Hazard Connotation of Fire Safety Terms

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Knowledge about the level of danger associated with fire hazards is crucial for avoiding injury when dealing with hazardous materials. Participants (N=107) comprised of undergraduate students and nonstudent adults rated 12 one- and two-word phrases based on the extent of fire hazard conveyed. Evaluated were four root words (Inflammable, Combustible, Flammable, and Explosive) combined with three qualifiers (no qualifier, Very, and Extremely). Inflammable has the same meaning as Flammable but was rated as if it was of very low flammability, consistent with previous research. Explosive was rated higher than the other root words but was followed closely by Flammable and Combustible, which themselves did not differ. By including qualifiers, there was an increased hazard connotation over the root word alone, with the qualifier Extremely producing significantly higher ratings than with the qualifier Very. Even though Inflammable was rated erroneously as low in flammability when Very or Extremely were added, participants (particularly nonstudents) gave higher ratings of hazard than the root word alone. Analyses including demographic variables showed the ratings of the terms interacted with student status and age, which were mainly due to how the term Inflammable was rated. The evidence suggests that Explosive is a good term to express severe fire hazard, and the confusing term Inflammable should be avoided as much as possible. The results give some guidance on terminology in warnings that could be useful in matching connotations of hazard words with different danger levels.

INTRODUCTION

In 2008, there were 1,451,500 fires reported in the U.S., these caused 3,320 fatalities with many others badly burned (NFPA, 2010; U.S. Fire Administration, 2009). Some of these very serious cases could have been prevented by good hazard control using design, guarding, and/or warning strategies. The main focus of this article is on the last of these strategies, warning about the hazard. In particular, the focus was on the meaning of wording used in warnings to assist in hazard communication. While there has been a growing body of research on evaluating connotations of signal words and other terms in warnings, relatively few studies have examined wording to convey fire hazards.

Leonard and Cummings (1994) evaluated the general public's knowledge of warning terms. Most people lack specific knowledge, training, and experience with hazardous materials, and they have low awareness of the extent of danger involved. Patten (1995) found that people have limited knowledge of hazard-related flammable vapor properties. Additional specific training on the intended meaning of fire safety terms would be useful in occupational settings, but in everyday consumer settings reaching and educating potential people at risk is difficult and expensive and such a program will not likely be completely effective.

Fundamentally, human factors/ergonomics (HFE) professionals would prefer that the words used to describe fire hazards be evaluated and selected so that they convey an accurate understanding of different degrees of fire hazard. If possible, it would be beneficial to use terms that people already know and understand based on people's vast amount of experience and use of language and semantics. Thus, terms to convey hazard might be selected based on people's existing knowledge base, rather than to use terminology that fire safety experts understand but virtually no one else does, and thus requiring extra work in terms of trying to train people.

Prior research suggests that people misunderstand the meanings of the words Combustible and Flammable (Main, Frantz, & Rhoades, 1993). According to the National Fire Protection Association (NFPA), Combustible substances are those with a flash point of 100 to 150 degrees Fahrenheit. Substances classified as Flammable have flash point temperatures between 20 and 100 degrees Fahrenheit.

Thus from the standard/regulatory definitions, Flammable presents a greater fire hazard than Combustible. However, research by Main et al. (1993) suggests that people are more likely to believe that Combustible connotes greater hazard than Flammable. The present research re-examined this issue, and it was thereby expected that consumers would rate Combustible more severe than Flammable, even though fire standards define it to be the opposite. Given the formal standard definitions, the qualifier term Extremely when added to Flammable is designated as a greater fire hazard than Flammable alone. The present research examined whether people perceived increased hazard when Extremely as well as another common qualifier term Very is added to Flammable and other root terms.

Besides Combustible and Flammable, two other root word terms used to denote fire hazard were examined. One was the term Explosive. Explosive is commonly used to express a very volatile reaction, which also frequently involves fire. Explosive was expected to receive high ratings of fire hazard given its association with fire and its definition. According to the NFPA, Explosive means "any chemical compound, mixture, or device that functions by explosion." The word explosion is defined as "an effect produced by the sudden, violent expansion of gases, which can be accompanied by a shockwave or disruption, or both, of enclosing materials or structures." This definition conveys an

immense amount of danger associated with the term. How the term Explosive is perceived compared to Combustible and Flammable was examined in the present study. It was expected to be rated highest among the fire safety terms evaluated.

