1991). Enrick's study, for instance, dealt with desired characteristics of appearance for margins, text, abbreviations, lettering, scales, titling, and symbols. Likewise, other studies have focused on improving the analytical usefulness of graphs (Huff, 1954; Christensen and Larkin, 1992; Tan and Benbasat, 1993). For example, Huff (1954) stressed that graphs can be truncated, extended, or displaced in order to exaggerate or minimize the effect displayed. Similarly, Christensen and Larkin (1992) identified nine separate criteria that can be followed to ensure graphs do not mislead decision makers.

Although all of the aforementioned graphical research is significant, not much of it can be utilized because risk ladders do not present information in a typical graphical format. Most of the research conducted dealt with graphs in the form of a picture that illustrated the functional relationship between independent and dependent variables as changes or differences in area, height, or slope. Common examples of these are pie charts, bar graphs, and surface graphs.

Unlike the graphs mentioned, a risk ladder is not a picture that demonstrate the functional relationship between an independent and dependent variable. Rather, it usually lists the independent variable (exposure level) vertically, and simply lists the corresponding dependent variable (risk) next to it. Instead of a picture, a risk ladder more closely resembles a data table.

RISK LADDER RESEARCH

The most significant research found on risk ladders was conducted as part of a cooperative agreement between the Environmental Communication Research Program of Cook College, Rutgers University, and the Office of Policy, Planning and Evaluation of the US Environmental Protection Agency (EPA). The two-phased study was entitled *Communicating Effectively About Risk Magnitudes,* hereafter referred to as the "EPA study". The EPA study evaluated the success of several presentation formats in communicating the risk associated with asbestos and geological radon. The results of the first phase were published in August of 1989, while the second phase was accomplished in September of 1991.

The first phase of the EPA study evaluated seven presentation formats (Weinstein et al., 1989). Of the seven formats, five used a risk ladder, one used a histogram, and the last contained no visual representation of exposure levels. Additionally, four of the formats contained "an action standard - a level below which mitigation was not recommended, and above which it was" (Weinstein et al., 1989:3). The research found that the presence of an action standard increased the likelihood that people would follow recommendations.

Another crucial finding of the study was the development of a locational hypothesis. Although location was not a factor separately tested, researchers were able to observe that risk perceptions were more a function of where the assigned risk was placed on the page, than an actual understanding of the risk magnitude. Subjects tended to view exposure levels at the bottom of the page as very low risk, and levels at the top as very high risk.

In phase two of the EPA study, six different factors were examined to determine their impact on risk perception: actual risk, the effect of a risk ladder, location on the risk ladder, units of exposure magnitude, differences between two hazards, and simultaneous presentation of two hazards (Weinstein et al., 1991).

Risk ladder effect was tested primarily because the first part of the study found that the presentation format which was void of any visual representation of exposure levels received the highest marks for perceived risk. Therefore an experiment was designed to test whether adding a risk ladder to the standard-only format would affect perceived risk. The results showed that perceived risk was only slightly stronger for those without the risk ladder, than for those with it.

The locational hypothesis was tested by displacing the risk ladder, so that the same assigned exposure levels and risk information were located either one-quarter of the way up the ladder or three-quarters of the way up the ladder. The finding supported the hypothesis. Subjects with assigned exposure levels located high on the ladder perceived a high risk than those with the same exposure level located lower on the ladder.

Building on the results of the EPA study, Baker (1995) tested the effect of two design factors on risk perception: location of assigned risk level on a ladder and the presence of an action standard on a ladder. The locational hypothesis test conducted by the EPA study was replicated, however Baker also tested the hypothesis in conjunction with the action standard hypothesis. In the EPA study the action standard was only located at the midpoint of the risk ladder. Results confirmed the locational effect of an assigned exposure level as a significant influence on risk perception. In addition, results demonstrated that the presence of an action standard above an assigned exposure level on a ladder significantly decreases the perception of risk.

SUMMARY

Many different presentation formats are available to communicators when they are attempting to communicate risk magnitudes to the public. Unfortunately, very little research has been conducted to determine the most effective presentation formats for explaining risk magnitudes. Aside from the few examples presented in this literature review, there is little empirical research to support any claims that one presentation format is more effective than another. Consequently, the risk communicator is left in the predicament of arbitrarily choosing a format which hopefully produces the desired public response.

It is the goal of this thesis research to provide more knowledge on the subject of risk ladders as a means of communicating risk magnitudes. Adapting the methods of previous studies, this thesis will examine the influence of three attributes: (1) the presence of a risk ladder, (2) the presence of a time interval comparison, and (3) the presence of a smoking comparison. Detailed explanations of the methods utilized in this study are provided in the following chapter.

III. Methodology

Introduction

This chapter is divided into six distinct sections. The first section discusses the subjects who participated in the research, while the second section describes the experimental design that was utilized. The third section explains the development of the experimental instrument, and the fourth section establishes the reliability of the instrument. Section five discusses the process used for data collection, while the final section details how the data will be analyzed.

Subjects in the Study

The subjects in this study consisted of 112 adults recruited from the AFIT Professional Continuing Education (PCE) program. They were all employed by the Air Force and worked primarily in the career fields of acquisition and logistics. The groups were made up of 92 (82 percent) males and 20 (18 percent) females. There were 63 (56 percent) civilian employees, 35 (31 percent) officers, and 14 (13 percent) enlisted. Table 2 summarizes the ages of the participants. Subjects were primarily between the ages of 31 and 40 years old, with only one individual being less than 20 years old.

TABLE 2. **DISTRIBUTION OF SUBJECTS' AGES**

Age Category	Frequency	Percent
Under 20	1	0.9
20 - 30	25	22.3
31 - 40	53	47.3
41 - 50	25	22.3
51 - 60	8	7.1
Over 60	0	0.0

Educational levels are depicted in Table 3. The groups were very well educated with 27 (24 percent) having a bachelor's degree, and 34 (30 percent) having attained a master's degree. Additionally, only 7 (6 percent) of the participants labeled themselves as regular cigarette smokers.

TABLE 3. **HIGHEST LEVEL OF EDUCATION ATTAINED BY SUBJECTS**

Amount of Education	Frequency	Percent
High School	18	16.1
College Graduate	27	24.1
Some Graduate School	29	25.9
Graduate Degree	34	30.4
Doctoral Degree	4	3.6

PCE students where chosen for this experiment primarily because of their proximity and availability. Consequently, the participants in this study were obtained conveniently, and not selected randomly. Creswell explains that "although random selection enables a researcher to generalize results to a population, one may need to settle for a convenience sample because an entire group of individuals (e.g., a classroom, an organization, a family unit) is available to participate in the study" (1994:127).

Chadwick (1984) maintains that because convenience samples do not represent any defined population, the results from research employing such a sample would be useless in determining pubic opinion. Other researchers, however, believe that the results from a study utilizing a convenience sample can be generalized beyond the participants in the study (Parsons, 1974; Keppel, 1991). Moreover, Keppel established that in past research where subjects were chosen from different sources, the actual differences proved insignificant to the research results. Understanding this about convenience samples, "an investigator working in this field may feel safe in generalizing the results beyond the single experiment" (Keppel, 1991:18).

EXPERIMENTAL DESIGN

This experiment incorporated a completely randomized, 2 x 2 x 2 full factorial design as illustrated in Figure 2. There were fourteen subjects per treatment for a total of 112 subjects. The independent variables were *Risk Ladder*, *Time Comparison*, and *Smoking Comparison*. Each independent variable consisted of only two levels, absent and present. Finally, the dependent variable was the construct *Risk Perception.*

This study utilized a factorial design because of its many distinct advantages over a single factor design. Keppel (1991) explains that factorial designs can strengthen the validity of research findings because they allow movement beyond a single-dimensional view to a more revealing multidimensional view. Additionally, they allow the manipulation of more than one independent variable in the same experiment. Lastly, factorial designs provide more insight into the main and interaction effects since "information can be obtained about the influence of each of the independent variables considered separately and about how the variables combine to influence behavior" (Keppel, 1991:19).

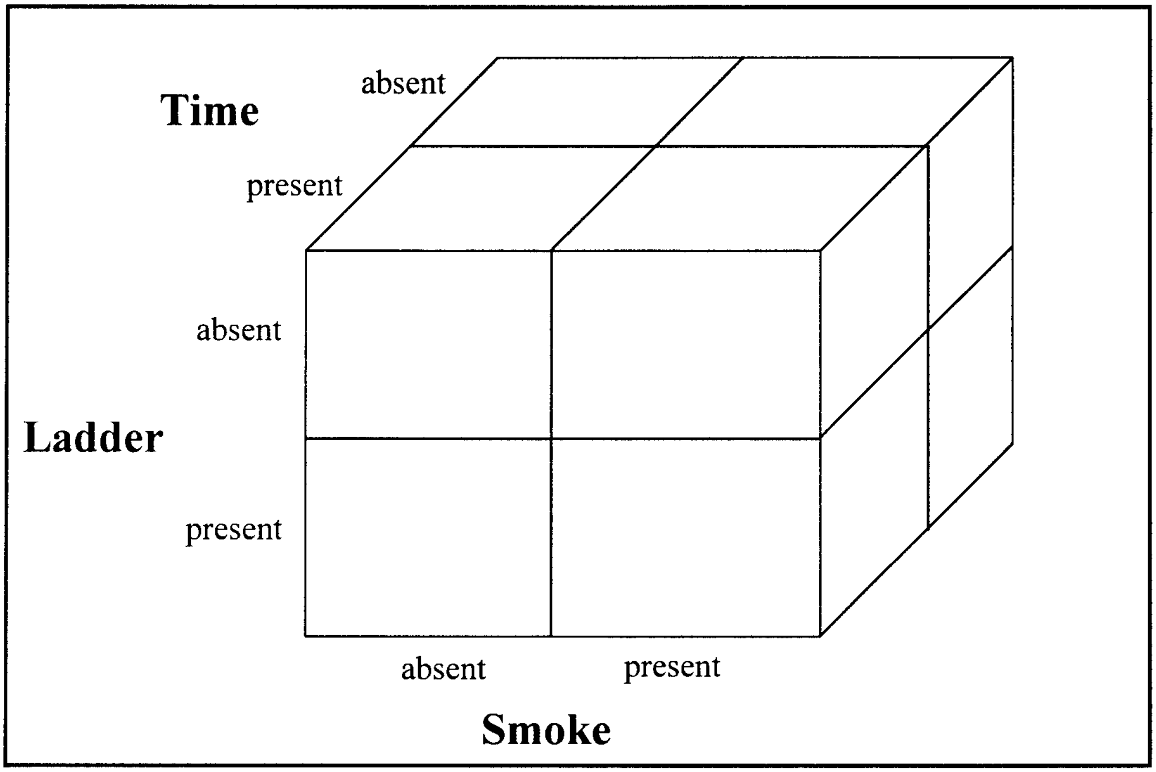

FIGURE 2. **EXPERIMENTAL DESIGN**

Besides being fully factorial, this experiment also incorporated a between-subjects design. In other words, each participant was randomly assigned to one and only one of the eight treatment conditions. In support of between-subject designs, Keppler explains that they are "simpler to understand conceptually, are easier to design and to analyze, and are relatively free from restrictive statistical assumptions" (1991:19).

