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Scientific Message Translation and the Heuristic Systematic Model: Insights for Designing Educational Messages About Progesterone and Breast Cancer Risks

Rose Hitt⁶, Evan Perrault¹, Sandi Smith², David M. Keating³, Samantha Nazione⁴, Kami Silk³, and Jessica Russell⁵

¹University of Wisconsin-Eau Claire, Eau Claire, WI, USA

²Michigan State University, East Lansing, MI, USA

³Fors Marsh Group, Arlington, VA, USA

⁴Berry College, Mt Berry, GA, USA

⁵California State University, Long Beach, CA, USA

⁶Niskayuna, NY, USA

Abstract

Results of ongoing scientific research on environmental determinants of breast cancer are not typically presented to the public in ways they can easily understand and use to take preventive actions. In this study, results of scientific studies on progesterone exposure as a risk factor for breast cancer were translated into high and low literacy level messages. Using the heuristic systematic model, this study examined how ability, motivation, and message processing (heuristic and systematic) influenced perceptions of risk beliefs and negative attitudes about progesterone exposure among women who read the translated scientific messages. Among the 1254 participants, those given the higher literacy level message had greater perceptions of risk about progesterone. Heuristic message cues of source credibility and perceived message quality, as well as motivation, also predicted risk beliefs. Finally, risk beliefs were a strong predictor of negative attitudes about exposure to progesterone. The results can help improve health education message design in terms of practitioners having better knowledge of message features that are the most persuasive to the target audiences on this topic.

Keywords

Breast cancer risk; Breast cancer progesterone; Heuristic systematic model breast cancer; Translational research breast cancer

Breast cancer is diagnosed in about a quarter million women and takes the lives of about 40,000 women per year [1]. While research reports potential links between environmental

Correspondence to: Rose Hitt.

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factors and cancer, much of it is only in peer-reviewed publications, written above the comprehension level of lay audience members. As part of the Breast Cancer and the Environment Research Program (BCERP) [2], this study used recent research findings from scientists and translated them into educational messages that lay individuals could more easily understand and use. The heuristic systematic model (HSM) proposes ways through which people are influenced by messages depending on their ability and motivation. The HSM was used here to examine how ability, motivation, and message processing predict risk beliefs and attitudes about progesterone as a risk for breast cancer.

Translation—Key to Education

The BCERP's Community Outreach and Translation Core (COTC), a program funded by the National Cancer Institute and the National Institute of Environmental Health Sciences [2], is a multidisciplinary team including research scientists, epidemiologists, community advocates, and communication scholars, whose purpose is to translate the latest findings from research scientists in ways that are accessible to the general public. The goal is to increase access, understanding, and the potential benefits from breast cancer research. One example is uncertainty surrounding the link between progesterone and future breast cancer risks.

Progesterone

The message content used for this study was the role that progesterone can play in increasing women's breast cancer risks. Progesterone is a hormone produced in the ovaries that helps to prepare women for pregnancy, but is also potentially linked with increases in breast cancer [3]. Progesterone's potential breast cancer risk may differ depending on a woman's genetics [4], age [5], and timing of exposure [6]. These various moderators can make it difficult to communicate simply about women's specific risks, which is why it was the focus of the educational efforts here. Simply reducing literacy levels of educational information is not sufficient to influence attitude and behavior change; thus, the HSM was used as a guide to determine the most effective way to write messages to educate the lay public about this topic.

Heuristic Systematic Model

The HSM explains how people are influenced by messages they read or hear. According to the HSM, people process and evaluate messages in one, or both, of two possible ways: heuristically and/or systematically [7, 8]. Heuristic processing happens when people do not put much effort into thinking about a message, instead judging the message based on heuristics, or simple decision rules [9]. Examples of these simple decision rules include experts as credible and trustworthy sources of information, message features such as "length implies strength" [10], and the overall quality of the message [11]. In systematic processing, however, people carefully think about messages. Systematic processing happens when people are motivated and have the ability to engage in detailed analyses of a message. It is assumed to require more cognitive capacity than heuristic processing [8].