Another root term sometimes used to describe fire hazard is Inflammable. The dictionary definition of Inflammable is flammable (e.g., American Heritage College Dictionary, 2007). Indeed, the NFPA defines the term Inflammable, as being something that is flammable. NFPA further defines it as "a combustible that is capable of easily being ignited and rapidly consumed by fire." The term Inflammable was examined to determine whether it would be rated at about the same levels as the other three root words (and particularly, Flammable) as indicated by its formal definition. Despite the formal definition as a fire hazard, anecdotal evidence suggests that the term Inflammable is confusing, and perhaps somewhat deceptive because of an erroneous belief by some people that it means very low fire hazard as in *non*flammable. If some people do not know or are confused with its meaning, then it could be expected that Inflammable would receive lower and highly variable ratings.

Thus, this study examines a set of root and qualifier terms through people's ratings of the hazard levels that they connote. Qualifiers such as Very and Extremely were examined to determine whether they suggest different degrees of hazard associated with the root words. It was expected that these words would intensify the meaning of the root words. Specifically, 12 one- or two- word phrases were used to determine if people can consistently differentiate them into different levels of hazard.

METHOD

Participants

A total of 107 individuals (54 males, 53 females) participated. Overall average age was 29.2 years (SD=13.9). Samples from two population pools were collected: Sixty (56%) were undergraduate students at North Carolina State University (M = 19 years, SD = 1.7), and 47 (44%) were non-student adult volunteers from the community (M = 40.9 years, SD = 13.7).

Materials and Procedure

Each participant was given a questionnaire that included a consent form, a demographics survey, and a set of materials described below. The questionnaire also included items unrelated to the research reported here.

Participants were told that their task was to rate a set of terms according to how dangerous of a fire hazard the terms conveyed. They were given 12 words and phrases that were formed from 4 root words (Inflammable, Combustible, Flammable, and Explosive), combined with 3 qualifiers (none, Very, and Extremely). The list of words is shown in Table 1.

Each term had an adjoining blank in which participants recorded their rating. Participants were asked to rate each word or phrase on a scale of 0 to 8. The scale had text descriptions at the even numbered anchors: 0 ("no fire hazard at all"), 2 ("somewhat of a fire hazard"), 4 ("a fire hazard"), 6 ("high fire hazard"), and 8 ("extremely high fire hazard"). Participants were encouraged to read over the entire list of words before making their ratings. Two orders of these words and phrases were administered to participants; one was a randomized order and the other was the reverse of that order.

RESULTS

Table 1 shows the means and standard deviations of 12 root word/qualifier conditions arranged in order from high to low hazard. The range of the two most extreme conditions differed by nearly six rating-scale points. The two highest rated conditions were Extremely Explosive (M= 7.53) and Extremely Flammable (M = 7.20); the lowest rated ones included the term Inflammable: Inflammable (M = 1.59), Extremely Inflammable (M = 2.88) and Very Inflammable (M = 2.73).

Selection of terms for use in warnings should not just simply be based on means. Higher variability in the ratings is indicative of differing interpretations in meaning (confusion) among participants. As can be seen in Table 1, some words had higher standard deviations than others. The most variable were associated with the term Inflammable: Extremely Inflammable (SD = 3.36) and Very Inflammable (SD = 3.14). Also high variability was indicated by significant heterogeneity of variance of these two terms relative to the variances for the other terms (ps < .05).

Table 1
Mean hazard ratings and standard deviations of 12 qualifier-root words shown ordered from high to low.

Words/Phrases	Mean (SD)
Extremely Explosive	7.53 (1.31)
Extremely Flammable	7.20 (1.33)
Very Explosive	7.08 (1.39)
Extremely Combustible	7.10 (1.46)
Explosive	6.64 (1.53)
Very Combustible	6.49 (1.59)
Very Flammable	6.20 (1.59)
Combustible	5.17 (1.90)
Flammable	4.64 (1.60)
Very Inflammable	2.88 (3.14)
Extremely Inflammable	2.73 (3.36)
Inflammable	1.59 (2.29)

Another analysis examined the effects of component factors (root words and qualifiers). Here interest was focused on whether there are significant main effects and interaction of the root words and qualifiers. The 12 terms were assembled to form a two-factor design involving root words and qualifiers. A 3 (qualifier words: none, Very, Extremely) X 4 (root words: Inflammable, Combustible, Flammable, Explosive) repeated measures ANOVA showed that there were significant main effects of qualifier, F (2, 212) = 159.8, MSe = 1.88, p < .0001, and root word, F (3, 318) = 209.51, MSe = 6.61, p < .0001.

