

Perceived Usefulness and Usability of a Visual Analytical System for Toxic Chemical Identification: Results from a National Survey of First Responders

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Abstract

Despite the critical importance of decision-support tools used by first responders during toxic chemical emergencies, little is known about the usage and design requirements for such tools. Guided by the results from a qualitative study of 20 first responders from 2 states, we conducted a nation-wide survey of first responders to analyze how current decision-support technologies are being used, and to solicit perceptions for the usefulness and usability of a prototypical visual analytical system for toxic chemical identification. The results (n=139) revealed that while respondents from regional jurisdictions had significantly different profiles for tool usage compared to single and countywide jurisdictions, there were uniformly high ratings for the perceived usability and usefulness of the prototypical visual analytical system across all jurisdictions. A closer inspection revealed a significant difference in perceived usefulness versus usability across all jurisdictions, with the textual comments providing clues for that difference. These results extend our prior understanding of technology use by first responders, and help to identify the critical features necessary for the wide adoption of future systems.

Introduction

Although the rapid identification of toxic chemicals during chemical incidents is a nation-wide imperative, few studies have analyzed technology usage nation-wide. Here we report preliminary results from a nation-wide survey of first responders designed to address the research question “How do first responders use technology during a toxic chemical incident, and what are their perceptions regarding a prototypical visual analytical system designed for toxic chemical identification?”

Method

Guided by a qualitative study¹ of technology usage by 20 first responders in 2 states, we conducted a nation-wide online survey consisting of 36 questions related to: (1) **demographics** (e.g., location and jurisdiction), (2) **tool usage** (e.g., frequency and type of tools used), and (3) **perceptions of the usefulness and usability** of a prototypical visual analytical system, using a validated instrument based on the technology acceptance model. The visual analytical system called *Mining And Interpretation of Diagnostic Networks* (MAIDN)² was demonstrated through an online video provided as part of the survey.

As shown in Figure 1, MAIDN integrates search and visual analytics in a single interface. The usefulness and usability of this design was iteratively refined through consultation with an expert first responder, and through the application of ten heuristics³ for designing general-purpose graphical user interfaces, and seven heuristics⁴ that are

specific to the interaction design of visual analytical systems. Furthermore, the contextual appropriateness of the design was verified through qualitative interviews⁵ with first responders in two states. The interface was designed to have few menu selections, appropriate for use in stressful and time critical situations. The top left pane provides a dynamically generated list of symptoms ranked by their ability to eliminate close to half of the remaining chemicals. For example, the top-ranked symptom (*Dizziness*) in the figure will eliminate 47% of the chemicals (as shown by the pop-up box) if it's yes option (“Y”) is selected, and about the same if the (“N”) option is chosen. In the middle pane, the visualization provides “at-a-glance” the chemicals that are eliminated (white dots), and candidate chemicals (black dots with labels) which progressively move into smaller rings

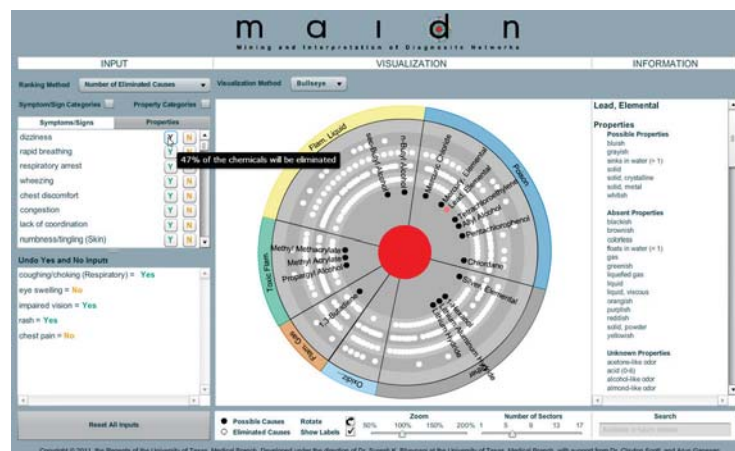


Figure 1. The MAIDN prototype integrates an algorithm which guides users to consider the most discriminating symptoms (upper left pane), and a visualization (center) that provides “at-a-glance” how the symptom selections reduce the candidate chemicals (black dots moving to the center), which are categorized by their chemical properties (sectors).

