

2016

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Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

You're my only hope: An initial exploration of the effectiveness of robotic platforms in engendering learning about crises and risks

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ARTICLE INFO

Article history:

Received 24 March 2016

Accepted 26 May 2016

Available online xxx

Keywords:

Social robotics

Crisis communication

Risk communication

Learning

ABSTRACT

In the face of crises and risks, emergency responders are often faced with challenges in terms of reaching audiences in treacherous locations, or that are unreachable due to infrastructure failure. Social robots offer one solution for delivering information cornering risks under these circumstances. An exploratory study examined the responses of individuals to risk messages disseminated through robotic delivery platforms. The results suggest that risk messages delivered through robots may engender equal knowledge acquisition as those delivered through legacy media, though sex differences are noted for high involvement events. The findings are discussed in terms of implications for emergency management.

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As environmental crises and risks become more severe and more common, communication practitioners are continually looking toward findings ways of reaching at risk audiences and informing them of the conditions surrounding imminent threats. This is often made challenging due to the fact that under conditions of crisis and duress, it may be difficult or even dangerous to reach those who are most affected by the event in question (Lachlan & Spence, 2007). The newly emerging field of social robotics may offer one solution, as it is plausible to send robotic delivery platforms into crisis and risk environments to deliver critical information concerning the risk at hand, without risking the well-being of emergency managers and first responders. At the same time, little is known about the effectiveness of these technologies in delivering risk information, and the extent to which audiences will retain information delivered through a presumably novel medium.

The current study serves as an initial exploration into the effectiveness of robots in delivering information concerning crises and risks. A simple experiment was conducted in the laboratory to investigate whether audiences would retain similar amounts of crisis and risk related information from robots or legacy media, and whether their level of involvement in the risk at hand would be a

factor in the effectiveness of the robot. The results are then discussed in terms of their implications for future field research, and for emergency managers and first responders who may be considering their use. We begin with a discussion of the motivation for acquiring information under conditions of crisis and duress.

1. Risk information processing

Crisis and risk communication strategies may be categorized as types of strategic communication. They tend to be implemented as parts of larger scale communication programs and interventions that are intended to address both the physical and psychological ramifications of environmental risks and hazards. These communication efforts may take place, before, during, and after such events, or may exist well ahead of a potential crisis by exposing a risk against which individuals should mitigate.

Crises and risks, by their very nature, elicit a certain degree of anxiety among those who may be affected. This is not necessarily problematic, as a certain degree of anxiety may be useful in motivating people to action. On the other hand, excessive anxiety may lead to inactivity, hopelessness, antisocial behavior, or worse (Lachlan & Spence, 2010). In reducing unnecessary anxiety, crisis communication efforts should ideally meet the public's need for control. This typically entails providing information about the risk, how to avoid the risk, and tangible steps that can be taken to minimize susceptibility.

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This underscores the importance of learning processes in crisis and risk communication efforts. Incomplete or inaccurate risk messages will impair individuals in terms of making good decisions and reacting appropriately to the risk at hand; accurate messages that are understood, internalized, and acted upon will be more effective in pushing individuals to act in ways that reduce susceptibility to harm. Of course, messages cannot be effective at engendering learning and responding if they never reach their intended audience; thus, placement and access are key concerns in the dissemination of this information (Spence, Lachlan, & Burke, 2011). Furthermore, messages delivered through different formats or media may elicit different responses or different degrees of knowledge retention, even if they contain ostensibly the same information; thus, crisis communication efforts should attempt to offer tangible recommendations for action, while at the same time considering issues related to access and source preference (Spence, Lachlan, & Griffen, 2007).

Several decades of research suggest that for most, mass media is the most commonly relied upon source for information concerning crises and risks (Brashers et al., 2000; Murch, 1971; Spence et al., 2006). Brashers et al. (2000) offer that the active processing associated with scanning through media, standing alone, brings about a sense of control and (Brashers et al., 2000). Of course, this is also contingent upon being able to access the information in question, and infrastructure failure, power outages, and other physical obstacles may make the use of media impractical.