Comparisons among the main effect means were conducted using Tukey's HSD test ($p < .05$). The main effect means for qualifier are shown along the bottom row of Table 2.

Table 2
Mean hazard ratings as a function of root and qualifier word factors.

	Qualifier Words			
Root Words	(none)	Very	Extremely	*Mean*
Inflammable	1.59	2.88	2.73	2.40
Combustible	5.17	6.49	7.10	6.25
Flammable	4.64	6.20	7.20	6.01
Explosive	6.64	7.07	7.53	7.08
Mean	4.51	5.66	6.14	

The means show an increase from no qualifier to Very to Extremely. All differences were significant. The root word main effect means are shown in the far right column of Table 2. Inflammable was rated significantly lower than the other root words. Explosive was rated significantly higher than the other terms. Combustible and Flammable were in the middle between the two extremes. While Combustible was rated slightly higher than Flammable, the difference was not significant.

Also, there was a significant interaction effect of qualifier and root word, F (6, 636) = 12.99, MSe = 1.46, $p <$ .0001. The means are shown within the cells of Table 1 and graphed in Figure 1. Comparisons were made using simple effects analysis together with Tukey's HSD. Explosive with no qualifier was rated significantly higher than Flammable with no qualifier and Combustible with no qualifier, with no difference between the latter two conditions. A similar pattern was found when Very was used; however this was not true with the term Extremely in which these three root words did not differ. The pattern was different for Inflammable, which showed a non-significant drop in the ratings from Very to Extremely.

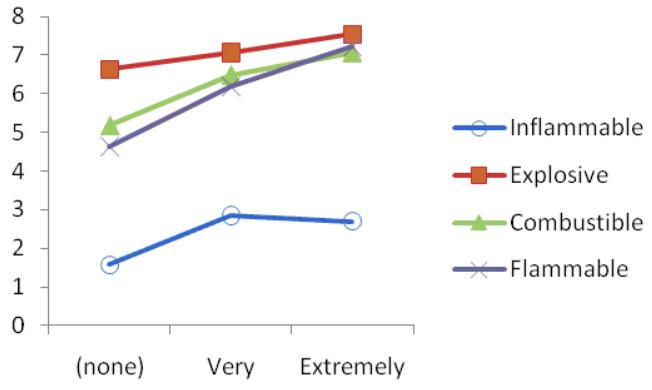

Figure 1. Graphed means of the Qualifier and Root word.

Additional analyses examined the potential relationships between demographic data and word connotations. Added to the analyses, were the factors of student versus nonstudent, younger versus older adults (groups formed using a median split), and gender into the main 3 X 4 repeated-measures design previously described. These analyses were 2 X 3 X 4 mixed-model ANOVAs. The analysis involving student status yielded an interaction of student vs. nonstudent with root words, F (3, 315) = 2.70, MSe = 6.50, $p < .05$. The means for this interaction showed that nonstudents rated Inflammable significantly higher than the students did. There were also two interactions in the ANOVAs involving age. Age significantly interacted with root word, F (3, 315) = 3.70, MSe = 6.44, $p <$ .02. This interaction was nearly identical to the above-described pattern of means involving student vs. nonstudent. There was also a significant 3-factor interaction involving age, root word, and qualifier word, F (6, 630) = 3.62, MSe = 1.42, $p < .01$. Nonstudents rated Inflammable higher than did the students when it was paired with the qualifiers Very and Extremely. There was no effect of gender, nor did it significantly interact with the main experimental variables.

DISCUSSION

This study examined the connoted level of hazard for several fire safety terms and phrases that include root and qualifier terms. Although some research has been conducted on fire hazard words, the present study included two additional root words and systematically manipulated the addition of qualifier terms.