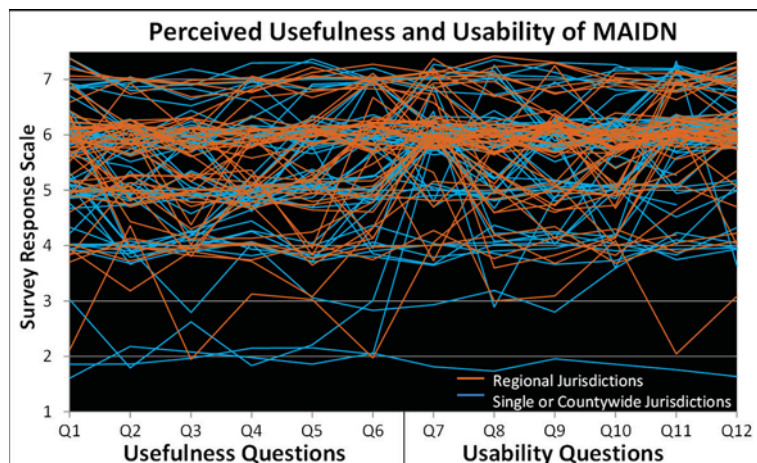


Figure 2. How 139 first responders across regional versus smaller jurisdictions perceived the usefulness and usability of MAIDN.

towards the inner red circle. When no more symptoms are available to distinguish between chemicals, the final candidate chemicals move into the inner red circle (the “bull’s eye”). The system therefore guides the user towards considering symptoms that eliminate many chemicals, and simultaneously provides visual feedback on the effects of different inputs to help make a rapid decision.

The survey, which included a video of MAIDN, was sent to 795 email addresses of first responders obtained from an organization that trains HAZMAT teams nation-wide in partnership with federal agencies, and therefore represented a wide cross-section of first responders.

Results

The survey yielded 191 responses (24% response rate) from 27 states, with 139 who completed all questions, and who were chosen for the current analysis. The analysis revealed a significant stratification of tool usage based on jurisdiction (response coverage). Compared to respondents from jurisdictions with smaller coverage combined (single and countywide), respondents from regional jurisdictions used significantly more ($U=843.5$, $p<.001$, two-tailed test) detection technologies (e.g., radiation detectors), and used WISER¹ (a decision-support system) significantly more often ($U=1185.0$, $p<.01$, two-tailed test). This difference in WISER use is important because there was no significant difference in the number of chemicals identified by respondents in regional jurisdictions compared to the rest. However, as shown in Figure 2, despite the above differences in tool use, there were no significant differences between the two jurisdiction groups in the 12 questions about the perceived usefulness and usability of MAIDN. Finally, while the overall ratings were mostly positive (higher score=more positive), the usefulness scores were significantly lower compared to usability across all jurisdictions.

Discussion and Conclusions

The results were presented to an expert first responder for interpretation. The discussion revealed that: (1) the difference in tool usage reflects the extra federal funding received by regional jurisdictions, and their increased usage of WISER suggests that they will be more frequent users of MAIDN, and (2) the absence of differences related to perceived usefulness and usability to the prototypical system suggests that the proposed design has the potential to be widely adopted. Furthermore, textual comments suggest that MAIDN could benefit from additional functionality such as inter-operability with other technologies used during chemical identification.

The combined results from the prior qualitative study, and the current quantitative survey therefore deepened and broadened our understanding for designing future tools for first responders.

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References

1. Bhavnani, S.K., Massey, M., Hichaud-Hanson, E., Zheng, K., Weber, C. Decision-Support in the Wild: A Qualitative Study on How First Responders Use Technology for Rapidly Identifying Toxic Chemicals. *Proc. of AMIA '12* (2012).
2. Bhavnani, S.K., Ganesan, A., Weber, C. Rapid Identification of Toxic Chemicals during Emergencies: Integrating Search with Visual Analytics. *Proc. of AMIA '11* (2011).
3. Nielsen, J., and Mack, R.L. (Eds.), *Usability Inspection Methods*, (1994) John Wiley & Sons, New York, NY.
4. Yi, J.S., Kang, Y.A., Stasko, J., & Jacko, J.A. Toward a Deeper Understanding of the Role of Interaction in Information Visualization. *IEEE Transactions on Visualization and Computer Graphics*, (2007), 13(6).
5. Bhavnani, S.K., Dang, B., Zheng, K., Weber, C. How First Responders Use Decision-Support Tools during Chemical Emergencies: The Nexus of Culture, Context, and Cognition. *Proc. of AMIA '13* (in press).

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