Involvement is also worth considering in this context. A significant body of research in dual processing suggests that the level of discomfort associated with risks, coupled with their relative novelty, may drive systematic (or information based) processing, as opposed to reliance on heuristic cues and information to make sense of threatening and equivocal situations (see Eagley & Chaiken, 1993; Trumbo & McComas, 2003). If this is the case, and those processing more actively are more inclined to learn, then efforts to engage affected audiences in systematic processing are paramount. In other words, risk messages need to find some way of inducing enough discomfort to motivate people toward internalizing information, without inducing so much stress as to shut these processes down (see Lachlan & Spence, 2010 for a discussion of inducing adequate levels of negative affect). Of course, this may be contingent upon what we can expect across different strata of the population in terms of their standing levels of risk perception and tendencies when processing risk information.

2. Demographic differences in processing

A substantive body of research also suggests that there may be differences across demographic strata in terms of their understanding and response to crisis and risk messages. Varying communities may respond to crisis and risk information based on pre-existing perceptions that are culturally bound, and great variability may exist from group to group in terms of responses that can be anticipated (Lindell & Perry, 2004). Message construction, channel preference, and language barriers are all potential barriers to effective risk communication and the extent to which audiences will internalize the knowledge they need to make good decisions (Fothergill, Maestas, & Darlington, 1999). Further, members of historically underserved or marginalized communities may be less likely to accept warning or risk messages without confirmation through interpersonal contacts with trusted others, thus leading to potential delays in response time and reinterpretation of the information delivered (Fothergill et al., 1999; Lindell & Perry, 2004).

2.1. Biological sex

In addition to intercultural differences, biological sex has been demonstrated as an important factor to consider when predicting response to crisis and risk messages (Seeger, Vennette, Ulmer, & Sellnow, 2002). Following the 9/11 attacks on New York and Washington, research indicates that women found radio and television more useful than interpersonal interactions and other sources (Spence et al., 2006); this finding was surprising in the context of decades of research to the contrary. For instance, a study examining information seeking concerning terrorist attacks in Israel revealed that men preferred to acquire information from more visual media, while women gravitated toward newspaper and radio (Keinan, Sadeh, & Rosen, 2003) past studies have indicated that women may find televised news and information less interesting than men (Jensen, 1988; Morley, 1986), may be less inclined to attend to it (Konig, Renckstorf, & Wester, 1988), and may largely avoid televised news as a result of primarily masculine presentation characteristics (Vettehen, Schaap, & Schlosser, 2004).

In addition to interest and preference, there is a large body of literature indicating sex differences in response to mediated messages that are otherwise identical (Bem, 1981; Burgoon, Dillard, & Doran, 1983; Cantor, Zillmann, & Einsiedel, 1978; Jacklin & Maccoby, 1978; Messaris & Kerr, 1983; Messaris & Saret, 1981; Mosher, 1973; Perse, Nathanson, & McLeod, 1996; Schuck, Schuck, Hallam, Mancini, & Wells, 1971; Signorielli, 1989; Terry & Calvert, 1997). In terms of crisis and risk specific contexts, research conducted in the aftermath of Katrina indicated that men comprehended direct instructions better than did women, though they expressed less of a desire to seek information under the circumstances (Lachlan & Spence, 2007). At the same time, a long history of research suggests that women may be better than men at internalizing nonverbal cues and information, and that women may be better able to internalize information in interpersonal contexts as a result (Briton & Hall, 1995; Burgoon & Dillman, 1995; Kette & Konecni, 1995; LaFrance & Henley, 1994); women are also more likely to report high levels of communication satisfaction when it comes to face-to-face exchanges (Knapp & Hall, 1997). Therefore, nonverbal cues may be of paramount importance when considering the responses of women to crisis and risk messages, despite the fact that nonverbal fidelity may be largely lost in mediated exchanges. Nonverbal cues may therefore play a greater role in communication behaviors of women compared to men. Of note, to some extent social robotics involve a degree of nonverbal fidelity, as even simple messages delivered through a robotic platform will present an interaction more closely resembling an interpersonal one, with particular consideration for proxemics and kinetics.