Previous research (e.g., Main et al., 1993) has examined people's perceptions of Combustible and Flammable. These terms have been defined in standards with respect to flash point temperatures. Accordingly, Flammable is defined in the standards as a greater fire hazard than Combustible. However, Main et al. found that people believed that the terms were reversed; they perceived Combustible worse than Flammable. The reasons for this are probably multifold. The term Combustible sounds more volatile or explosive, and the term Flammable seems suggestive of a relatively tame candle flame. In the present study, no significant difference was found between these two root words, although Combustible was rated somewhat higher than Flammable. Thus, this does not replicate the reversal of perceived fire hazard that other researchers have found. However, it does indicate that people's perceptions are not calibrated as defined in standards and how standards are used by safety professionals to label products. In other words, people see no difference between the terms which is somewhat disappointing since the purpose of using different words is to denote different degrees of severity.

Explosive was included in the set of root words investigated because it is a term that is commonly used in fire safety communications and it was of interest to determine how it stood relative to the other terms on hazard connotation. The results showed that people believe it to convey a greater hazard than Combustible or Flammable. It suggests that Explosive is a potentially good word for a severe and volatile fire hazard.

Inflammable was the fourth root word, which means the same as Flammable according to dictionary definitions. Inflammable is not commonly used in U.S. English as a term to describe fire hazard. However, Inflammable is commonly used to convey flammability in other countries and languages

(such as French and Spanish). To a U.S. English-speaking native, the use of Inflammable (as a translation of Flammable) in French and Spanish could result in a dangerous critical confusion, and potentially lead to erroneous understanding and very bad consequences if one were to believe that it means little or no fire hazard. Warning developers should be aware of this potential problem when designing warnings with the term Inflammable in them (even if used in Spanish and French language versions) as some English language users could misinterpret the level of hazard involved.

In general, the addition of qualifier terms to the root words enhanced the degree of hazard connoted. The term Extremely produced higher ratings than Very, and Very was higher than no qualifier. The results suggest that qualifiers can significantly affect hazard connotations regarding the root words. However, note that the effect of Extremely was not as large with the term Explosive as it was with Flammable and Combustible, due possibly to a ceiling effect of Explosive.

There was an unexpected, somewhat interesting finding with respect to the addition of qualifiers to the word Inflammable. If people believe that the word Inflammable is of a low fire hazard as apparently they did, given their ratings, then the addition of the two qualifiers should have meant less of a fire hazard than Inflammable alone. This was not found. Student participants showed a small trend upwards in their ratings from no qualifier to Very and Extremely, but nonstudents' ratings had even a greater slope up in their ratings when the two qualifiers were added. The reason for this finding is unclear at this point, but a few possible reasons might be offered. Note again that Inflammable is a term that people do not seem to understand very well. Both students and nonstudents rated it very low in fire hazard when it actually means the same as Flammable, which they rated very highly in terms of hazard. The confusion of meaning can be seen in the highly variable ratings for Inflammable as indicated by the standard deviations. This was even more apparent when Inflammable was accompanied by the qualifiers Very and Extremely. The 3-factor interaction involving student vs. nonstudent together with the main experimental variables of root word and qualifier showed that the effect was due to nonstudents rating Very Inflammable and Extremely Inflammable higher than the students. It could be that some people believed that Inflammable meant complete incapability of catching fire whereas others knew that it was synonymous with flammable. Together they probably caused the relatively large standard deviations seen in the data. Possibly more of the nonstudents knew its definition than the students. Additional investigation is needed to clarify whether this is a real finding or simply a chance effect. Clearly, it would not be recommended to use the term Inflammable on product labels or environmental signs given the present study's findings.

In summary, the findings suggest that the term Inflammable is more likely to inspire confusion about the extent of hazard involved. One method of dealing with incorrect beliefs and understanding of what words mean is through education and training. While this might be possible in occupational settings where employers can control the training of employees, training the general public is more difficult and costly. A case in point would be to train people that the word Inflammable means flammable and that Inflammable is not the same as *non*flammable. It would be difficult to reach all people. Another method would be to avoid its use when potential receivers are U.S. English language users. A good method is to choose words that people already know and have preexisting beliefs about. Consider also that it could be difficult to change beliefs about the word Combustible meaning less hazardous than Flammable. Many people have already existing preconceptions and their relative meaning would need to be reversed. People know that it means hazard but do not know the extent of hazard. Additionally the results suggest that different levels of danger can be accomplished using qualifier words that could help to calibrate people's beliefs about the degree of hazard involved (Edworthy & Adams, 1996). Warning words and phrases should be indicative of the actual risk that is present. If this assignment is done well, people could be cued in predictable, appropriate ways.

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