PILOT STUDY

The pilot study was conducted in April with eleven graduate students from the AFIT School of Logistics and Acquisition Management. The brochure in the pilot test was the exact same one used for the actual experiment (see Appendix A). Subjects were interviewed after they had completed the pilot test to solicit suggestions and comments about the experiment. Based on the pilot study and discussion with the participants, the verbal treatment conditions were rephrased to more clearly communicate the risk comparison being portrayed.

EXPERIMENTAL INSTRUMENT

The experimental instrument used in this research was a modification of the instrument used by Baker (1995), which in turn was based on the materials used in the second phase of the EPA study. The experimental tool consisted of a short brochure which described a fictitious health hazard called *fibronite*. In reality, fibronite was asbestos in disguise. Unlike the EPA's brochure which described the risks associated with asbestos exposure, Baker chose to conceal the hazard because "it was felt that some subjects might have preconceived notions about asbestos and that these feelings would bias the results" (Baker, 1995:26).

The participants were to image that their homes had been tested for fibronite and then use the hypothetical test result, along with a risk ladder or verbal risk comparison, to answer some questions. The first two pages, with basic information about fibronite, were constant across all treatments. However, the last page of the brochure contained the specific treatment being tested. Attached to the end of the brochure were some questions designed to measure the individuals perceived risk and to gather some demographic information.

The experiment consisted of eight treatment groups (see Appendix B), four with risk ladders and four with verbal risk comparisons. A single risk ladder format was used for all four treatments, with the only variant being the presence of a smoking or time risk comparison. The four verbal treatments were worded to translate the exact same risk information contained in the four risk ladders at a specified exposure level. All treatments utilized a constant exposure level of 120 fibers/liter. Understanding that the EPA study validated the locational hypothesis, it was decided to place the exposure level right in the middle of the risk ladder. This was done in hopes of removing any location bias that might have been experience by those receiving risk ladders.

Based on the findings of Weinstein et al. (1996), the time interval risk comparisons were placed in the setting of a small town with a population size of 1000 people. In calculating the actual time interval values, a lifetime of 70 years was assumed. The smoking risk comparisons were taken directly from the risk ladders used by Baker and the EPA study. The actual smoking comparison values were based on government publications describing the risks from asbestos exposure.

The questionnaire used in this study was taken directly from Baker's research. Baker had taken four questions verbatim from the EPA questionnaire, and utilized them as the risk-related response measures. Then, a composite index of risk (threat) perception was created from the questions. The four questions were designed to measure responses related to:

> 1. *Perceived Likelihood*: a 7-point scale assessed subjects' perception of the likelihood of harmful effects from their hypothetical test results. The scale values ranged from 1 = no chance to 7 =certain.
>
> 2. *Perceived Seriousness*: a 6-point scale assessed perceived seriousness, with values ranging from 1 = no risk to 6 = very serious risk.
>
> 3. *Concern*: Concern was measured using a 5-point scale ranging from 1 = not at all concerned to 5 = extremely concerned.
>
> 4. *Fear*: Fear was measured using a 5-point scale ranging from 1 = not at all frightened to 5 = extremely frightened.
>
> 5. *Composite Index of Perceived Threat*: the four items pertaining to perceived likelihood, perceived seriousness, concern, and fear were added together to form a composite index of perceive threat which ranged in value from 4 to 23. (Weinstein et al., 1991: 35-36)

Spector (1991) explains that using a composite index provides the researcher with several advantages . First, it produces scales with good reliability and validity. Second, a composite index is relatively cheap and easy to develop. Finally, a well-devised scale is usually quick and easy for respondents to complete. Furthermore, Weinstein et al. state that the composite index was "developed to provide a more sensitive and reliable response measure, and because these four variables were highly inter-correlated suggesting they tapped the same general dimension" (1991:35-36). It should be noted that the questionnaire utilized in this study did not have a uniform number of choices across each of the questions. The original EPA study did not provide rational for this decision however, Spector asserts that "although there are some minor differences in opinions, generally between five and nine choices are optimal for most questions" (1991:21).

RELIABILITY OF TEST INSTRUMENT

To establish the effectiveness of a test instrument, its reliability must be determined (Spector, 1991). One manner of doing so is with the internal consistency method. Spector explains that "internal consistency reliability is an indicator of how well the individual items of a scale reflect a common, underlying construct" (1991:65). In turn, Cronbach coefficient alpha is the statistic most often used to assess internal consistency. Nunnaly (1978) provides a widely accepted rule of thumb that coefficient alpha should be at least 0.70 for a scale to demonstrate internal consistency. Accordingly, this study adopted this rule in assessing internal consistency, and therefore the reliability of its test instrument. The results of the reliability calculations are provided in Table 4.

TABLE 4. **CRONBACH'S ALPHA AND CORRELATION FOR THE COMPOSITE INDEX**

Cronbach Coefficient Alpha for RAW variables = **0.86**		
Deleted Variables	**Item-Remainder Coefficient**	**Alpha if Variable Removed**
Question 1	0.73	0.82
Question 2	0.58	0.88
Question 3	0.81	0.78
Question 4	0.74	0.81

The overall value of the Cronbach coefficient alpha is 0.86, which satisfies the adopted criterion of 0.70. The item-remainder coefficient values are quite high, ranging from 0.58

to 0.81. These values are similar to those obtained by Baker (1995), where inter-item correlation ranged from 0.69 to 0.78 and coefficient alpha was 0.88 for the composite index. It should be noted, however, that removal of the second question from the scale will slightly raise the coefficient alpha value 0.88. Nevertheless, it can still be concluded that the composite index used in this experiment is a reliable measure of the construct, *Risk Perception.*

DATA COLLECTION

The experimental sessions were conducted over a two week period and consisted of three AFIT PCE acquisition and logistics classes. Each class varied in size: the first had 54 students; the second had 21 students; and the third had 37 students. The three sessions were conducted on two consecutive Thursdays between the hours of 8 a.m. and 11 a.m. The author greeted each class, provided instructions for completing the experiment, and informed the participants of their rights. A detailed script was followed to ensure continuity between sessions. Each participant was also given a brochure which included an informed consent form, the hazard information, a risk ladder or verbal risk comparison, and a short questionnaire. All sections of the brochure were held constant for each subject with the exception of the risk ladder or verbal risk comparison, which was the treatment condition. On average, each participant required 15 minutes to complete the entire experiment.

The process of randomly assigning participants to treatment conditions was accomplished with the aid of a random number table. Each of the eight treatments was assigned a number ranging from one to eight. Using the random number table, one of the eight treatment conditions was chosen, assigned to a subject, then withdrawn from the pool. This process was followed until the last treatment was picked by default. The next set of eight participants were assigned treatments in the same manner, until every participant had a treatment condition.

Keppel explains that randomly assigning treatment conditions will "guarantee that each of the treatment conditions is equally likely to be assigned to a given subject and to whatever other uncontrolled factors that might be present during any period of testing" (1991:16). Therefore, the critical features of random assignment are that each subject-treatment combination is equally likely to be assigned to any one of the eight treatments, and that the assignment of each subject is independent of the others.

DATA ANALYSIS

This study applied a completely randomized, 2 x 2 x 2 full factorial design. Each of the 112 participant experienced only one of the eight treatments. Analysis of Variance (ANOVA) was used to make inferences about the dependent variable, while post hoc F-tests were performed to evaluate significant interactions. Finally, independent samples t-tests were run to make judgments about the demographic information collected. An overall family level of significance of $\alpha = 0.05$ was used for all calculations. This assures that there will be only 1 chance in 20 of finding significance, when in fact it is not present. All calculations were performed using SAS on a VAX Model 6000-420 and the Student Edition of Statistix Version 1.0.

Prior to using the ANOVA procedure for inferential purposes, the following three assumptions must be met: independence of observations; homogeneity of variance; and normally distributed treatment populations (Keppel, 1991). The assumption of independence means that each observation is in no way related to any other observations in the experiment. In this study, the requirement for independence of observations was satisfied by randomly assigning subjects to each treatment condition, and by testing each subject individually. Next, the assumption for homogeneity of variance was determined by using the Hartley test (Keppel, 1991:102). This test is based solely on the ratio of the largest treatment variance to the smallest treatment variance. A test statistic value near 1 support the claim of homogeneity, while a large value tend to discredit the claim. Finally, the Wilk-Shapiro/Rankit Plot procedure was utilized to examine whether the dependent variable conformed to the normality assumption (Conover, 1980:363). In the procedure, a Rankit Plot of the dependent variable is produced, and an approximate Wilk-Shapiro normality statistic is calculated. A statistic value near 1 and a relatively straight 45 degree line for the Rankit Plot are indications of normality. Since Wilk-Shapiro statistic tables seem to approach a limit at sample sizes above fifty, this study will utilize the critical value of 0.947 ($N = 50$, $\alpha = 0.05$) as its criterion point for normality.

The underlying linear model used for the three-factor ANOVA procedure is provided below:

$$Y_{ijkl} = \mu_{ijk} + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \varepsilon_{ijkl}$$

where

Y_{ijkm}	=	an observation in the experiment
μ_{ijk}	=	the overall mean of the population
α_i, β_j, and γ_k	=	the average treatment effects at levels a_i, b_j, and c_k, respectively
$(\alpha\beta)_{ij}$, $(\alpha\gamma)_{ik}$, and $(\beta\gamma)_{jk}$	=	the average interaction effects at a_ib_j, a_ic_k, and b_jc_k, respectively
$(\alpha\beta\gamma)_{ijk}$	=	the three-way interaction effect at cell $a_ib_jc_k$
ε_{ijkl}	=	the experimental error associated with each observation

As the above model illustrates, for a three-factor ANOVA procedure there are seven potential tests which are simultaneously performed. Namely, the three main effect terms and the four interaction terms are examined. So in order to maintain the overall family level of significance at $\alpha = 0.05$, it is necessary to invoke the Kimball inequality: $\alpha = 1 - (1 - \alpha_i)^N$ (Neter et al., 1990:841). Solving the equation with $N = 7$ and $\alpha = 0.05$, finds that $\alpha_i = 0.0073$. Thus, a significance level of $\alpha_i = 0.0073$ must be used for each of the seven tests to ensure that the overall family level of significance will not exceed 0.05.

SUMMARY

This study consisted of an experiment designed to determine if the presence of a risk ladder, time interval comparison, and smoking comparison affected an individual's perceived risk. The experiment used a completely randomized, 2 x 2 x 2 full factorial design. The dependent variable for the study was the construct *Risk Perception*, while the independent variables were *Risk Ladder*, *Time Comparison*, and *Smoking Comparison.* Each independent variable was either absent or present for a particular treatment condition. There were 14 subjects per treatment for a total of 112 participants. Finally, the experimental results were analyzed using ANOVA procedures and independent samples t-tests.

IV. Findings and Analysis

This chapter presents the data obtained from the experiment and an analysis of the results. The study utilized a completely randomized, 2 x 2 x 2 full factorial design. The independent variables in the research were *Risk Ladder*, *Time Comparison*, and *Smoking Comparison*. Each variable consisted of two levels, absent and present. Every subject was exposed to only one of the eight treatments, with 14 subjects assigned to each treatment condition.

Appendices C & D contain the complete results of the experiment. Specifically, Appendix C contains the raw data and descriptive statistics for each treatment. Appendix D provides the actual SAS and Statistix output for the ANOVA and t-test tables included in this chapter.

