Enhancing Smoking Risk Communications: The Influence of Health Literacy and Message Content

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Abstract

Background Efforts are needed to ensure that smokers with lower health literacy are provided with understandable and impactful information about the health consequences of smoking and benefits of quitting.

Purpose To test the influence of health literacy on smokers' responses to health risk messages manipulated on framing (gain vs. loss) and emotionality (factual vs. emotional).

Methods Participants ($N = 402$) were randomized to evaluate one of four sets of smoking risk messages (factual gain-framed, factual loss-framed, emotional gain-framed, or emotional loss-framed). Multiple linear regressions examined main effects of health literacy, message emotionality, and message framing on: (a) risk perceptions, (b) behavioral expectations (i.e. cut down, limit, quit), and (c) risk knowledge. Two-way interactions of health literacy with emotionality and framing were examined for these outcomes. Analyses were based on theory-driven, a priori hypotheses.

Results As hypothesized, main effects emerged such that smokers with higher health literacy reported stronger risk perceptions and knowledge retention regardless of message type. Additionally, emotional (vs. factual) and gain- (vs. loss-) framed messages were associated with certain lower risk perceptions regardless of health literacy level. Consistent with hypotheses, two-way crossover interactions emerged between health literacy and emotionality. Among smokers with higher health literacy, factual messages produced higher perceived risk and stronger expectations for quitting. Among smokers with lower health literacy, emotional messages produced higher perceived risk and stronger expectations for quitting.

Conclusions Health literacy plays an important role in influencing how smokers respond to different risk messages. One's health literacy should be considered when determining whether risk communications emphasize factual or emotional content.

Keywords Smoking • Risk communications • Health literacy • Message tailoring • Health disparities

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Introduction

Tobacco smoking is the most preventable cause of morbidity and mortality in the USA, accounting for one-third of all cancer-related deaths [1]. While overall smoking rates have declined, smoking has become concentrated among racial/ethnic minorities and those with the lowest levels of education, income, and occupation [2]. Individuals from these groups are less likely to quit smoking, as they have less access to evidence-based cessation resources, and are less likely to use such resources [3, 4]. Thus, smoking is the leading behavioral risk factor contributing to social disparities in the incidence and mortality of disease [5], and has a critical impact on racial/ethnic and socioeconomic disparities in cancer morbidity and mortality [3, 4].

Health Literacy and Smoking

Health literacy is the degree to which one has the ability to obtain, understand, and use health information to make appropriate decisions about health and medical care [6]. Nearly half of U.S. adults have health literacy difficulties; yet, racial/ethnic minorities and those with low education, income, and occupational status are unduly affected [7]. Low health literacy is associated with poor health and adverse health outcomes [8], and has been linked with unhealthy behaviors [8], including smoking [9]. Furthermore, findings suggest that lower health literacy is associated with established predictors of smoking relapse (i.e. nicotine dependence, positive smoking expectancies and attitudes, low smoking risk knowledge and perceptions; [10, 11]) and relapse following treatment [12]. Although these and other studies have indicated that smoking and health literacy are strongly associated, no previous studies have established a causal link between health literacy and smoking.

Risk Communications Targeted to Individuals With Low Health Literacy

It is vital that smokers with health literacy difficulties are provided with information concerning the health consequences of smoking and benefits of quitting in a way that they are able to understand. Nevertheless, little is known about how health literacy might influence smokers' responses to different types of smoking risk communications. Among individuals with lower education and income, even targeted interventions have been found to produce smaller knowledge gains and fewer health behavior changes than among individuals with higher education and income [13]. Risk communications that are not understood by intended audiences are likely to result in confusion and poor adherence to recommendations [14].

No known studies have examined how to best communicate smoking risk information to smokers with health literacy difficulties, yet ample work has evaluated how to communicate about other health risks to individuals with low health literacy [15–17]. Recommendations emphasize the importance of simplifying information [15, 17]. While some studies suggest that messages targeted to those with lower health literacy may also be appropriate for those with higher health literacy [18–20], others have refuted this [21, 22]. Efforts to elucidate optimal methods of tailoring smoking risk communications for individuals with health literacy difficulties are critically needed.

Message Tailoring

Reviews of studies evaluating tailored health risk communications indicate that message tailoring enhances efficacy [23–25]. Tailored messages are more closely attended to, better remembered, perceived as more credible and relevant, and have greater efficacy in influencing health behaviors such as smoking, healthy eating, and mammography screening [25–28]. In the health literacy literature, most studies have tailored the content of health messages on reading level, general comprehensibility, mode of communication (i.e. written vs. verbal), and/or the use of plain language, bulleted text, and illustrations [16, 29, 30]. No interventions that we know of have simultaneously manipulated risk message content on both framing and emotionality, two critical dimensions shown to influence the efficacy of risk communications [31, 32].