3. Social robotics

It may be the case that under certain high involvement circumstances, robotic delivery technologies may be useful for delivering information concerning environmental risks, crises, and other circumstances that present threats to those who stand to be negatively impacted. First, it may be the case that under particular circumstances, it may be too dangerous to get human informants to the scene of a risk, or that traditional media have gone offline due to infrastructure failures or loss of power. Take for example the case of a chemical spill. In the event of a shelter in place order, where a number of people are isolated to a particular location and unable to move without incurring risk of harm, robotic technologies could be used to interact with these individuals and deliver information concerning cleanup, timeline, and risks that are posed, while at the same time taking effort to provide calm and a sense of efficacy.

At the same time, it may be the case that the novelty of the robot itself serves to engender more systematic processing. While past research has indicated that people may be initially more comfortable with the human-to-human script than with the human-to-robot interaction script (Edwards, Edwards, Spence, & Westerman, 2016; Spence, Westerman, Edwards, & Edwards, 2014), a certain degree of discomfort may be ideal under the circumstances of an environmental or human risk. This research also suggest that robot interactions may induce a certain degree of uncertainty, which may be helpful in eliciting active processing of the information presented. This is consistent with arguments forwarded elsewhere in the interpersonal literature, which suggest that expectancy violations may elicit uncertainty and a desire for information (Berger & Calabrese, 1975; Burgoon, 1993). However, the degree to which an appropriate degree of uncertainty can be induced by robots communicating about risks is completely unknown, as is the manner in which this effectiveness may vary across groups of people who may have predictable differences in information needs and desire to reduce uncertainty when placed under duress.

As an initial exploration of the viability of using robotic delivery platforms to induce learning, an experimental procedure explored these factors in the context of information concerning two risks. Given what is known about social robotics and comfort with interactions, the role of involvement in the processing risk information, and past research suggesting demographic differences in the processing of risk information, it becomes important to evaluate these factors in the context of using robots to deliver information concerning risks. While these platforms may hold promise for delivering this information in difficult circumstances, their effectiveness in eliciting retention of information is largely unknown. To that end, a quasi-experiment was conducted as an initial test of the following research questions:

- RQ1: Will factual retention vary when risk information is presented through HDTV or through a robotic delivery platform?
 RQ2: Will factual retention vary across higher and lower levels of audience involvement?
 RQ3: Do demographic factors impact the retention of information across involvement and delivery platform?

4. Methods

In order to examine the proposed research questions, a four condition quasi-experiment was conducted using one of two risk messages delivered either through traditional media or through the robot technology. A total of 175 participants were recruited from a student pool at a large research university in the northeast; the sample consisted of 93 women and 79 men (with 3 choosing not to answer). Participants were 62% Caucasian, 19% Asian, 10% African American, and 5% Latino, with 4% indicating “other” or choosing not to respond. Average respondent age was 19.65 ($SD = 4.93$).

4.1. Procedure

Participants signed up for laboratory times through an online scheduling tool, and arrived in groups of five for afternoon laboratory sessions. Sessions were held on the hour and lasted approximately 35 min each. Each group of five was randomly assigned to one of the four conditions, resulting in a fully crossed 2 X 2 (high/low involvement by robot/HDTV message delivery). Upon arrival each participant was presented with a laptop computer and asked to indicate their consent on an online survey. They were then told to await further instruction. At this time they were shown the

risk message on an HDTV or by the robot. Participants were then asked to complete a survey tapping the dependent variables of interest, along with basic demographic indicators.