Initial Analysis

Descriptive statistics by treatment condition and by factor are provided in Tables 5 & 6, respectively. The minimum value any one participant could score on the composite index was four, and the maximum value was twenty-two. By the quantity of composite scores above 20, it is apparent that many participants felt very threatened by the scenario presented in the brochure. Of particular interest is the 2nd treatment which generated the highest mean score (17.79), and the 6th treatment which received the lowest score (14.07). Both treatment conditions provided participants with solely the smoking risk comparison, however the 6th treatment provided the information within the constructs of a risk ladder.

TABLE 5. **DESCRIPTIVE STATISTICS BY TREATMENT**

Treatment	Ladder	Time	Smoke	Size	Mean	Standard Deviation	Max	Min
1	Absent	Absent	Absent	14	16.93	2.62	21	12
2	Absent	Absent	Present	14	17.79	2.91	22	12
3	Absent	Present	Absent	14	16.00	2.75	20	12
4	Absent	Present	Present	14	16.86	2.63	21	12
5	Present	Absent	Absent	14	14.50	3.16	20	11
6	Present	Absent	Present	14	14.07	3.67	21	8
7	Present	Present	Absent	14	14.21	3.98	21	9
8	Present	Present	Present	14	16.29	4.03	21	8

TABLE 6. **DESCRIPTIVE STATISTICS BY FACTOR LEVEL**

Factor	Level	Size	Mean	Standard Deviation	Max	Min
Ladder	Absent	56	16.89	2.73	22	12
	Present	56	14.77	3.73	21	8
Time	Absent	56	15.82	3.42	22	8
	Present	56	15.84	3.46	21	8
Smoke	Absent	56	15.41	3.28	21	9
	Present	56	16.25	3.54	22	8

ANOVA ASSUMPTIONS

As detailed in the Methodology Chapter, ANOVA has three basic underlying assumptions: independence of observations; homogeneity of variance; and normally distributed treatment populations. The assumption of independence was satisfied by randomly assigning subjects to each treatment condition. Next, homogeneity of variance was tested using the Hartley test. The observed value of the H statistic was $H_{observed}$ =

2.37, with the critical value calculated at $H_{critical}$ (0.95, 8, 13) = 6.01. Therefore, since $H_{observed} \leq H_{critical}$, it was concluded that the variances of each treatment group were equal. Finally, the normality assumption was verified by performing a Wilk-Shapiro plot of the residuals (Figure 3).

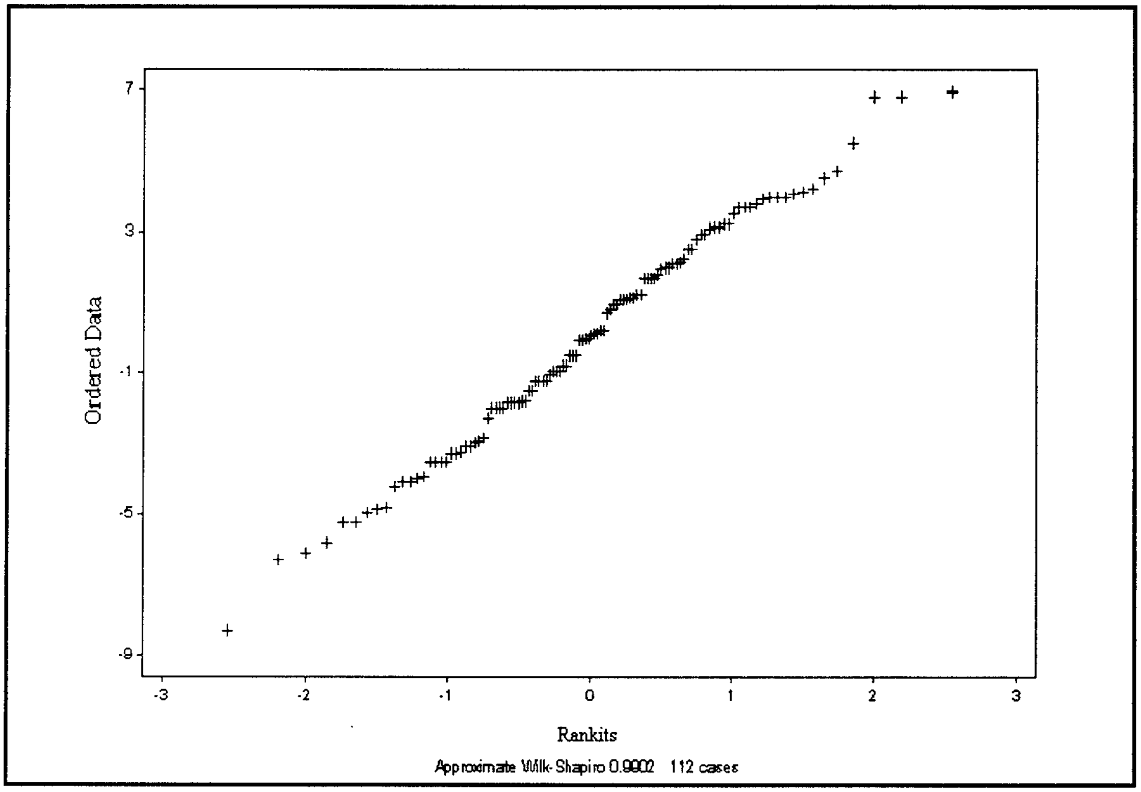

FIGURE 3. **WILK-SHAPIRO NORMALITY PLOT OF THE RESIDUALS**

The approximate Wilk-Shapiro normality statistic for the residual values is 0.99, which is above the 0.947 criterion point for normality. Moreover, the Rankits Plot is a relatively straight 45 degree line. In Figure 4, the residual values were displayed using a histogram with a normal distribution plot overlaid, to further validate the assertion of normality.

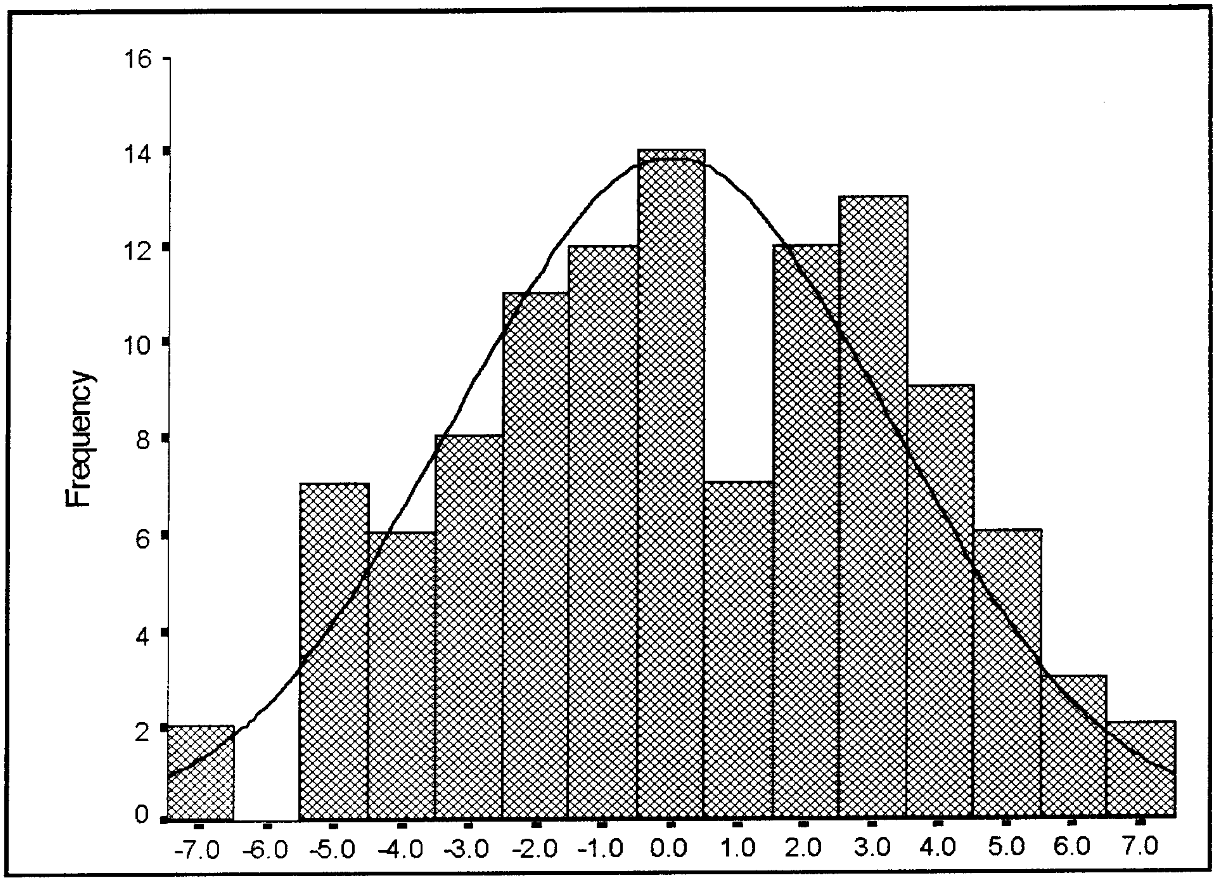

FIGURE 4. **HISTOGRAM OF THE RESIDUALS**

HYPOTHESIS TESTING

This section describes the results of the statistical tests used to answer the research questions established in Chapter I. The research questions and their statistical hypotheses are:

1. Does the presence of a risk ladder affect risk perception?

H_o: $\mu_{L\text{-absent}} = \mu_{L\text{-present}}$
(There is no difference between the risk ladder means.)

H_a: $\mu_{L\text{-absent}} \neq \mu_{L\text{-present}}$
(There is a difference between the risk ladder means.)

2. Does a time interval comparison affect risk perception?

H_o: $\mu_{T\text{-absent}} = \mu_{T\text{-present}}$
(There is no difference between the time interval means.)

H_a: $\mu_{T\text{-absent}} \neq \mu_{T\text{-present}}$
(There is a difference between the time interval means.)

3. Does a smoking comparison affect risk perception?

H_o: $\mu_{S\text{-absent}} = \mu_{S\text{-present}}$
(There is no difference between the smoking means.)

H_a: $\mu_{S\text{-absent}} \neq \mu_{S\text{-present}}$
(There is a difference between the smoking means.)

The results of the three-factor ANOVA on the dependent variable *Risk Perception* are provided in Table 7. The significance level for each test within the ANOVA procedure is set a $\alpha_i = 0.0073$ to ensure an overall family significance level of 0.05.