Message Tailoring Dimensions

Message framing

The framing postulate of Kahneman and Tversky's Prospect Theory [33] posits that people are risk averse when problems are framed in terms of potential gains, but prefer risky outcomes when decisions are framed in terms of potential losses. In their seminal work, Rothman and Salovey [34] applied this reasoning to the framing of health messages. They suggested that gain-framed messages, which stress the benefits of engaging in a behavior, are more persuasive for illness prevention behaviors, while loss-framed messages, which highlight the consequences of not engaging in a behavior, are more effective for illness detection or screening behaviors. Simply put, for quitting smoking, an example of a gain-framed message is, "Quitting smoking adds years to your life," and a loss-framed message is "Continuing to smoke takes away years from your life." Notably, the content of the messages is identical, and only the framing is different. Results from a recent meta-analytic review support

Rothman and Salovey's [34] perspective, and suggest that gain-framed messages are more effective than loss-framed messages for encouraging preventive behaviors (e.g. quitting smoking; [32]).

Message emotionality

The factual versus evaluative, or emotional, orientation of a persuasive message provides a dimension upon which message complexity can be systematically manipulated. As defined by Holbrook [35], factual messages emphasize logically and objectively verifiable information, whereas evaluative messages contain information that is emotional and subjective. While factual messages often require more extensive and effortful information processing, emotional messages tend to require less thoughtful deliberation [36, 37]. It is possible that individual difference factors such as health literacy may impact whether individuals are more strongly influenced by factual versus emotional messages. No known studies have tested if health literacy influences responses to risk messages manipulated on emotionality.

Health Literacy and the Elaboration Likelihood Model of Persuasion

The elaboration likelihood model of persuasion posits that one's level of cognitive motivation and their ability influences how persuasive information is processed, with the eventual goal of behavior change [38, 39]. The elaboration likelihood model is based on two modes or "routes" of information processing: central and peripheral. The central route involves cognitive elaboration, and operates when individuals are both highly motivated and have the ability to scrutinize issue-relevant message components. When information is processed via the central route, resultant attitudes are persistent, predictive of future behavior, and difficult to change. Conversely, the peripheral route operates when individuals are less motivated or able to process critical message components. Thus, when information is processed via the peripheral route, individuals may rely on cues such as attractiveness or credibility of the message source, number of arguments, and/or whether the message is easy to understand. Attitudes resulting from peripheral (vs. central) route processing are easier to change, and are poorer predictors of future behavior. Prior research has found that individuals with lower health literacy have trouble processing information-dense and complex health material [8]. Thus, it is posited that individuals with lower health literacy may be more likely to process complex persuasive information through the peripheral route, thereby rendering these messages as less potent. Health literacy may therefore function as a key variable that influences the route through which messages are processed, and the ultimate persuasiveness and potency of such messages.

The Current Study

No known studies have examined how health literacy influences smokers' responses to different types of smoking risk communications. Efforts are needed to address this gap in the literature and to elucidate ways of effectively communicating about the health consequences of smoking to smokers with limited health literacy. This laboratory study examined the influence of health literacy on smokers' responses to different types of messages manipulated in terms of framing (gain vs. loss) and emotionality (factual vs. emotional). Primary outcomes included smoking risk perceptions, behavioral expectations for changing smoking behavior (i.e. cut down, limit smoking, quit), and risk message knowledge retention, as these constructs (i.e. risk perceptions, behavioral expectations, risk knowledge) are associated with both theoretical models of health behavior change as well as actual behavior change [40–42]. Our five hypotheses are consistent with the elaboration likelihood model [38, 39], and are driven by prior findings related to smoking risk communications [31].

First, a main effect of health literacy was hypothesized on each of the three primary outcomes such that smokers with higher (vs. lower) health literacy would be more strongly influenced by the smoking risk messages, regardless of message type. This hypothesis was based on data indicating that those with higher health literacy are better able to comprehend and assimilate health-relevant information [8].

Second, although we had no hypotheses regarding the emergence of a potential main effect for message emotionality (factual vs. emotional), we tested for the presence of a main effect for emotionality on each of the three primary outcomes.

Third, because evidence suggests that gain-framed messages are more effective than loss-framed messages in motivating prevention behaviors [32, 34], a main effect for message framing was hypothesized such that gain-framed messages were predicted to more strongly influence each of our primary outcomes.