4.1.1. Stimuli

Two short news packages were used as the stimuli materials in the current study. They were chosen given their use in previous studies and demonstrated evidence that they presented high exemplar messages that were capable of producing significant risk perceptions. Each news package was approximately four minutes in length. One was drawn from an ABC News feature concerning the dangers of Lean Finely Textured Beef (“pink slime”) in commercial meat production. The second described a recent campus shooting that took place at the University of Central Arkansas and the likelihood of shootings on college campuses. Zaitchowsky's (1985) measure of issue involvement was used to test for differences between the stimuli in terms of involvement. Coefficient alpha for the scale was found to be 0.93. Group mean comparisons between the stimuli indicated that the participants experienced greater involvement when viewing the LFTB condition ($M = 5.68$, $SD = 0.97$) than when viewing the school shooting condition ($M = 5.11$, $SD = 1.04$), $t(171) = 3.65$, $p < 0.001$. Participants expressed greater involvement with the news clip concerning LFTB, perhaps due to the fact that the campus shooting feature concerned an isolated event that took place at one location, and the risk of LFTB appeared imminent. In any case, there was clear evidence of differences between the stimuli in terms of participant involvement.

4.2. Stimuli delivery

4.2.1. HDTV conditions

In the linear media condition, participants were seated about five feet from a 40-inch high definition television. The stimuli were uploaded to a private YouTube channel and streamed from a laptop to the HDTV through an HDMI cable. At no time was a lack of fidelity or video hesitation evident in the data collection.

4.2.2. Robot conditions

In the social robot conditions, participants were seated in the same manner as in the HDTV condition. After completing the informed consent, the stimuli were delivered using a Suitable Technologies BEAM + smart presence system (see <https://suitabletech.com/beam-plus/>). The Beam+ is a virtual reality robot device used for telecommuting and long distance interactions. Users may “beam” into the robot device (not unlike Skype and other teleconferencing software) and move the robot from place to place. Users may also stream video, web pages, and slide presentations through the robot's face display.

Following informed consent, the robot came out from behind a scrim where it had been previously out of view to the participants; it travelled about 25 feet around the back of the seating area and stopped about three feet in front of the participants, or roughly the same distance that a human would stand if addressing the group. A blocking mark was made on the floor with masking tape and was used as a target by those driving the robot, thus ensuring that the robot delivered the stimuli from the exactly the same position in every data collection session.

Upon stopping in front of the participants, the same clips used in the HDTV condition were streamed through the “face” of the Beam+. Once again, there were no accounts of fidelity loss or video hesitation. After delivering the news package, the robot then turned and rode away to dock on its charging station, out of view of the participants. Participants were asked to complete the remainder of the survey on their laptops.

Learning was assessed using ten true/false questions regarding each of the stimuli used in the procedure. In each case the questions addressed factual information in the same order in which it appeared in the news feature, and the instruments were calibrated to be similar in level of difficulty. A summary score of correct answers was produced for each participant. Mean comparisons between stimulus indicate that the learning measures were not significantly different in terms of level of difficulty, $t(170) = 0.22$, $p = 0.828$, *n.s.* In fact, the average scores for the LFTB stimulus (7.29) and campus stimulus (7.24) were remarkably similar, and their placement suggests neither basement nor ceiling effects in the measure.

5. Results

In order to assess the combined impact of the stimulus material and the method of delivery on retention of information, a 2 X 2 ANCOVA analysis examined the learning scores for those who watched a news clip about whether a campus shooting or a LFTB, delivered through a robotic platform or through a conventional HDTV; in order to explore research question two, questions concerning respondent sex, ethnicity, and income were included in the analysis as covariates. A power analysis conducted using G*Power (see Faul, Erdfelder, Lang, & Buchner, 2007) suggested adequate statistical power given the sample size and anticipated effect sizes of 0.05, $(1-\beta) = 0.84$. The results revealed neither a main effect for stimulus, $F(1, 159) = 0.218$, $p = 0.641$, *n.s.*, nor means of delivery, $F(1, 159) = 0.040$, $p = 0.842$, *n.s.* The analysis also failed to detect any kind of interaction between stimulus and delivery method, $F(1, 159) = 3.53$, $p = 0.553$, *n.s.* Sex ($B = -0.613$, $p = 0.005$) and ethnicity ($B = -0.254$, $p = 0.003$) both emerged as significant covariates.