TABLE 7. **SUMMARY OF ANOVA RESULTS**

Source	***df***	***SS***	***MS***	***F***	***p***
Ladder	1	126.437	126.437	11.86	0.0008*
Time	1	0.009	0.009	0.0	0.9770
Smoke	1	19.723	19.723	1.85	0.1767
Ladder x Time	1	25.080	25.080	2.35	0.1281
Ladder x Smoke	1	0.009	0.009	0.0	0.9770
Time x Smoke	1	10.937	10.937	1.03	0.3134
Ladder x Time x Smoke	1	10.937	10.937	1.03	0.3134
Error	104	1108.643	10.660		
Total	111	1301.777			

* *Denotes significance at p < 0.0073*

Prior to making inferences concerning the three research questions, it must initially be determined whether interaction effects are present. Keppel explains that "an interaction is present when the pattern of differences associated with an independent variable changes at the different levels of the other independent variables" (1991:196). The first level of interaction effect to be examined is the three-factor term, *Ladder x Time x Smoke*. Table 7 indicates that the observed value for the F statistic was $F_{observed} = 1.03$, with the critical value calculated at $F_{critical}$ (0.9927, 1, 104) = 7.49. Therefore, since $F_{observed} \leq F_{critical}$, it can be reasoned that the factors *Ladder*, *Time*, and *Smoke* do not interact significantly. In a similar manner, the 3 two-factor interactions were also tested. The observed F statistic values for each interaction were compared to the critical value of 7.49. In each case, the observed values were much smaller than the critical value. Consequently, this evaluation can assert that there are no two-factor or three-factor interaction effects that significantly affect the dependent variable *Risk Perception*.

Now understanding that there are no significant interaction effects, a proper assessment of the research questions can be conducted. The first research question addressed the impact of a risk ladder on risk perception. As illustrated in Figure 5, when the risk ladder was absent the mean score for risk perception was 16.89, but when it was present the score decreased to 14.77. To determine whether this difference was significant, the observed value of the F statistic ($F_{observed} = 11.86$) was compared with the critical value ($F_{critical} = 7.49$). Since $F_{observed} \geq F_{critical}$, the null hypothesis for the first research question is rejected, resulting in the acceptance of the alternative hypothesis. The results indicate that the presence of a risk ladder decreases the perception of risk below those elicited by the absence of a risk ladder. Therefore, the presence of a risk ladder does significantly affect risk perception.

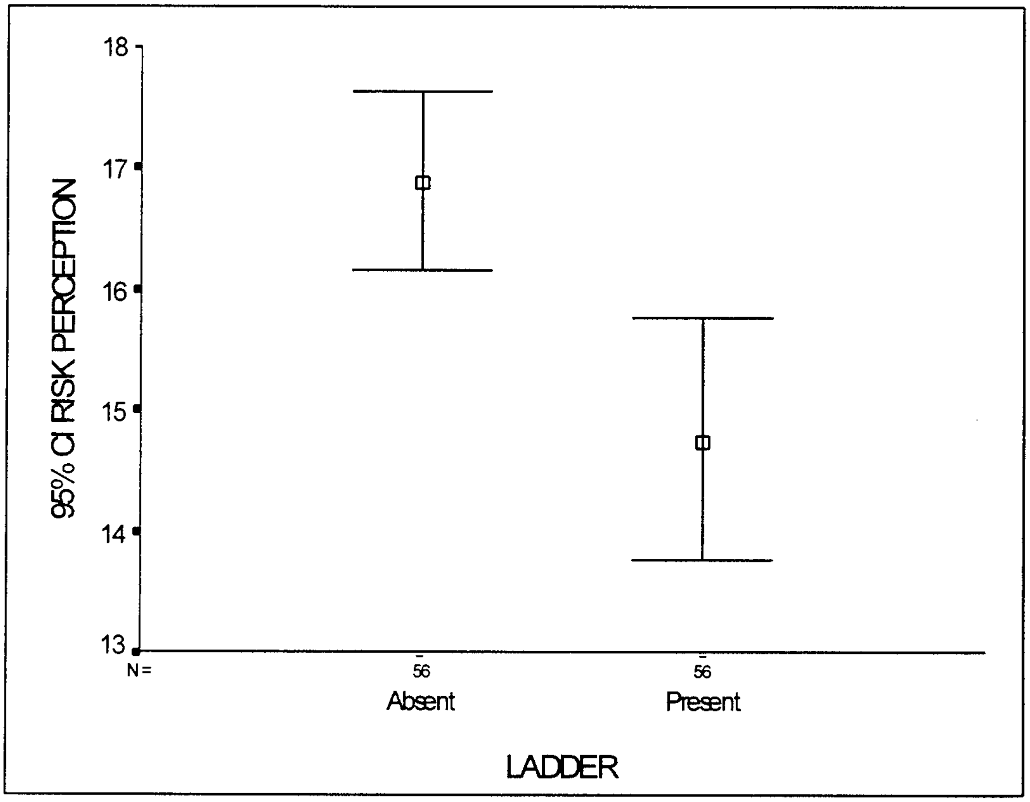

FIGURE 5. **95% CONFIDENCE INTERVAL FOR MEAN SCORE AS A FUNCTION OF LADDER**

The second research question was concerned with how a time interval comparison might affect risk perception. Figure 6 shows that the mean score for the time comparison being absent (15.82) is almost identical to the score obtained when present (15.84). Moreover, the observed F statistic (0.0) is much less than the critical value (7.49) which indicates that the null hypothesis cannot be rejected. Consequently, these results indicate that a time interval comparison does not significantly affect an individual's risk perception.

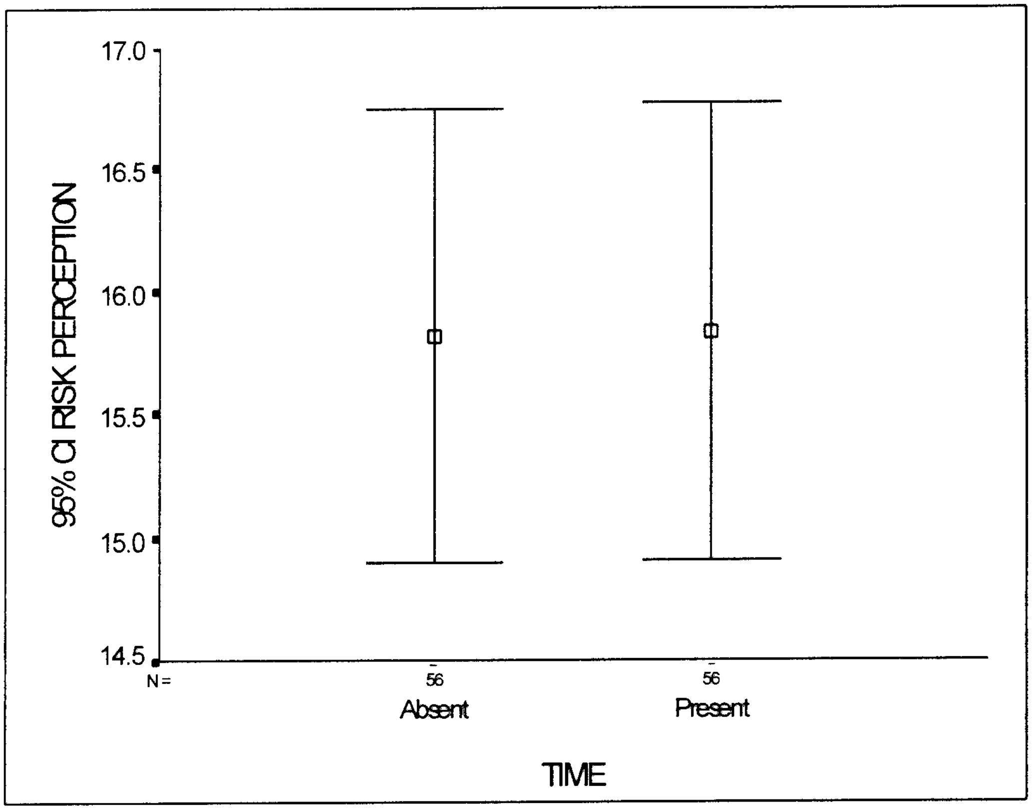

FIGURE 6. **95% CONFIDENCE INTERVAL FOR MEAN SCORE AS A FUNCTION OF TIME**

The final research question dealt with the presence of a smoking comparison. Figure 7 is used to demonstrate that when the smoking comparison is present its mean score for risk perception (16.25) is slightly increased above that attained when the comparison is absent from the experiment (15.41). However, the observed F statistic (1.85) was found to be lower than the critical value (7.49). Therefore, the null hypothesis for this third research question cannot be rejected, resulting in the conclusion that risk perception is not significantly affected by a smoking comparison.

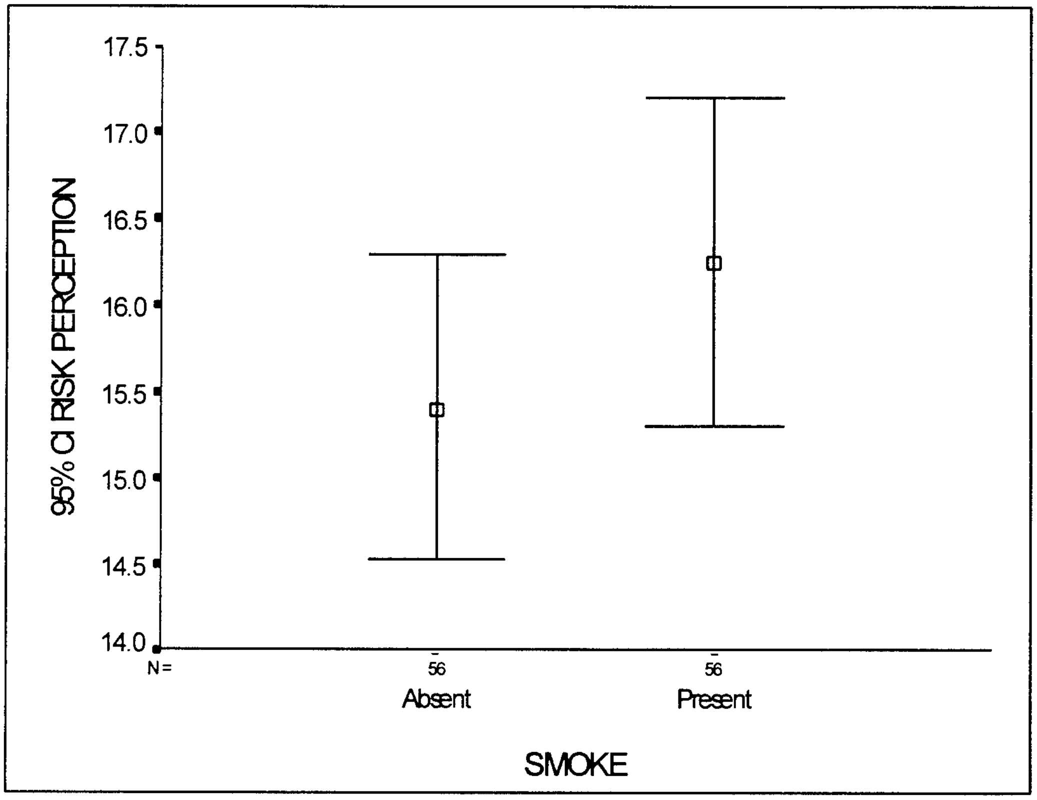

FIGURE 7. **95% CONFIDENCE INTERVAL FOR MEAN SCORE AS A FUNCTION OF SMOKE**

POST HOC ANALYSIS

It has been well documented that factors such as gender, age, and education affect an individual's risk perception just as much as risk magnitudes (Covello et al., 1988; Ontani et al., 1992; Campbell and Stewart, 1992). Accordingly, it is appropriate to determine if these factors in any way impacted the scores of risk perception in this experiment. In addition to the factors already mentioned, the factor of smoking habit (non-smoker vs. smoker) will also be evaluated to check for possible bias from the smoking comparisons used in the study.

