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Application of Mental Models Approach to Inform the Design of a Firefighters Personal Exposure Reporting System

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Author Note: Dr Barbara Millet is a Research Asst. Professor at the University of Miami**.** She received her PhD in Industrial Engineering from the University of Miami. Barbara has more than 15 years of research and industry experience in product design and user experience. She has taught undergraduate and graduate courses in human factors and cognitive engineering at Texas Tech University, plus has taught many short courses in user experience and user interface design for industry. Her interest areas include handheld and wearable usability, quantifying the user experience, and human factors in healthcare.

Extended Abstract: Firefighters are exposed to various risks on-the-job. Recording on-the-job exposures, we will help identify when, where and under what circumstances Firefighters are exposed to hazardous agents. The documentation of Firefighters' occupational exposures to hazardous agents may then facilitate efforts aimed at cancer prevention and treatment. There is no research on firefighter specific occupational hazard exposure reporting in the literature. However, in practice few fire organizations have implemented voluntary, personal exposure reporting system. Many of the existing exposure reporting systems are facilitated through manual efforts such as completion of paper forms and verbal reports to management. These traditional methods are limited in the type of data that is collected and are generally thought to be too time consuming, may not yield sufficient and accurate data, and limits the opportunities to conduct analyses for preventive measures. There are also practical problems in the submission of printed reporting forms. The forms are not easily obtained, the staff must be motivated to find one, fill it in, and then submit it. Some organizations have responded to these problems by introducing web-based systems. However, these efforts are largely flawed in system design and usability. Exposure reporting should be easy to use, non-punitive, readily accessible, and better designed to encourage voluntary reporting of occupational hazards exposure. To successfully deploy an exposure reporting system, the system itself must be designed for its users. The primary research objective for this study was to explore design attributes and information presentation priorities in designing a personal exposure reporting system for Firefighters. We conducted mental models approach techniques to inform the design of a digital exposure reporting system. The research examined user needs and information processing styles to determine the most appropriate content and content order for the exposure reporting system to be developed.

Thirty firefighters recruited across 15 fire stations participated in the study. Among them were 6 driver operators, 11 firefighters, 4 lieutenants, 6 captains, and 3 district chiefs. Twenty firefighters had greater than 6 years of experience in the fire service and 12 participants had no experience with exposure reporting systems prior to the study. All had experience with computers and smartphones.

Participants were informed of participants' rights through the verbal informed consent script. Participants complete a demographic questionnaire and then sorted 68 cards containing chunks of information comprised of exposure reporting variables. Participants were also asked to identify and prioritize the categories of information to be included in the exposure reporting system and what those categories should be called. Participants were encouraged to think out loud while working, so as to better understand the participant's thoughts and rationale.

Participants sorted 68 cards into an average of 7 groups. On average, participants took 35 minutes to complete the study. A similarity matrix was created to identify key relationships between individual items. The matrix provided the strength of the relationship between each pair of individual content items, and how strong a group the items form. Figure 1. represents a segment of the similarity matrix, showing the number of times, as a percentage, participants grouped each individual card with each other card in the set. The higher numbers represent stronger item-to-item relationships. Figure 2. shows a segment of the result of the hierarchical cluster analysis represented as a tree diagram or dendrogram. The items that joined together are more similar than those that joined together later.

93									Was your contaminated gear separated from you during Post Incident Analysis?
80	80								Did you have post incident decontamination procedures at the station?
76	76	90							Were post incident decontamination procedures at the station followed?
76	76	83	90						Decontamination at Station: Washed, Rinsed, Replaced
76	76	80	83	86					Were post incident decontamination procedures at the scene followed?
66	66	80	86	83	83				Decontamination on Scene: Washed, Rinsed, Replaced
66	66	80	73	76	80	83			Did you have on scene decontamination procedures?
80	73	70	73	70	63	60	63		Was your contaminated gear separated from you during Rehabilitation?
63	63	46	53	60	56	50	50	50	Was your gear decontaminated and/or cleaned prior to incident response?
43	46	36	40	43	33	40	33	36	60 Where is your gear stored between shifts?

Figure 1. Similarity Matrix

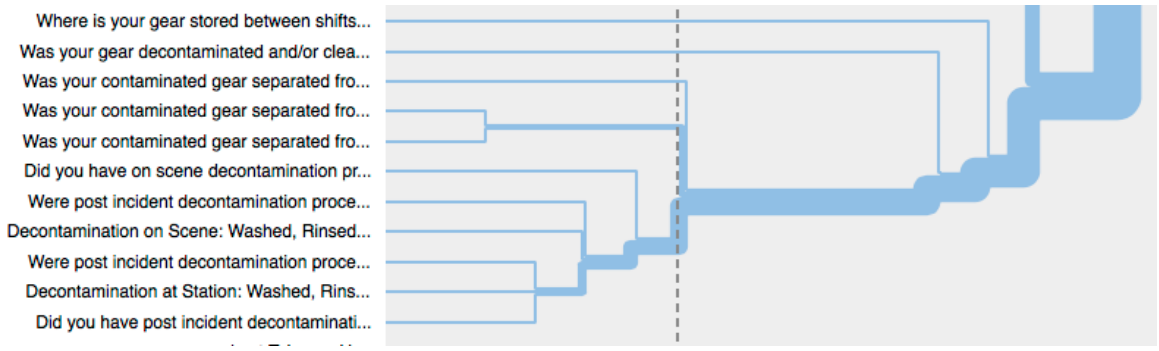

Figure 2. Dendrogram

Study results showed how firefighters organize event-based information when describing occupational, exposure incidents. For this type of information, Firefighters followed a chronological pattern of organization by arranging information according to representations of a particular period of time. The organizational strategy was to divide topics into "before-during-after" segments. To align with established mental models, reporting instruments for each incident type were organized by phases of work from the incident call, to activities on the scene, through to decontamination procedures on scene and at the station. The research outcomes provided a better understanding of those who will be using the system, the context in which it will be used, and the appropriate design attributes to support ease of use.

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