Fourth, an interaction between health literacy and emotionality was hypothesized. Smokers with higher (vs. lower) health literacy were expected to perceive the factual (vs. emotional) messages as more potent given that these messages emphasized discrete, factual pieces of information that they would be required to interpret and evaluate. Because smokers with higher health literacy

were expected to have greater cognitive resources to process information-dense messages that emphasized facts and statistics compared to smokers with lower health literacy, those with higher health literacy were expected to perceive the factual (vs. emotional) messages as more potent. Conversely, those with lower health literacy were expected to have fewer cognitive resources available to process the factual (vs. emotional) messages and to, therefore, be more strongly influenced by the emotional messages because these messages relied heavily on subjective and emotional descriptors to enhance interpretability.

Finally, an interaction between health literacy and message framing was predicted such that framing effects would be stronger among those with lower (vs. higher) health literacy. That is, because lower (vs. higher) health literacy smokers were expected to be less likely to understand and carefully scrutinize issue-relevant components of a message, lower (vs. higher) health literacy smokers were expected to be more strongly influenced by characteristics peripheral to the actual message content. Thus, the gain- (vs. loss-) framed messages were expected to have a larger influence on outcomes for all smokers, but this effect was predicted to be larger among those with lower (vs. higher) health literacy.

Method

Development of Smoking Risk Messages

The content of the smoking health risk messages was developed using sources including the American Cancer Society, the National Cancer Institute, the American Lung Association, and scientific journal articles. Content was specifically designed to emphasize health consequences of smoking that are less well-known (e.g. gum disease, ulcers, fertility problems, chronic heartburn, cervical cancer, skin cancer, osteoporosis, brain aneurysm) as well as more well-known consequences (e.g. lung cancer, emphysema, heart disease). Potential messages were developed and then evaluated using learner verification and revision procedures.

Learner verification and revision procedures

Using procedures outlined by Doak et al. [29], we conducted three focus groups with socioeconomically and racially/ethnically diverse smokers with varying levels of health literacy. Focus groups followed learner verification and revision procedures [29] to help identify message content that was less than optimal, and to ensure that the information included in the smoking risk messages was appropriate for the target population. These procedures aim to verify five critical elements: (a) attraction (whether a message is appealing to the intended audience); (b) comprehension (whether intended

audience members are able to describe and interpret the message content into their own words); (c) self-efficacy (whether individuals have confidence in their ability to carry out behaviors proscribed in a message); (d) cultural acceptability (whether a message contains any offensive content); and (e) persuasion (whether the message is capable of convincing intended audience members to take a recommended action). Potential messages were presented to focus group participants for discussion and feedback, and then revised based on this feedback. Messages were equivalent in length, content, and readability, and written at a 5th to 6th grade Flesch-Kincaid reading level [43].

Development of message sets

Messages were manipulated in terms of framing (gain vs. loss) and emotionality (factual vs. emotional). Gain- and loss-framed messages were created to be consistent with recommendations by Rothman and Salovey [34]. Gain-framed messages reflected either the protective behavior's (i.e. quitting smoking) capacity to produce or fail to produce an expected outcome. Loss-framed messages emphasized the likelihood of achieving an undesirable outcome or the probability of failing to achieve it. The factual versus emotional manipulation was drawn from the advertising literature [35–37] and messages were created to be consistent with prior work in the area of smoking risk communications [31]. Factual messages described each health consequence of smoking using logical, well-documented, and objectively verifiable information, and emotional messages conveyed smoking risks in terms of emotional, impressionistic, and subjective statements. Framing and emotionality were crossed to create four distinct message sets, each comprising 10 messages: (a) factual gain-framed, (b) factual loss-framed, (c) emotional gain-framed, and (d) emotional loss-framed (Fig. 1).

Participants

Participants ($N = 402$) were recruited in Houston, Texas via newspaper advertisements. Eligible individuals were daily smokers (≥5 cigarettes per day/past year) with expired carbon monoxide levels of ≥10 ppm, 18–70 years old, and able to speak, read, and write English. Exclusion criteria were: current enrollment in smoking cessation treatment, use of nicotine replacement therapy or bupropion, and intention to quit smoking within 30 days of enrollment.