The variable of gender was examined using a two sample t-test. The results of which are contained in Table 8. Although the samples are not equal in size, they were able to pass the test for equal variances. The mean composite score for females was larger than that of males, however the p-value of 0.19 indicates this difference is not notable at a significance level of 0.05. Therefore, it can be concluded that gender did not significantly affect risk perception.

TABLE 8. **INDEPENDENT T-TEST FOR GENDER**

Gender	Size	Mean	Standard Deviation	Standard Error
Male	92	15.63	3.46	0.36
Female	20	16.75	3.19	0.71
$p = 0.19$ (Equal Variances)				

The two sample t-test was also implemented to test the smoking habit factor. In this case, the dramatically large difference in sample sizes cause unequal variances to exists. Therefore, a t-test for unequal variances was conducted and its results are seen in Table 9. Although the mean perceived risk for smokers was quite a bit lower than that of non-smokers, the p-value of 0.25 indicates that it is not significant. Therefore, smoking habit did not significantly affect the scores for perceived risk.

TABLE 9. **INDEPENDENT T-TEST FOR SMOKING HABIT**

Gender	Size	Mean	Standard Deviation	Standard Error
Non-Smoker	105	15.98	3.27	0.32
Smoker	7	13.57	4.99	1.89
$p = 0.25$ (Unequal Variances)				

The variables of education and age each involved more than two samples, therefore 2 one-way ANOVA's were performed with results provided in Tables 10 & 11.

TABLE 10. **ONE-WAY ANOVA FOR EDUCATION**

Source	*df*	*SS*	*MS*	*F*	*p*
Between	4	14.73	3.68	0.31	0.87
Within	107	1287.05	12.03		
Total	111	1301.78			

TABLE 11. **ONE-WAY ANOVA FOR AGE**

Source	*df*	*SS*	*MS*	*F*	*p*
Between	4	53.27	13.32	1.14	0.34
Within	107	1248.51	11.67		
Total	111	1301.78			

The education factor resulted in a p-value of 0.87, which is well above the significance level of 0.05. Likewise, the age factor's p-value was large at 0.34. Consequently, it can be concluded that education and age did not affect the risk perception of the subjects.

SUMMARY

ANOVA procedures and t-tests were utilized to assess the impact of several experimental treatment conditions on risk perception. Specifically, a three-factor ANOVA was performed to determine the main and interaction effects of the factors *Risk Ladder*, *Time Interval Comparison*, and *Smoking Comparison* on the dependent variable *Risk Perception.* Additionally, t-tests and one-way ANOVA's were utilized to determine the influence of several demographic factors on perceived risk. The criterion level for statistical significance was set at 0.05 for all tests. Key findings are summarized below:

1. There are no significant three-factor or two-factor interactions between the main effects *Ladder*, *Time*, and *Smoke*. In other words, the main effect factors do not significantly interact to affect risk perception.

2. The main effect *Ladder* is a significant factor. Subjects who received a risk ladder had significantly lower perceptions of risk than those without a risk ladder. However, the main effects *Time* and *Smoke* were found to be not significant.

3. A Post Hoc analysis revealed that the demographic factors of gender, smoking habit, education, and age were all not significant in affecting risk perception of subjects.

V. Conclusions and Recommendations

Introduction

The purpose of risk communications is to alert people when they should be altered, and to soothe peoples' concerns when their concerns should be soothed. However, communicating risk magnitudes to the public is not an easy task. Risk messages commonly convey qualitative information that is unfamiliar and difficult for the public to comprehend. These "magnitudes and risk estimates are not easily understood without benchmarks or points of reference, and providing careful comparisons can help people understand this information" (NRC, 1989:96).

In an attempt to present risk comparisons in a manner that is understandable to the public while still accurate, researchers have investigated a number of presentation formats. Of those formats, the most encouraging is the risk ladder. Many researchers believe that risk ladders have proven to be an effective tool for communicating risk magnitudes, however they are not without their problems. Yet, these problems primarily stem from the lack of empirical research available on its various attributes.

Accordingly, this research examined risk ladders as a presentation format, and tested their effectiveness in communicating an imaginary hazard called fibronite. Specifically, this study evaluated the following three attributes: (1) presence of a risk ladder; (2) presence of a time interval comparison; and (3) presents of a smoking comparison. Of these attributes, only the risk ladder factor was shown to significantly affect risk perception.

RISK LADDER EFFECT

It should not be surprising to learn that the presence of a risk ladder significantly affects an individual's perceived risk. The risk ladder is a unique tool that is able to convey vital risk comparison information, while at the same time placing this information within an understandable perspective. Although this experiment succeeded in verbally translating the risk comparison contained in the ladder, it was unable to verbally provide subjects with the perspective aspect. Consequently, it was probably this missing element which caused participants without ladders to perceive a significantly higher level of risk. This is illustrated by noting that the mean composite score for the 2nd treatments condition (Ladder absent, Time absent, Smoking present) was the highest (17.79) in the experiment, while the mean score for the 6th treatment (Ladder present, Time absent, Smoking present) was the lowest (14.07). As is evident, the only distinction between theses two particular treatment conditions was that one consisted of a verbal risk comparison and the other had a risk ladder, yet this difference was able to generate scores at both ends of the spectrum. However, perhaps a more telling test of the risk ladder's influence would have been to include the verbal risk comparisons along with an established action standard. This would enable communicators to verbally capture some of the perspective which is lost without a graphical image.

TIME INTERVAL EFFECT

This experiment was unable to duplicate the findings of Weinstein et al. (1996). The time interval comparison produced essentially no effect. The mean scores for when the comparison was absent (15.82) was identical to the score when present (15.84). Perhaps individuals did not fully comprehend, or were not accustomed to risks being portrayed in terms of time. Either way, the time interval comparison had no significant affect on risk perception.

SMOKING EFFECT

The experiment found the added smoking comparison attribute to be not significant in affecting risk perception. This result was unanticipated considering the dominating number of non-smokers who participated in this study. With all the information available on the hazardous effects of cigarette smoking, common sense would lead one to assume that a smoking comparison would elevate the risk perception of at least non-smokers. Even a Post Hoc analysis of smoker vs. non-smoker, revealed no significant difference in risk perception. Of course, this latter finding may be slightly tainted because of the limited sample size of smokers (7). An analysis of the raw data reveals that only two of the seven regular smokers received treatments with smoking comparisons. Interestingly, those two individuals both provided the lowest composite score (8) for risk perception in this experiment. Perhaps a sample more representative of the smoking community would have generated different results. Nevertheless, the findings from this experiment indicate that the smoking comparison did not notably affect the participants' perceived risk.

RECOMMENDATIONS

Presentation formats are a useful means of communicating risk magnitudes to the public. Accordingly, risk communicators should develop formats with regard to their attributes and known effects on perception. This study has empirically shown that the presence of a risk ladder notably affects the risk perception of individuals. Therefore, communicators should consider utilizing risk ladders to effectively convey hazard information. This understanding should be coupled with the particular attribute findings from Baker's (1995) risk ladder study. Specifically, Baker found that risk communicators should always include an action standard whenever possible, and that they should be aware of the locational effect inherent in a risk ladder design. By utilizing the results of this research and that of Baker, it is hoped that the discontinuity between expert views and public perceptions of risk will be significantly reduced.

FURTHER RESEARCH

The possibilities for further research in the area of risk presentation are endless. In fact, most of the efforts in graphics research have been accomplished only within the last decade. One prospect would be to do a similar study as this one, but examining a different set of risk ladder attributes. As mentioned earlier, an action standard could be added to the verbal risk comparison, or a new comparisons could be added to the risk ladder. Another study might determine when two risks are similar enough in nature to be compared without misleading or confusing the public. Many times it is difficult for communicators to find equivalent risks that can be compared without misrepresenting or undermining the risk hazard. Finally, a study could be performed to evaluate whether right-brain dominant people process graphical information differently from those who are left-brain dominant. A short personality test could be administered prior to the experiment to assign participants into specified treatment conditions.

In conclusion, the need exists for more study in the area of risk presentations. As more empirical research is conducted and a better understanding is achieved, risk communicators will be able to more effectively and more accurately portray risk hazards to the public. In turn, this successful transmittal of information will empower the public by providing them with the knowledge needed to make crucial health decisions.

APPENDIX A: EXPERIMENTAL INSTRUMENT

Thank you for participating in this study. The purpose of this research is to examine presentation formats and perceived risk. You will be asked to read a short brochure about a health hazard. In the brochure you will be given an *imaginary* test result. This *imaginary* test result will be used to answer a few questions. The entire task will take approximately 10 minutes. If you have any questions before, during or after the test please notify the experimenter.

As a participant in this experiment you have certain rights. The purpose of this document is to make you aware of your rights and to obtain your informed consent to certify your willingness to participate in this research study. You will not be paid for your participation.

1) You have the right to stop participating in this experiment at any time. If you decide to do so, you should notify the experimenter immediately.

2) You have the right to personal privacy. All information you provide will be held in the strictest confidence and your identity will remain anonymous.

3) You have the right to be informed of the overall results of the experiment. If you wish to receive information about the results, a summary of the overall results of the experiment will be made available to you upon request free-of-charge. You may request a summary of results by including your address below your signature on the informed consent form and results will be sent to you after all data have been collected and analyzed.

If you have any questions please feel free to contact Captain Steve Dinzart or Dr. Kim Campbell at the Air Force Institute of Technology, Wright-Patterson AFB, OH, or call (937) 255-7777 ext 3354.

CONSENT STATEMENT

I have read the above information and understand that participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled and I may discontinue participation at any time without penalty or loss of benefits to which I am entitled. My signature below means that I have freely agreed to participate in this research study.

____

Signature

If you wish to receive the overall results of this study, please provide your address below:

INSTRUCTIONS

Pretend that you have just had your residence tested for a new type of hazard called **FIBRONITE**. The testing company tells you that you have a reading of **120 fibers per liter**. Please read all the information contained in the following brochure, then use your fibronite test result to complete the feedback questionnaire at the end of the brochure.

WHAT IS FIBRONITE ?

Fibronite is a mineral fiber found in rocks. There are several kinds of fibronite fibers, all of which are fire-resistant and not easily destroyed by natural processes. Because of its desirable qualities, fibronite has been used in a wide variety of products including appliances, ceilings, wall and pipe coverings, floor tiles, and some roofing materials.

WHY THE CONCERN ABOUT FIBRONITE ?

Although fibronite has many benefits for humans, it is also a very dangerous mineral. Breathing airborne fibronite fibers has been shown to cause: **(1)** Mintosis - a serious lung disease which can lead to disability and death; **(2)** Lung cancer - a disease that is incurable and almost always fatal; and **(3)** Mesothelioma - cancer of the lining of the lungs or abdominal cavities. The greater the exposure to fibronite, the more likely it is that one of these serious diseases will develop. Workers who handle or come into contact with fibronite on a daily basis are open to the greatest health risks.

HOW DOES FIBRONITE AFFECT US?

The danger arises when the fibronite fibers are released from the product or material. These fibers are so small they cannot be seen. They can float in the air for a long time and can pass through the filters of normal vacuum cleaners and get back into the air. Once inhaled, fibronite fibers can become lodged in tissue for a long time. After many years cancer or mintosis can develop. Cigarette smoking combined with fibronite exposure is especially hazardous.