A simple assessment of the descriptive data for all four conditions confirms the lack of deviation in mean scores from group to group. Those exposed to the news clip regarding LFTB through HDTV recorded an average of 7.21 correct scores ($SD = 1.69$), while those who saw the clip from the robot displayed an average of 7.43 ($SD = 1.48$) correct responses. Similarly, those who watched the news clip regarding the campus shooting scored an average of 7.36 in the HDTV condition ($SD = 1.36$), while those watching the clip when delivered by a robot reported an average score of 7.10 ($SD = 1.19$). In sum, the evidence indicates that when presented with tightly calibrated learning measures, subjects retained almost an almost identical amount of factual information. Across the sample on the whole, there was no variability in retention based on level of involvement, or on whether they received the message from a legacy media (HDTV) or through robotic delivery.

Post hoc analyses were used to explore the relationship between sex and knowledge acquisition. A simple *t*-test comparing men and women across the entire sample suggests that on the whole, men ($M = 7.56$, $SD = 1.27$) retained more information than did women, ($M = 7.01$, $SD = 1.49$). However, a 2 X 2 X 2 ANOVA analysis, crossing involvement, delivery platform, and sex suggests that there may be variability in the difference under certain conditions; statistical power was detected as $(1-\beta) = 0.83$.

Unsurprising given the analyses above, a main effect was detected for sex, $F(1, 164) = 6.41$, $p = 0.012$, $\eta^2 = 0.04$. What is more interesting, however, is that a substantial interaction effect emerges between sex and delivery platform, $F(1, 164) = 8.06$, $p = 0.005$, $\eta^2 = 0.05$. In the HDTV conditions, there is a substantive difference between men ($M = 7.89$, $SD = 1.16$) and women ($M = 6.76$, $SD = 1.58$) in terms of their retention scores. However, these differences practically disappear in the robot conditions, with men ($M = 7.24$, $SD = 1.31$) and women ($M = 7.25$, $SD = 1.35$) reporting almost identical scores on the learning test. While a significant three-way interaction was not detected, an examination of the cell

means across all eight conditions suggests that in the higher involvement condition the sex differences actually reversed, and that women retained more information than men when it was presented through a robotic delivery platform (see Table 1).

Given that more complex analyses would produce very small cell sizes, the analyses for ethnicity are limited to a one way ANOVA, examining knowledge acquisition across category; power was found to be $(1-\beta) = 0.63$. While the analysis was found statistically significant, $F(4, 166) = 4.35$, $p = 0.002$, $\eta^2 = 0.09$, it is still rather difficult to draw conclusions from these data. Caucasian ($M = 7.46$, $SD = 1.41$) and African American respondents ($M = 7.61$, $SD = 1.03$) were almost identical in their level of retention, followed by Asian respondents ($M = 6.42$, $SD = 1.35$); Latinos and those identifying as “other” comprised a total of 12 cases.

6. Discussion

Taken together, the results of this initial exploration offer some interesting insights into the effectiveness of robots in delivering information concerning risks, at least when compared to traditional media. While the study is confined to a laboratory setting and risks that may be less imminent, the results offer some evidence of the effectiveness of the robots in engendering learning, and directions for future field research in the area.

More than anything, these results suggest that on the whole, robots may be no more or less effective than more traditional media in delivering information that is immediately retained by observers. Using instrumentation that was tightly calibrated in terms of level of difficulty, respondents in the higher and lower involvement conditions retained demonstrated almost identical retention of the information they received, as did those in the HDTV and robot conditions. Some research has suggested that humans may typically feel a certain degree of surprise or a lack of comfort when experiencing an interaction with a robot, which may in turn impact subsequent interactions (see Edwards et al., 2016; Spence et al., 2014). This may be due to expectancy violations (Burgoon, 1993), as our conventional understandings of interpersonal interaction center around interactions with humans. While our expectations of mediated interactions may extend beyond linear media to include various forms of computer-mediated communication, they are unlikely to include interactions with robots (whether those interactions more closely resemble interpersonal or mediated exchanges).