Procedures

Potential participants were screened for eligibility and eligible individuals were scheduled for in-person visits,

	Loss-Framed	**Gain-Framed**
Factual	An ulcer is an open sore in the stomach. It can be very painful. Smokers are more likely than people who don't smoke to get ulcers. If you smoke, ulcers are less likely to heal. Also, smokers die more often from ulcers. Some studies find that smokers are more likely to get infected with the bacteria that cause ulcers. This type of bacteria is called *Helicobacter pylori*. Other studies find that regular smoking may increase the amount of acid that the stomach makes. If you smoke, your ulcer is more likely to burst. This can cause you to have bloody stools and to throw up. *[reading level: grade 5.3; 105 words]*	An ulcer is an open sore in the stomach. It can be very painful. People who don't smoke are less likely than smokers to get ulcers. Ulcers heal more often in people who don't smoke. Also, nonsmokers die less often from ulcers. Some studies find that nonsmokers are less likely to get infected with the bacteria that cause ulcers. This type of bacteria is called *Helicobacter pylori*. Other studies find that not smoking reduces the amount of acid that the stomach makes. If you don't smoke, your ulcer is less likely to burst. This can prevent you from having bloody stools and throwing up. *[reading level: grade 5.8; 104 words]*
Emotional	If you smoke, you are much more likely than a person who doesn't smoke to suffer from the scary and serious effects of ulcers. Ulcers can cause you to bleed inside your stomach. This bleeding can be hard for your doctor to find. Ulcers can cause stabbing pains that course through your stomach. The awful pain may move to your back or your chest. If you smoke, your ulcer is more likely to burst. If it bursts, you may suffer from black or bloody stools. You may also throw up blood or something that looks like coffee grounds. *[reading level: grade 4.3; 98 words]*	If you don't smoke, you are much less likely than a person who smokes to suffer from the scary and serious effects of ulcers. Ulcers can cause you to bleed inside your stomach. This bleeding can be hard for your doctor to find. Ulcers can cause stabbing pains that course through your stomach. The awful pain may move to your back or your chest. If you don't smoke, your ulcer is less likely to burst. By preventing an ulcer from bursting, you may avoid black or bloody stools. You may also avoid throwing up blood or something that looks like coffee grounds. *[reading level: grade 4.7; 102 words]*

Fig. 1. Example of message types.

during which the study was described further, written informed consent was obtained, eligibility was finalized, and baseline questionnaires were completed. Baseline questionnaires assessed demographics, smoking history, nicotine dependence, smoking risk perceptions, behavioral expectations, and smoking risk knowledge. Questionnaires were administered using the Questionnaire Design System, a computer-administered self-report interview system that includes audio and visual scripts. Participants were randomly assigned to review one of the four message sets based on age, gender, race/ethnicity, and education using a form of adaptive randomization called minimization [44]. Messages were presented on the computer in written form and accompanied by human-recorded audio scripts. Participants then completed a manipulation check to assess the degree to which they perceived the smoking risk messages as intended. Post-message questionnaires assessing risk perceptions, behavioral expectations, and risk knowledge were completed, and participants received $35 in compensation. Procedures were approved by the institution's Institutional Review Board.

Baseline Pre-Message Measures

Demographics

Demographics included age, gender, race/ethnicity, education, total annual household income, employment, and relationship status.

Health literacy

Health literacy was assessed with the Test of Functional Health Literacy in Adults [45], which consists of two timed parts: a 50-item reading comprehension section and a 17-item numeracy section. Reading comprehension is assessed at the 4th, 10th, and 19th grade levels using a modified cloze procedure where every fifth to seventh word is omitted. Readers choose the word that best fits each missing space from four possible choices. Reading comprehension passages include: instructions for preparation for an upper gastrointestinal series, the patient rights and responsibilities section of a Medicaid application form, and a standard hospital informed consent form. Numeracy items measure participants' ability to comprehend hospital forms and prescription labels. The

sum of scores from both sections yields the total score, which ranges from 0 to 100. Scores are classified into three categories of functional health literacy: inadequate (score of 0–59), marginal (score of 60–75), and adequate (score of 76–100); however, scores can also be handled continuously [45]. The content and criterion validity of this measure are well-supported and internal consistency is excellent with an alpha of 0.98 [45].

Nicotine dependence

Nicotine dependence was assessed with the Heaviness of Smoking Index, which comprises number of cigarettes smoked per day and time to first cigarette upon waking. This index is a good indicator of nicotine dependence [46], is reliable [47], and predicts relapse [48].

Smoking risk perceptions

Risk perceptions were assessed in terms of absolute (personal risk) and relative risk (risk compared to other smokers). Participants responded to the following four questions on a 7-point, verbally-anchored Likert scale with responses ranging from "extremely unlikely" to "extremely likely": (a) "If you don't quit smoking for good, what are your chances of ever developing a smoking-related health problem?"; (b) "If you quit smoking for good, what are your chances of ever developing a smoking-related health problem?"; (c) "Compared to other smokers, what are your chances of ever developing a smoking-related health problem if you continue smoking?"; and (d) "Compared to other smokers, what are your chances of ever developing a smoking-related health problem if you quit smoking for good?" Two other items used a numerical response scale ranging from 0% to 100%: (e) "What is your perceived risk of developing at least one health consequence of smoking if you quit smoking for good?" and (f) "What is your perceived risk of developing at least one health consequence of smoking if you continue smoking?" These items were developed for this study based on prior research, suggesting that risk perceptions be assessed using a variety of assessment strategies [49, 50]. Because each item measured a conceptually distinct concept, we analyzed each item individually and did not combine items to create composite indices.