Fibronite found in "friable" materials is most dangerous. Friable materials are materials that can be crumbled, pulverized, or reduced to powder by hand pressure. Materials containing fibronite which are sprayed on ceilings and walls are examples of friable materials. In contrast, vinyl fibronite floor tile is not usually friable. The fibronite fibers are firmly bound or sealed into the tile and can be released into the air only if the tile is cut, ground, or sanded.

WHERE IS FIBRONITE LIKELY TO BE FOUND IN THE HOME?

Having significant amounts of fibronite in a residence is not rare. The following areas in the home are where fibronite problems are most likely to arise:

- Wall construction material and pipe insulation, especially those dating from 1932-1968.
- Friable ceilings in buildings built or remodeled between 1940 and 1970.
- Material found in stoves and furnaces such as insulation and door gaskets.

Other fibronite-containing products that you may find in the home include:

- Patching compounds and textured paints (applied prior to 1967)
- Vinyl floor tiles and flooring.
- Roofing, shingles, and siding.
- Appliances with fibronite-containing parts or components, such as toasters, broilers, slow cookers, dishwashers, refrigerators, ovens, ranges, and clothes dryers.

HOW CAN I TELL IF I HAVE FIBRONITE IN MY RESIDENCE?

People who have worked frequently with fibronite (such as plumbers, and building or heating contractors) can often tell you whether or not material contains fibronite by looking at it. If you suspect that you have a problem, you may also want to have an air sample taken to measure the number of fibronite fibers circulating inside your residence. To collect the sample, a laboratory will send a technician to your home. A pump is used to draw air from the room into a filter that will trap the fibronite. An electron microscope is used to count the sample. The test costs between $100 and $500, depending upon the laboratory technique used. The results of the test can be reported in units of "fibers per liter of air." This unit tells how much fibronite there is in one liter of air.

WHAT SHOULD I DO IF I HAVE A FIBRONITE PROBLEM?

If you discover that you have a fibronite problem, the best thing to do is to contact a contractor who has experience in the proper procedures for repairing and removing fibronite. There are special guidelines for handling fibronite materials. It is highly recommended that you hire an experienced contractor or get professional advice if you are thinking of doing the work yourself. Using improper techniques can make an existing problem much worse by contaminating the entire residence. For more information about identifying, testing, handling, and fixing fibronite problems call the Ohio Department of Health at (937) 285-6250.

"ONE OF THE EIGHT

TREATMENT CONDITIONS

WOULD APPEAR

ON THIS PAGE"

FEEDBACK QUESTIONNAIRE

Please choose one and only one answer for each question, then mark your response on the provided answer sheet. If none of the answers match your exact response, mark the one that best matches how you feel. There are no right or wrong answers.

Note that it is important for you to answer these questions realistically, as if you had actually received the fibronite test result. Feel free to refer back to the brochure when answering these questions.

001. How would you describe the danger from your imaginary fibronite level?

1 - no danger
2 - very slight danger
3 - slight danger
4 - moderate danger
5 - serious danger
6 - very serious danger

002. How likely do you think it is that continued exposure to your imaginary fibronite level would eventually have harmful effects? (Even though you may feel uncertain, please choose an answer to tell us what impression you got from the information you read.)

1 - no chance
2 - very unlikely
3 - unlikely
4 - moderate chance
5 - likely
6 - very likely
7 - certain to happen

003. How much concern do you think you would feel if your own residence actually had the fibronite level found by the imaginary test?

1 - not at all concerned
2 - slightly concerned
3 - concerned
4 - very concerned
5 - extremely concerned

004. How much fear do you think you would feel if your residence actually had the fibronite level found by the imaginary test?

1 - not at all frightened
2 - slightly frightened
3 - frightened
4 - very frightened
5 - extremely frightened

005. What is your sex?

1 - male
2 - female

006. Are you a regular smoker?

1 - no
2 - yes

007. What is your classification?

1 - civilian
2 - enlisted
3 - officer

008. What is your age group?

1 - less than 20 years old
2 - 20 to 30 years old
3 - 31 to 40 years old
4 - 41 to 50 years old
5 - 51 to 60 years old
6 - over 60 years old

009. What is your highest level of education?

1 - high school
2 - bachelor's degree (BA, BS, or equivalent)
3 - some graduate studies, but no master's degree
4 - master's degree or equivalent
5 - doctoral degree (PhD, JD, DBA, or equivalent)

For categorizing purposes, please do the following:

010. Darken circle **1**.

011. Darken circle **1**.

O12. Darken circle **1**.

Thank you, again, for your participation in this study. We must inform you that fibronite is an imaginary hazard created solely for the purposes of this study. Most of the information about fibronite which you read was taken from a brochure on asbestos. If you would like more information about the hazards associated with asbestos, you can contact the Department of Health in your state, the Environmental Protection Agency, or the National Institute for Environmental Health & Safety at 1-800-NIEHS-94.

APPENDIX B: EXPERIMENTAL TREATMENT CONDITIONS

TREATMENT 1

INTERPRETING YOUR TEST RESULT

To assist you in understanding the magnitude of your risk, the following comparison can be made:

> Out of every 1000 individuals who live in a residence where fibronite levels are at 120 fibers per liter, it is expected that 25 people will die of fibronite related cancer.

<u>TREATMENT 2</u>

INTERPRETING YOUR TEST RESULT

To assist you in understanding the magnitude of your risk, the following two comparisons can be made:

1) Out of every 1000 individuals who live in a residence where fibronite levels are at 120 fibers per liter, it is expected that 25 people will die of fibronite related cancer.

2) An individual who smokes 10 cigarettes per day has the same cancer risk as one who lives in a residence containing a fibronite level of 120 fibers per liter.

TREATMENT 3

INTERPRETING YOUR TEST RESULT

To assist you in understanding the magnitude of your risk, the following two comparisons can be made:

1) Out of every 1000 individuals who live in a residence where fibronite levels are at 120 fibers per liter, it is expected that 25 people will die of fibronite related cancer.

2) In a community of 1000 people, it is expected that every 3 years one resident will die of cancer as a result of living in a residence with fibronite levels of 120 fibers per liter.

TREATMENT 4

INTERPRETING YOUR TEST RESULT

To assist you in understanding the magnitude of your risk, the following three comparisons can be made:

1) Out of every 1000 individuals who live in a residence where fibronite levels are at 120 fibers per liter, it is expected that 25 people will die of fibronite related cancer.

2) In a community of 1000 people, it is expected that every 3 years one resident will die of cancer as a result of living in a residence with fibronite levels of 120 fibers per liter.

3) An individual who smokes 10 cigarettes per day has the same cancer risk as one who lives in a residence containing a fibronite level of 120 fibers per liter.

Treatment 5

INTERPRETING YOUR TEST RESULT

Fibronite level (fibers/liter)	Extra Cancer Deaths (out of 1000 people)
2000	400 in 1000
1000	200 in 1000
500	100 in 1000
250	50 in 1000
120	25 in 1000
60	12 in 1000
30	6 in 1000
15	3 in 1000
8	1.5 in 1000

Your test result → (pointing at 120)

<u>**TREATMENT 6**</u>

INTERPRETING YOUR TEST RESULT

	Fibronite level (fibers/liter)	Extra Cancer Deaths (out of 1000 people)	Comparison to Smoking Risk
	2000	400 in 1000	8 packs/day
	1000	200 in 1000	
	500	100 in 1000	2 packs/day
	250	50 in 1000	
Your test result →	120	25 in 1000	10 cigarettes/day
	60	12 in 1000	
	30	6 in 1000	2 ½ cigarettes/day
	15	3 in 1000	
	8	1.5 in 1000	½ cigarette/day

TREATMENT 7

INTERPRETING YOUR TEST RESULT

Your test result → 120

Fibronite level (fibers/liter)	Extra Cancer Deaths (out of 1000 people)	Comparison to Frequency of Extra Cancer Deaths in a town of 1000 people
2000	400 in 1000	1 every 2 months
1000	200 in 1000	1 every 4 months
500	100 in 1000	1 every 8 months
250	50 in 1000	1 every 1 ½ years
120	25 in 1000	1 every 3 years
60	12 in 1000	1 every 6 years
30	6 in 1000	1 every decade
15	3 in 1000	1 every 2 ½ decades
8	1.5 in 1000	1 every 5 decades

TREATMENT 8

INTERPRETING YOUR TEST RESULT

	Fibronite level (fibers/liter)	Extra Cancer Deaths (out of 1000 people)	Comparison to Frequency of Extra Cancer Deaths in a town of 1000 people	Comparison to Smoking Risk
	2000	400 in 1000	1 every 2 months	8 packs/day
	1000	200 in 1000	1 every 4 months	
	500	100 in 1000	1 every 8 months	2 packs/day
	250	50 in 1000	1 every 1 ½ years	
Your test result →	120	25 in 1000	1 every 3 years	10 cigarettes/day
	60	12 in 1000	1 every 6 years	
	30	6 in 1000	1 every decade	2 ½ cigarettes/day
	15	3 in 1000	1 every 2 ½ decades	
	8	1.5 in 1000	1 every 5 decades	½ cigarette/day