However, in this instance it does not appear as though these expectancy violations led to any kind of inhibition in terms of learning processes. This may be good news for emergency managers considering the use of robotic technologies in responding to risks and crises. While the stakes are obviously not as high in a laboratory experiment, and the stimulus centered on an event that had taken place elsewhere, initial results suggest that audiences retain just as much information from robots as they do from televised messages.

Table 1
Retention scores by condition.

Stimulus	Delivery	Sex	M	SD
High involvement	HDTV	Male	7.68	1.45
		Female	6.77	1.70
	Robot	Male	7.21	1.39
		Female	7.65	1.56
Low involvement	HDTV	Male	8.10	0.73
		Female	6.75	1.44
	Robot	Male	7.27	1.27
		Female	6.87	1.26

This held for both lower and higher involvement risks. Given what is known about involvement and uncertainty reduction, it could be speculated that individuals perceiving higher risk involvement would be less likely to become distracted by the expectancy violation, as under these conditions knowledge acquisition becomes paramount and source becomes a secondary concern. Conversely, it could be speculated that when informed of a risk perceived as less imminent, audiences may be more likely to become distracted by the robot. While this manipulation was admittedly weak, the current evidence suggests that neither of these processes took place.

This calls for replication in a field setting with higher involvement risks. The current results are an interesting beginning, and provide some evidence that robot technologies may be as useful as more traditional media information campaigns in delivering information to audiences concerning crisis and risks, at least in terms of the retention of facial information. Replicating the study in a more naturalistic environment, with a robotic interaction more closely resembling an interpersonal one, would serve to build upon this research and provide additional evidence of the utility of these technologies in field settings.

The observed sex effects are also noteworthy. While the homogeneity of the sample makes commentary on the intercultural differences difficult to comment on, the sex effects are fairly clear. Men reported slightly higher learning scores than did women, which is consistent with past research in the crisis and risk canon suggesting that masculine message presentation characteristics may inhibit processing or interest on the part of female viewers (Jensen, 1988; Vettehen et al., 2004). What is particularly interesting is the reverse of this sex effect for the higher involvement/robot delivery condition. Women reported retaining more information in this condition only, while men reported retaining more in the other three. This may be consistent with a preference for receiving information from non-visual media, as the interaction with the robot may have felt more like an interpersonal exchange than a mediated one (see Keinan et al., 2003). It may also be the case that the robot interaction more closely mirrored nonverbal cues related to proxemics and kinesics; the robot approached the participants much in the way a human would, and “stood” at approximately the same range a human would when speaking to a group of people in a more intimate setting. It may be the case that the proxemics and kinesic similarities to a human interaction were effective for the female participants, consistent with past evidence that women may be better than men at decoding nonverbal cues and may experience greater satisfaction with face-to-face communication than with other types of exchanges (Briton & Hall, 1995; Knapp & Hall, 1997; LaFrance & Henley, 1994). What is not clear, however, is why this particular response only occurred in the higher involvement condition. Future research should further explore these sex differences, not only in terms of factual retention, but in terms of satisfaction with the interaction and with motivation to use the information received to mitigate against the risk in question.

6.1. Conclusions

While this study in only a single exploratory study, it does offer some insight into the effectiveness of robot delivery platforms in bringing risk messages to affected publics. The initial evidence suggests that these systems may be as effective on the whole as more traditional mediated strategies, and emergency managers may wish to begin considering their utility in reaching audiences that are isolated or somehow disconnected from other forms of information. It may also be the case that the effectiveness of robotic delivery platforms may vary across demographics, and across

specific crisis and risks depending upon the risks of harm they pose to the audience in question. Future research should replicate the current procedures in field settings, with diverse audiences and varying stimuli, in order to build upon these initial discoveries. Field research in this domain should also attempt to develop message strategies that more closely mirror interpersonal interactions (as opposed to mediated messages delivered through robots), in order to investigate whether this will further drive the retention of information that can be used to mitigate against potential harm. In sum, it appears as though robots may provide emergency managers and responders with a new and useful means of delivering risk information to isolated individuals, though more field testing is necessary to further understand these processes.

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