Behavioral expectations

Behavioral intentions are conceptualized as one's specific plan to perform a behavior, and behavioral expectations are one's perceived likelihood of performing a behavior [51]. Behavioral expectations have shown greater predictive validity than intentions [41], and were assessed in this study. Participants were asked how likely it was that they would do the following during the next 2 months: (a) "Cut down on the number of cigarettes I smoke;" (b) "Begin to limit my smoking to certain places or situations;" and (c) "Quit smoking completely." Responses were on a Likert scale ranging from 1 ("not at all") to 9 ("extremely").

Smoking risk knowledge

Knowledge about smoking health risks was measured with a 20-item multiple-choice measure developed for the current study and based on the content of the smoking health risk messages.

Post-Message Measures

Manipulation check

A 10-item manipulation check was administered to evaluate the degree to which factual messages were perceived as factual, emotional messages were perceived as emotional, gain-framed messages were perceived as emphasizing the good about quitting smoking, and loss-framed messages were perceived as emphasizing the bad things about not quitting smoking. Five of the 10 items assessed the degree to which messages were perceived as factual versus emotional, and five items assessed the degree to which messages were perceived as gain- versus loss-framed. Responses were rated on a Likert scale ranging from 1 ("not at all") to 9 ("entirely"). The emotionality items and the framing items were summed to create separate composite indices, with higher scores reflecting a greater degree of agreement that messages were perceived as intended.

Smoking risk perceptions, behavioral expectations, and smoking risk knowledge

Post-message risk perceptions, behavioral expectations, and risk knowledge were assessed using the same items administered at baseline.

Statistical Analyses

T-tests were conducted on emotionality and framing composite manipulation check scores to determine if the messages were perceived as intended. Next, multiple linear regression analysis was used to examine main effects of health literacy, emotionality (factual vs. emotional) and framing (gain vs. loss) on: (a) risk perceptions, (b) behavioral expectations, and (c) knowledge retention. Next, two-way interactions between health literacy and emotionality and health literacy and framing were examined using multiple regression with respect to these same outcomes. Significant interactions were plotted at two values (±1 standard deviation of the mean). Two sets of models were run. First, unadjusted analyses including only baseline levels of the dependent variables were conducted. Next, adjusted models controlling for baseline levels of the dependent variables along with demographics (i.e.

age, gender, race/ethnicity, education, relationship status) and nicotine dependence were conducted. Unadjusted and adjusted results were identical with one exception. Therefore, we have reported only the results of the adjusted models, and described the one finding that differed between the two models. Consistent with prior research, and because scores were skewed toward the higher end of the health literacy spectrum, scores on the Test of Functional Health Literacy in Adults were treated as continuous in all analyses [45]. Because all hypotheses were theoretically-based and a priori, no adjustments were made for multiple comparisons [52, 53]. Analyses were conducted in SAS version 9.4 (SAS Institute, Cary, NC).

Results

Manipulation Check

As expected, the 5-item composite score designed to evaluate perceived factualness versus emotionality indicated that the factual messages were rated as significantly more factual (vs. emotional), and that the emotional messages were rated as significantly more emotional (vs. factual; factual, $M = 24.5$, $SD = 5.9$; emotional, $M = 25.7$, $SD = 5.3$; $t(398) = 2.2$, $p = .03$). Similarly, the 5-item composite score designed to assess whether participants perceived the messages as gain- versus loss-framed indicated that these messages were also perceived as intended (gain, $M = 25.1$, $SD = 5.7$; loss, $M = 22.1$, $SD = 6.5$; $t(399) = 4.9$, $p < .001$).

Participant Characteristics

Participants had a mean age of 43.2 years (±10.8), and were mostly male (66%) and Black (69.7%). Twenty-seven percent had less than a high school education and 70% had a total annual household income of less than $10,000. Most (81.6%) were not married or living with a partner. Participants smoked an average of 17.9 cigarettes per day (±9.2), and 47% reported smoking their first cigarette within 5 min of waking. Participants had an average health literacy score of 86.9 (±11.2, range 78–100), suggesting that most had adequate health literacy.