APPENDIX C: RAW DATA AND DESCRIPTIVE STATISTICS

The SAS System

OBS	Q1	Q2	Q3	Q4	GENDER	REGULAR	ORG	AGE	SCHOOL	LADDER	TIME	SMOKE	QSUM
1	5	5	4	4	1	1	1	5	2	1	1	1	18
2	4	4	5	5	1	1	1	4	4	1	1	1	18
3	4	3	3	3	1	2	2	3	1	1	1	1	13
4	5	6	5	5	2	2	1	3	1	1	1	1	21
5	6	4	5	5	1	1	3	3	2	1	1	1	20
6	3	3	3	3	1	1	1	4	2	1	1	1	12
7	5	5	3	3	1	1	1	4	2	1	1	1	16
8	3	3	4	4	1	1	3	2	2	1	1	1	14
9	5	6	4	4	1	1	3	2	3	1	1	1	19
10	4	5	4	4	1	1	3	3	4	1	1	1	17
11	4	6	4	5	1	1	3	3	3	1	1	1	19
12	5	4	3	4	1	1	1	3	2	1	1	1	16
13	3	5	4	4	2	1	1	5	4	1	1	1	16
14	5	5	4	4	1	1	1	3	3	1	1	1	18
15	4	6	3	3	1	1	3	3	3	1	1	2	16
16	4	3	5	5	1	1	1	4	4	1	1	2	17
17	5	5	4	4	1	1	1	2	4	1	1	2	18
18	5	6	3	3	1	1	1	3	2	1	1	2	17
19	3	4	3	3	2	1	1	3	2	1	1	2	13
20	5	6	4	4	1	1	2	3	2	1	1	2	19
21	4	6	4	4	2	1	2	3	1	1	1	2	18
22	5	6	5	5	1	1	3	3	2	1	1	2	21
23	4	4	4	4	1	1	2	3	1	1	1	2	16
24	3	3	3	3	1	1	3	3	4	1	1	2	12
25	5	7	5	5	1	1	1	5	2	1	1	2	22
26	6	5	5	5	1	1	3	2	4	1	1	2	21
27	6	5	5	4	1	1	1	3	3	1	1	2	20
28	5	6	4	4	1	1	3	2	4	1	1	2	19
29	5	5	5	5	2	1	1	2	2	1	2	1	20
30	4	6	4	4	2	1	3	3	3	1	2	1	18
31	4	4	3	3	1	1	1	3	2	1	2	1	14
32	3	4	3	4	1	1	2	3	1	1	2	1	14
33	5	4	4	3	1	2	2	3	1	1	2	1	16
34	3	4	4	4	1	1	3	2	3	1	2	1	15
35	3	3	3	3	1	1	3	2	3	1	2	1	12
36	4	6	3	3	1	1	1	4	4	1	2	1	16
37	4	3	4	3	1	1	1	3	4	1	2	1	14
38	3	4	3	3	1	1	3	2	3	1	2	1	13
39	5	5	4	4	2	1	1	3	2	1	2	1	18
40	5	6	5	4	1	1	3	3	3	1	2	1	20
41	5	6	5	4	1	1	1	4	3	1	2	1	20
42	4	4	3	3	1	1	3	2	4	1	2	1	14
43	4	6	5	4	1	1	1	3	4	1	2	2	19
44	4	3	3	2	1	1	1	5	3	1	2	2	12
45	4	5	3	2	2	1	1	5	2	1	2	2	14
46	4	5	3	3	1	1	1	4	2	1	2	2	15
47	4	4	4	3	1	1	3	3	4	1	2	2	15
48	5	4	4	4	2	1	1	2	2	1	2	2	17
49	5	5	5	5	2	1	1	1	1	1	2	2	20
50	5	5	5	5	2	1	3	4	4	1	2	2	20
51	5	4	5	4	1	1	1	3	4	1	2	2	18
52	5	5	4	4	1	1	1	4	5	1	2	2	18
53	3	3	5	4	1	1	1	4	4	1	2	2	15
54	4	4	3	4	1	1	1	3	4	1	2	2	15
55	6	6	5	4	1	1	1	3	3	1	2	2	21
56	5	4	4	4	2	1	1	3	3	1	2	2	17

OBS	Q1	Q2	Q3	Q4	GENDER	REGULAR	ORG	AGE	SCHOOL	LADDER	TIME	SMOKE	QSUM
57	3	3	3	2	1	1	3	3	3	2	1	1	11
58	4	4	3	2	1	1	3	2	5	2	1	1	13
59	4	5	3	2	1	1	1	4	3	2	1	1	14
60	3	6	3	2	1	1	3	2	3	2	1	1	14
61	4	6	4	4	2	1	2	2	1	2	1	1	18
62	4	6	4	3	1	1	3	3	3	2	1	1	17
63	5	6	4	4	1	1	3	3	4	2	1	1	19
64	3	3	3	2	1	1	1	3	2	2	1	1	11
65	6	5	5	4	1	1	1	3	5	2	1	1	20
66	4	4	3	2	1	1	1	3	3	2	1	1	13
67	3	4	2	2	1	1	3	3	4	2	1	1	11
68	4	5	4	4	2	1	1	4	1	2	1	1	17
69	3	4	2	2	1	1	1	5	4	2	1	1	11
70	4	4	3	3	1	1	1	3	3	2	1	1	14
71	3	3	2	2	1	1	2	4	3	2	1	2	10
72	2	5	3	4	1	1	1	4	4	2	1	2	14
73	3	3	3	2	1	1	3	2	3	2	1	2	11
74	5	6	4	2	1	1	1	4	1	2	1	2	17
75	2	2	2	2	1	2	1	3	4	2	1	2	8
76	4	4	4	3	2	1	2	3	1	2	1	2	15
77	5	5	4	4	1	1	2	2	1	2	1	2	18
78	4	4	4	3	2	1	3	2	2	2	1	2	15
79	4	5	4	3	1	1	3	3	4	2	1	2	16
80	4	5	4	4	2	1	1	4	2	2	1	2	17
81	4	4	3	3	1	1	1	3	4	2	1	2	14
82	3	4	2	2	1	1	1	3	3	2	1	2	11
83	6	6	5	4	1	1	1	3	3	2	1	2	21
84	3	3	2	2	1	1	1	4	2	2	1	2	10
85	3	4	2	1	2	1	3	2	4	2	2	1	10
86	6	5	5	5	1	1	1	3	2	2	2	1	21
87	3	3	2	1	1	1	3	4	5	2	2	1	9
88	3	3	3	2	1	2	2	3	1	2	2	1	11
89	5	5	4	4	1	2	2	2	1	2	2	1	18
90	4	4	3	2	1	1	3	2	2	2	2	1	13
91	4	4	3	2	1	1	2	2	1	2	2	1	13
92	2	3	2	2	1	1	1	3	3	2	2	1	9
93	4	4	3	2	1	1	3	4	3	2	2	1	13
94	5	5	4	3	1	1	1	4	1	2	2	1	17
95	4	5	4	3	1	1	1	3	4	2	2	1	16
96	4	4	3	2	1	1	1	4	2	2	2	1	13
97	5	6	5	5	2	1	1	3	3	2	2	1	21
98	4	4	4	3	1	1	3	3	3	2	2	1	15
99	5	5	4	4	1	1	1	2	2	2	2	2	18
100	5	6	5	5	1	1	3	2	4	2	2	2	21
101	5	4	5	4	1	1	3	2	4	2	2	2	18
102	4	4	3	3	1	1	1	5	4	2	2	2	14
103	4	4	3	2	1	1	3	3	4	2	2	2	13
104	4	4	5	4	1	1	2	2	2	2	2	2	17
105	3	3	2	2	2	1	1	4	4	2	2	2	10
106	4	6	5	5	1	1	1	4	1	2	2	2	20
107	5	6	5	4	1	1	1	3	4	2	2	2	20
108	6	4	5	5	1	1	1	5	2	2	2	2	20
109	5	5	4	4	1	1	1	3	3	2	2	2	18
110	2	2	2	2	1	2	1	4	1	2	2	2	8
111	4	2	4	3	1	1	1	4	4	2	2	2	13
112	5	6	4	3	1	1	1	3	4	2	2	2	18

Analysis Variable : QSUM

LADDER	TIME	SMOKE	N Obs	N	Mean	Std Dev
1	1	1	14	14	16.9285714	2.6154654
		2	14	14	17.7857143	2.9135907
	2	1	14	14	16.0000000	2.7456259
		2	14	14	16.8571429	2.6269943
2	1	1	14	14	14.5000000	3.1561905
		2	14	14	14.0714286	3.6682481
	2	1	14	14	14.2142857	3.9841720
		2	14	14	16.2857143	4.0273788

Univariate Procedure

Variable=QSUM

Moments

N	112	Sum Wgts	112
Mean	15.83036	Sum	1773
Std Dev	3.424576	Variance	11.72772
Skewness	-0.27908	Kurtosis	-0.7681
USS	29369	CSS	1301.777
CV	21.63297	Std Mean	0.323592
T:Mean=0	48.92073	Pr>|T|	0.0001
Num ^= 0	112	Num > 0	112
M(Sign)	56	Pr>=|M|	0.0001
Sgn Rank	3164	Pr>=|S|	0.0001
W:Normal	0.94739	Pr<W	0.0006

Normal Probability Plot

```
22.5+                                                 ++     *
    |                                             ***** * *
    |                                        ******+
    |                                      ***+++
    |                                  *****++
    |                                ***+++
    |                              ***++
15.5+                            ***+
    |                         ****
    |                      ****
    |                    **+
    |                 ****
    |              ***
    |           *+*
 8.5+*       *++
     +----+----+----+----+----+----+----+----+----+----+
         -2        -1         0        +1        +2
```

APPENDIX D: ANOVA AND T-TEST TABLES

The SAS System

Correlation Analysis

4 'VAR' Variables: Q1 Q2 Q3 Q4

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
Q1	112	4.17857	0.96061	468.00000	2.00000	6.00000
Q2	112	4.52679	1.12274	507.00000	2.00000	7.00000
Q3	112	3.73214	0.93945	418.00000	2.00000	5.00000
Q4	112	3.39286	1.04284	380.00000	1.00000	5.00000

Correlation Analysis

Cronbach Coefficient Alpha

for RAW variables : 0.861131
for STANDARDIZED variables: 0.866790

	Raw Variables		Std. Variables	
Deleted Variable	Correlation with Total	Alpha	Correlation with Total	Alpha
Q1	0.725234	0.816886	0.727392	0.825685
Q2	0.582323	0.880643	0.583116	0.882211
Q3	0.813449	0.783354	0.818912	0.787478
Q4	0.738812	0.809769	0.748212	0.817157

Pearson Correlation Coefficients / Prob > |R| under Ho: Rho=0 / N = 112

	Q1	Q2	Q3	Q4
Q1	1.00000 0.0	0.57189 0.0001	0.71235 0.0001	0.59483 0.0001
Q2	0.57189 0.0001	1.00000 0.0	0.51080 0.0001	0.49108 0.0001
Q3	0.71235 0.0001	0.51080 0.0001	1.00000 0.0	0.83484 0.0001
Q4	0.59483 0.0001	0.49108 0.0001	0.83484 0.0001	1.00000 0.0

The SAS System

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LADDER	2	1 2
TIME	2	1 2
SMOKE	2	1 2

Number of observations in data set = 112

General Linear Models Procedure

Dependent Variable: QSUM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	193.13392857	27.59056122	2.59	0.0168
Error	104	1108.64285714	10.66002747		
Corrected Total	111	1301.77678571			

R-Square	C.V.	Root MSE	QSUM Mean
0.148362	20.62474	3.2649698	15.830357

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LADDER	1	126.43750000	126.43750000	11.86	0.0008
TIME	1	0.00892857	0.00892857	0.00	0.9770
SMOKE	1	19.72321429	19.72321429	1.85	0.1767
LADDER*TIME	1	25.08035714	25.08035714	2.35	0.1281
LADDER*SMOKE	1	0.00892857	0.00892857	0.00	0.9770
TIME*SMOKE	1	10.93750000	10.93750000	1.03	0.3134
LADDER*TIME*SMOKE	1	10.93750000	10.93750000	1.03	0.3134

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LADDER	1	126.43750000	126.43750000	11.86	0.0008
TIME	1	0.00892857	0.00892857	0.00	0.9770
SMOKE	1	19.72321429	19.72321429	1.85	0.1767
LADDER*TIME	1	25.08035714	25.08035714	2.35	0.1281
LADDER*SMOKE	1	0.00892857	0.00892857	0.00	0.9770
TIME*SMOKE	1	10.93750000	10.93750000	1.03	0.3134
LADDER*TIME*SMOKE	1	10.93750000	10.93750000	1.03	0.3134

TWO-SAMPLE T TESTS FOR QSUM BY GENDER

GENDER	MEAN	SAMPLE SIZE	S.D.	S.E.
1	15.630	92	3.4569	0.3604
2	16.750	20	3.1933	0.7141

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

ASSUMPTION	T	DF	P
EQUAL VARIANCES	-1.33	110	0.1864
UNEQUAL VARIANCES	-1.40	29.5	0.1720

	F	NUM DF	DEN DF	P
TESTS FOR EQUALITY OF VARIANCES	1.17	91	19	0.3604

TWO-SAMPLE T TESTS FOR QSUM BY REGULAR

REGULAR	MEAN	SAMPLE SIZE	S.D.	S.E.
1	15.981	105	3.2728	0.3194
2	13.571	7	4.9952	1.8880

NULL HYPOTHESIS: DIFFERENCE = 0
ALTERNATIVE HYP: DIFFERENCE <> 0

ASSUMPTION	T	DF	P
EQUAL VARIANCES	1.82	110	0.0713
UNEQUAL VARIANCES	1.26	6.3	0.2526

	F	NUM DF	DEN DF	P
TESTS FOR EQUALITY OF VARIANCES	2.33	6	104	0.0374

ONE-WAY AOV FOR QSUM BY SCHOOL

SOURCE	DF	SS	MS	F	P
BETWEEN	4	14.7292	3.68231	0.31	0.8737
WITHIN	107	1287.05	12.0285		
TOTAL	111	1301.78			

	CHI-SQ	DF	P
BARTLETT'S TEST OF EQUAL VARIANCES	1.55	4	0.8186

COCHRAN'S Q	0.3470
LARGEST VAR / SMALLEST VAR	2.3406

COMPONENT OF VARIANCE FOR BETWEEN GROUPS	-0.39450
EFFECTIVE CELL SIZE	21.2

SCHOOL	MEAN	SAMPLE SIZE	GROUP STD DEV
1	16.111	18	3.3235
2	16.333	27	3.2463
3	15.586	29	3.6986
4	15.588	34	3.3405
5	15.000	4	4.9666
TOTAL	15.830	112	3.4682

ONE-WAY AOV FOR QSUM BY AGE

SOURCE	DF	SS	MS	F	P
BETWEEN	4	53.2686	13.3171	1.14	0.3411
WITHIN	107	1248.51	11.6683		
TOTAL	111	1301.78			

	CHI-SQ	DF	P
BARTLETT'S TEST OF EQUAL VARIANCES	0.58	3	0.9008

COCHRAN'S Q	0.3061
LARGEST VAR / SMALLEST VAR	1.5174

COMPONENT OF VARIANCE FOR BETWEEN GROUPS	0.08772
EFFECTIVE CELL SIZE	18.8

AGE	MEAN	SAMPLE SIZE	GROUP STD DEV
1	20.000	1	M
2	15.960	25	3.1422
3	16.189	53	3.4253
4	14.760	25	3.5152
5	15.875	8	3.8707
TOTAL	15.830	112	3.4159

BIBLIOGRAPHY

Allen, F.W. "Towards a Holistic Appreciation of Risk: The Challenge for Communicators and Policymakers," Science, Technology, and Human Values, 12: 138-143 (1987).

American National Standards Institute. American National Standard Time-series Chart. New York: The American Society of Mechanical Engineers, 1979.

Baker, Lonny P. How Location and an Action Standard on a Risk Ladder Affect Perceived Risk. MS thesis, AFIT/GEE/ENV/95D-02. School of Engineering, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, December 1995 (AD-A305343).

Brown, Rex V. Presenting Risk Management Information to Policymakers: Executive Summary. Falls Church VA: Decision Science Consortium, July 1985.

Campbell, L.F. and A. E. Stewart. "Effects of Group Membership on Perception of Risk of AIDS," Psychological Reports, 70: 1075-1092 (1992).

Chadwick, Bruce A. Research Methods. Englewood Cliffs NJ: Prentice-Hall, 1984.

Christensen, David S. and Albert Larkin. "Criteria for High Integrity Graphics," Journal of Managerial Issues, 4: 130-153 (1992).

Conover, W.J. Practical Nonparametric Statistics. New York: John Wiley & Sons, 1980.

Covello, Vincent T., Peter M. Sandman, and Paul Slovic. Risk Communication, Risk Statistics, and Risk Comparisons: A Manual for Plant Managers. Washington DC: Chemical Manufacturers Association, 1988.

Covello, Vincent T. "Communicating Right-To-Know Information on Chemical Risks," Environmental Science and Technology, 23: 1444-1449 (December 1989).

Creswell, John W. Research Design: Qualitative and Quantitative Approaches. Thousand Oaks CA: Sage Publications, 1994.

Enrick, Norbert L. Handbook of Effective Graphic and Tabular Communication. Huntington NY: R. E. Krieger Publishing, 1980.

Groth, E. III. "Communicating With Consumers About Food Safety and Risk Issues," Food Technology, 45: 248-253 (1991).

Gutteling, Jan M. and Oene Wiegman. Exploring Risk Communication. Dordrecht, Netherlands: Kluwer Academic Publishers, 1996.

Huff, D. How to Lie with Statistics. New York: Norton, 1954.

Ibrekk, H. and G. M. Morgan. "Graphical Communication of Uncertain Quantities to Non-technical People," Risk Analysis, 7: 519-529 (1987).

Kasperson, R. E., et al. "The Social Amplification of Risk: A Conceptual Framework," Risk Analysis, 8: 177-187 (1988).

Kasperson, R. E. and I. Palmlund. Effective Risk Communication: The Role and Responsibility of Government and Non-government Organizations. New York: Plenum Press, 1989.

Keppel, Geoffrey. Design and Analysis: A Researcher's Handbook. 3rd ed. Englewood Cliffs NJ: Prentice-Hall, 1991.

Krimsky, S. and A. Plough. Environmental Hazards: Communicating Risks as a Social Process. Dover MA: Auburn House Publishing Company, 1988.

Lundgren, Regina E. Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks. Columbus OH: Battelle Press, 1994.

National Research Council. Improving Risk Communication. Washington DC: National Press, 1989.

Neter, John, Willliam Wasserman, and Michael H. Kutner. Applied Linear Statistical Models. 3rd ed. Boston: Irwin, 1990.

Nunnally, J. C. Psychometric Theory. New York: McGraw-Hill, 1978.

Ontani, H., S. Leonard, V. Ashford, M. Bushroe, and G. Reeder. "Age Differences in Perception of Risk," Perceptual Motor Skills, 74: 587-594 (1992).

Parsons, Robert. Statistical Analysis: A Decision-Making Approach. New York: Harper & Row, 1974.

Raymond, Colonel Neil V. Handout, Environmental Seminar. School of Engineering, Air Force Institute of Technology, Wright-Patterson AFB OH, February 1995.

Sandman, Peter M. "Risk Communication: Facing Public Outrage," EPA Journal, 13: 21-22 (1987).

Sandman, Peter M., Neil D. Weinstein, and Paul Miller. "How Location on a 'Risk Ladder' Affects Perceived Risk," Risk Analysis, 14: 35-45 (January 1994).

Singer, E. and P. Endreny. Reporting On Risk. New York: Russell Sage Foundation, 1993.

Slovic, P. "Informing and Educating the Public About Risk," Risk Analysis, 6: 403-415 (1986).

Spector, Paul E. Summated Rating Scale Construction: An Introduction. Series/Number 07-082. Newbury Park: Sage Publications, 1992.

Szoka, Alan, Kathryn Paller, and Nan Nelson. Choosing the Right Chart: A Comprehensive Guide for Computer Users. San Diego: Integrated Software Systems Corporation, 1991.

Tan, Joseph K. H. and Izak Benbasat. "The Effectiveness of Graphical Presentation for Information Extraction: A Cumulative Experimental Approach," Decision Sciences, 24: 167-191 (1993).

Thal, Major Alfred E. Handout, Environmental Seminar. School of Engineering, Air Force Institute of Technology, Wright-Patterson AFB OH, November 1994.

Weinstein, Neil D., Peter M. Sandman, and Nancy E. Roberts. Communicating Effectively About Risk Magnitudes. Document EPA-230-08-89-064. Washington DC: U.S. Environmental Protection Agency, August 1989.

Weinstein, Neil D., Peter M. Sandman, and Nancy E. Roberts. Communicating Effectively About Risk Magnitudes, Phase Two. Document EPA-230-09-91-003. Washington DC: U.S. Environmental Protection Agency, September 1991.

Weinstein, Neil D., Peter M. Sandman, and W. H. Hallman. "Testing a Visual Display to Explain Small Probabilities," Risk Analysis, 14: 895-896 (1994).

Weinstein, Neil D., Kathryn Kolb, and Bernard D. Goldstein. "Using Time Intervals Between Expected Events to Communicate Risk Magnitudes," Risk Analysis, 16: 305-308 (1996).

Vita

Captain Steve Alfonso Dinzart [redacted] He graduated from Charles A. Lindbergh High School in June of 1988. Shortly thereafter, he was ushered off to basic training and became a cadet at the US Air Force Academy. On 27 May 1992, he was granted a pardon and was allowed to leave the Academy with a Bachelor of Science degree in Operations Research. Captain Dinzart's first assignment was to Los Angeles AFB, where he served as the Network Integrator for the Satellite and Launch Control System Program Office. Upon hearing the call for higher education, he went off to the Air Force Institute of Technology in pursuit of a Masters degree in Systems Management. Pending graduation, Captain Dinzart's next assignment is to AFOTEC at Kirtland AFB.

Permanent Address: [redacted]

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1997	Master's Thesis

4. TITLE AND SUBTITLE
HOW THE PRESENCE OF A RISK LADDER, TIME INTERVAL COMPARISON, AND SMOKING COMPARISON AFFECT RISK PERCEPTION

5. FUNDING NUMBERS

6. AUTHOR(S)
Steve Alfonso Dinzart, Captain, USAF

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)

Air Force Institute of Technology
2750 P Street
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT/GSM/LAL/97S-2

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 Words)***

The objective of this study is to increase the knowledge available on the relative effectiveness of risk ladders as a presentation format for explaining risk magnitudes to the public. An experiment was conducted to test the hypotheses that an individual's risk perception varies with the presence of a risk ladder, time interval comparison, and smoking comparison. Subjects were AFIT Professional Continuing Education students, asked to assume a particular level of a health hazard in their homes, to read a brochure explaining the hazard, and then to complete a questionnaire. Results demonstrated that subjects exposed to a graphical risk ladder perceived lower levels of risk than subjects not exposed to a risk ladder. Also, the study found that time interval and smoking comparisons did not significantly affect the risk perception of the participants. These findings suggest that the discontinuity between expert views and the public perceptions of health risk can be bridged by effectively utilizing risk ladders when presenting risk magnitudes to the public.

14. SUBJECT TERMS
Communication, Risk Communication, Risk Ladders, Risk Perception, Risk Magnitudes

15. NUMBER OF PAGES
85

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

AFIT Control Number AFIT/GSM/LAL/97S-2

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. **Please return completed questionnaire** to: AIR FORCE INSTITUTE OF TECHNOLOGY/LAC, 2950 P STREET, WRIGHT-PATTERSON AFB OH 45433-7765. Your response is **important.** Thank you.

1. Did this research contribute to a current research project? a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?
a. Yes b. No

3. **Please estimate** what this research would have cost in terms of manpower and dollars if it had been accomplished under contract or if it had been done in-house.

Man Years___________ $___________

4. Whether or not you were able to establish an equivalent value for this research (in Question 3), what is your estimate of its significance?

a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments (Please feel free to use a separate sheet for more detailed answers and include it with this form):

_______________________ _______________________
Name and Grade Organization

_______________________ _______________________
Position or Title Address