Main Effects of Health Literacy

Risk perceptions

As hypothesized, a main effect emerged for health literacy on risk perceptions such that health literacy was significantly and positively associated with perceived risk. Specifically, regardless of message type, participants with higher health literacy perceived greater absolute personal risk, risk relative to other smokers, and perceived risk assessed in terms of percent risk of developing a smoking-related health problem if one were to continue

smoking ($β = 0.02$, $SE = 0.01$, $p = .006$, $ω^2 = 0.01$, for item 1; $β = 0.01$, $SE = 0.01$, $p = .025$, $ω^2 = 0.01$, for item 3; $β = 0.02$, $SE = 0.01$, $p = .037$, $ω^2 = 0.01$, for item 6). Similarly, those with higher health literacy perceived lower absolute personal risk and risk relative to other smokers for developing a smoking-related health problem if one were to quit smoking for good ($β = −0.03$, $SE = 0.01$, $p < .001$, $ω^2 = 0.04$, for item 2; $β = −0.03$, $SE = 0.01$, $p < .001$, $ω^2 = 0.03$, for item 4). Health literacy was not associated with perceived percent risk of developing a smoking-related health consequence if one were to quit smoking ($β = −0.0004$, $SE = 0.01$, $p = .97$ for item 5).

Behavioral expectations

Contrary to hypotheses, there was no main effect of health literacy on behavioral expectations for cutting down, limiting, or quitting smoking ($ps > .05$).

Knowledge retention

As hypothesized, a main effect emerged such that health literacy was associated with greater retention of message content knowledge ($β = 0.32$, $SE = 0.07$, $p < .001$, $ω^2 = 0.02$).

Main Effects of Message Emotionality

A main effect was not predicted for emotionality; yet, results indicated that emotional (vs. factual) messages were related to lower perceived percent risk of developing a smoking-related health problem if one were to continue smoking ($β = −0.65$, $SE = 0.23$, $p = .004$, $ω^2 = 0.01$, for item 6). Emotionality was not associated with any other outcomes ($ps > .05$).

Main Effects of Message Framing

A main effect was hypothesized for framing such that gain- (vs. loss-) framed messages were expected to more strongly influence perceived risk, behavioral expectations, and knowledge. Results from unadjusted analyses were nonsignificant ($ps > .05$), but results from adjusted analyses indicated that gain-framed messages were associated with lower perceived risk compared to other smokers if one were to quit smoking for good ($β = −0.34$, $SE = 0.17$, $p = .044$, $ω^2 = 0.01$, for item 4). Framing was not associated with any other outcomes ($ps > .05$).

Interactions Between Health Literacy and Message Emotionality

Risk perceptions

Consistent with hypotheses, results revealed a significant two-way crossover interaction between health literacy and message emotionality (factual vs. emotional) on one of the six smoking risk perception items ($β = −0.03$,
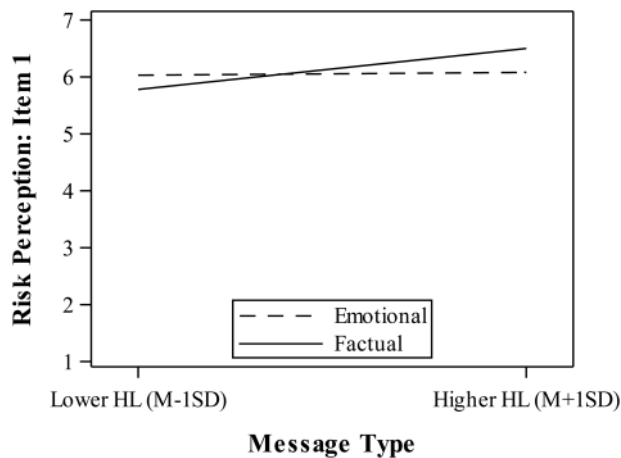
Fig. 2. Two-way crossover interaction between Health Literacy and Message Emotionality on Smoking Risk Perception Item 1 ("If you don't quit smoking for good, what are your chances of ever developing a smoking-related health problem?").

Fig. 3. Two-way crossover interaction between Health Literacy and Message Emotionality on Behavioral Expectation for Quitting Smoking Completely.

$SE = 0.01$, $p = .01$ for item 1). This item assessed perceived risk of developing a smoking-related health condition if one were to continue to smoke (i.e. "If you don't quit smoking for good, what are your chances of ever developing a smoking-related health problem?"). As illustrated in Fig. 2, smokers with higher health literacy reported greater perceived risk in response to factual (vs. emotional) messages. On the other hand, smokers with lower health literacy reported higher levels of perceived risk in response to emotional (vs. factual) messages. Health literacy did not significantly interact with message emotionality on any of the other risk perception outcomes.

Behavioral expectations

As hypothesized, results revealed a significant two-way crossover interaction between health literacy and message emotionality on behavioral expectations for quitting completely ($\beta = -0.04$, $SE = 0.02$, $p = .034$). Fig. 3 illustrates that smokers with higher health literacy reported stronger expectations of quitting smoking completely in response to factual messages and lower expectations of quitting in response to emotional messages. On the other hand, smokers with lower health literacy reported stronger behavioral expectations of quitting in response to emotional messages and weaker expectations of quitting in response to factual messages. Health literacy and message emotionality did not interact significantly to predict other outcomes related to expectations of changing smoking behavior (i.e. cutting down or limiting smoking, ps > .05).

Knowledge retention

Contrary to hypotheses, health literacy and message emotionality (factual vs. emotional) did not interact to predict smoking risk knowledge retention ($p = .444$).
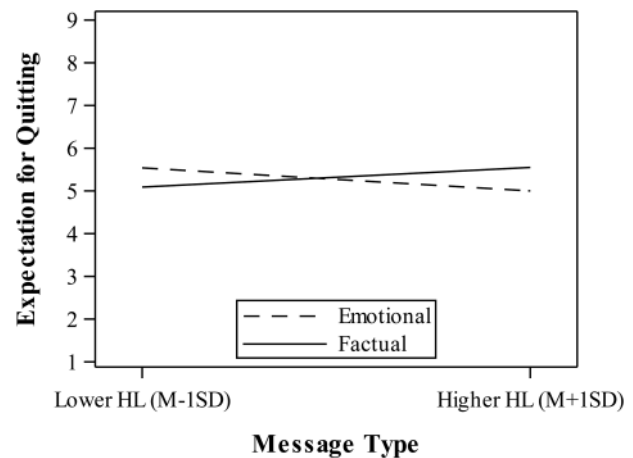
Interactions Between Health Literacy and Message Framing

Unexpectedly, no significant interactions emerged between health literacy and message framing (gain vs. loss) on risk perceptions, behavioral expectations, or knowledge (ps > .05).

Discussion

This is the first known study to examine the influence of health literacy on smokers' responses to different types of smoking health risk messages manipulated on the dimensions of framing (gain vs. loss) and emotionality (factual vs. emotional) in a sample of racially/ethnically diverse smokers with low socioeconomic status. Results provide compelling evidence that health literacy may play an important role in the way that smokers perceive smoking health risk information. Findings have important implications for public health campaigns, patient-provider communication and cessation interventions. Results and implications are discussed in detail.

As hypothesized, main effects emerged such that smokers with higher health literacy reported stronger smoking risk perceptions and demonstrated greater smoking risk knowledge retention, regardless of message type, whereas smokers with lower health literacy reported lower levels of perceived risk and knowledge retention in response to all of the messages. These findings are in line with prior research suggesting that lower health literacy is associated with lower smoking risk perceptions and less knowledge about the health risks of smoking [10, 11]. This is important given that lower perceived vulnerability is associated with current smoking and poor cessation outcomes [40, 42].

We had no hypotheses regarding a potential main effect of message emotionality on our primary outcomes, but analyses revealed a significant main effect for emotionality on one of the risk perception outcomes—perceived risk assessed in terms of percent. Specifically, emotional (vs. factual) messages were associated with lower perceived risk. In the absence of a priori hypotheses, and given that only one of the 11 outcomes examined was significant, it is difficult to make much of this finding, and it should be interpreted cautiously. However, this finding is consistent with the Extended Parallel Process Model [54, 55], a framework for effective communication of health and risk-related information. According to this model, danger control processes, which are cognitive in nature, involve removing threat and are a function of higher self-efficacy. Conversely, fear control processes, which are emotional in nature, involve coping with the emotion (i.e. fear) rather than the threat, are a function of low self-efficacy, and result in the minimization of perceived risk rather than acknowledging danger. Thus, it is possible that the emotional (vs. factual) messages elicited fear control rather than danger control processes. Additional research is needed to further investigate this possibility.

Main effects of message framing on risk perceptions, behavioral expectations, and risk knowledge were hypothesized, and results indicated that gain-framed messages were associated with significantly lower perceptions of personal risk if one were to successfully quit smoking for good. This finding is in line with our hypotheses given that gain- (vs. loss-) framed messages more strongly influenced perceptions of risk that were conditional upon permanently changing a health behavior that would reduce their personal risk (i.e. to successfully quit smoking for good). Contrary to hypotheses, results indicated that framing was not associated with any other outcomes. This was unexpected given that prior research has linked the use of gain-framed messages to higher uptake in prevention behaviors [32, 34]. Nevertheless, two recent meta-analytic reviews reported that gain-framed messages demonstrated little to no advantage over loss-framed messages when *attitudes* or *intentions* for adopting illness prevention behaviors (e.g. quitting smoking) were the outcomes [32, 56]. Recent work in the area of message framing has found that the impact of gain- and loss-framed messages may depend on certain personal characteristics such as the motivational orientation of message recipients [57]. Future studies should examine if such characteristics (e.g. motivation, ability) play a role in the association of message framing with risk perceptions, behavioral expectations, and risk knowledge.

While main effects of health literacy, message framing, and message emotionality were examined, our primary interest was related to the hypothesized interactions between health literacy and message framing and between health literacy and message emotionality on each of the primary outcomes. Our hypotheses for interactions between health literacy and message emotionality were partially supported. Two-way crossover interactions emerged between health literacy and emotionality such that among smokers with lower health literacy, emotional (vs. factual) messages produced both higher perceived risk for developing a smoking-related health problem if one were to continue smoking and stronger expectations for quitting smoking completely. Conversely, smokers with higher health literacy reported greater perceived risk and stronger expectations of quitting in response to factual (vs. emotional) messages. These findings are in line with the elaboration likelihood model [38, 39], which posits that one's level of cognitive motivation influences the mode through which persuasive information is processed. Smokers with higher health literacy may have been more strongly influenced by the factual messages because they processed them centrally rather than peripherally, whereas the emotional messages may have been less carefully attended to and invoked peripheral processing. Central processing requires strong motivation and ability to scrutinize relevant components of a message. Because individuals with health literacy difficulties have trouble processing complex and information-dense materials (for a review, see [8]), smokers with lower health literacy might have been lacking in ability, and processed all of the risk messages peripherally. The emotional messages may have ultimately been more impactful among smokers with lower health literacy in the current study because they required fewer cognitive resources to process and were, ultimately, more understandable. It is important to highlight that the outcomes of interest in this study (risk perceptions, behavioral expectations, and knowledge) are powerful proximal predictors of actual smoking cessation. Thus, health literacy appears to play a key role in influencing how smokers respond to different types of smoking risk messages. Solely tailoring the content of risk messages on attributes such as reading level or general comprehensibility may not be sufficient. The current findings provide clear support to indicate that emotionality may influence the overall impact and persuasiveness of smoking health risk messages intended to help facilitate cessation.

Limitations and Future Directions

This study has several limitations that should be acknowledged. First, this laboratory study represents an initial step toward examining how tailoring smoking risk messages on theoretically-derived dimensions influences proximal predictors of cessation in a controlled environment. Nevertheless, the message "dose" delivered to participants was minimal and occurred during a single

exposure. The next logical step in this line of research is to examine how to optimally dose the delivery of messages matched to level of health literacy over time and in real-world contexts. Repeated exposures over a longer time period are likely needed to produce meaningful changes in risk perceptions, knowledge, intentions, and actual cessation.

Second, although participants were racially/ethnically diverse with varying levels of education, income, and employment, health literacy scores were rather high. This issue has been observed in prior research using the Test of Functional Health Literacy in Adults [58, 59]. Thus, evidence suggests the utility of using shorter and less-time intensive measures [9, 60], such as the Brief Health Literacy Screen [61] or the Single Item Screener [62], in research and clinical practice to identify those who may have health literacy difficulties. In cases when the utilization of either of these measures is not practical, using educational attainment (i.e. less than high school education) as a proxy may be appropriate.

Third, though two of our a priori, theoretically-driven hypotheses were supported, our other hypotheses were not. That is, health literacy and message emotionality did not interact to predict smoking knowledge retention. Moreover, health literacy did not interact with framing to influence outcomes. This finding is in line with results from two meta-analytic reviews [32, 56]. Furthermore, recent work on message framing in the area of cigarette packaging and health warning labels has yielded mixed findings. Results from one study found that on cigarette packs with no industry branding, warnings combining pictorial depictions of health risks with gain- (vs. loss-) framed messages led to greater motivation to quit among U.S. adult smokers [63]. Conversely, another study found that adolescent smokers reported more favorable attitudes and lower intentions to continue smoking in response to loss- (vs. gain-) framed warnings [64].

Implications

Findings have potential implications for media campaigns designed to assist tobacco cessation, patient-provider communications related to tobacco, and smoking cessation interventions. The most important implication is that a "one-size-fits-all" approach to communicating about smoking health risks may have limited impact. This study provides initial evidence that health literacy influences how smokers respond to different types of smoking risk messages, and the results add to the existing knowledge base regarding optimal methods of communicating health risk information to individuals with lower health literacy.

Compliance with Ethical Standards

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