Message Processing

The degree to which message recipients engage in either heuristic or systematic message processing depends upon motivation and ability to think about the message. When people are motivated, they are more likely to use systematic processing. Personal involvement with environmental determinants of breast cancer is one way to think about motivation. Thus, when people feel that breast cancer and environmental factors are important, they should have greater motivation to process a message on the topic. In addition, knowledge of the message content should increase systematic processing because it demonstrates message comprehension. Prior research has reported that motivation predicts knowledge, or systematic processing, about other breast cancer risk factors such as *perfluorooctanoic acid* (PFOA) and genetics [12]. Thus, it is important to understand how motivation relates to both types of message processing about progesterone as a breast cancer risk.

RQ1 Does motivation predict message processing?

Ability

Ability, defined as cognitive resources available for processing a message [9], is the second proposed factor influencing systematic processing. Ability was assessed through self-reported scientific ability and the following research question is presented:

RQ2 Does self-assessed scientific ability predict message processing?

Ability can also be conceptualized in terms of literacy level [13]. In this study, there was one condition in which participants read a lower literacy message while others read a more complex, higher literacy message. Research suggests that breast cancer materials for patients are often written at a greater literacy level than the target audience possesses [14]. Studies have also indicated that, even among highly educated women, reading a message about breast cancer written at a lower literacy level produces greater knowledge gain than a high literacy counterpart [15]. Prior research has further reported that ability predicts knowledge about breast cancer risks [12]. As such, the following hypothesis is proposed:

H1 The literacy level of the progesterone message will predict systematic message processing such that those in the lower literacy message condition will have greater knowledge scores than those in the higher literacy message condition.

To understand how people are influenced by these messages, it is important to investigate whether ability relates to heuristic processing of the message about progesterone exposure.

RQ3 Will the literacy level of the progesterone exposure message predict perceptions of heuristic messages cues?

Risk Beliefs

Risk beliefs have important implications for health education and communication because of their impact on behavior [16, 17]. Women's beliefs about risks for breast cancer associated with progesterone, in particular, and what shapes those beliefs, are important to understand for health message designers. According to the HSM, people are motivated to possess correct beliefs, and thus, it is important to investigate predictors of these risk beliefs. Therefore, it is hypothesized:

H2 Perceptions of heuristic processing cues and systematic processing (measured as knowledge) will predict risk beliefs.

Risk Beliefs and Attitudes

Finally, attitude, or "...a person's general feeling of favorableness or un-favorableness toward some stimulus object" [18] are fundamental predictors a wide variety of behavioral health intentions and behaviors [19]. Attitude about progesterone is the ultimate dependent variable here. According to the Theories of Reasoned Action and Planned Behavior, salient beliefs about a particular item determine an individual's attitudes [20]. Thus, the following hypothesis is proposed:

H3 Risk beliefs about progesterone will predict attitudes about progesterone.

Method

Participants

Online surveys were completed by 1254 women recruited through the Love Research Foundation's Army of Women breast cancer research pool. Participants ranged in age from 21 to 77 years ($M=50.4$, $SD=11.6$). Participants were primarily white (95.9 %), followed by African American (1.2 %), Hispanic (1.2 %), 0.6 Asian/Pacific Islander (0.6 %), multiracial (0.4 %), and "other" (0.7 %). Educational levels ranged from 34.5 % graduate school, 38.1 % college degree, 22.8 % some college or technical training, 4.4 % high school degree, and 0.2 % had completed some high school.

Survey

The women completed a survey in which they were randomly assigned to read a message that was either high literacy (11.4 grade level) or low literacy (8.6 grade level) about progesterone, inflammation, and breast cancer ($n=614$ for low literacy, $n=640$ for high literacy). The message explained results of scientific studies conducted as part of the BCERP.

Measures

All measures were comprised of 7-point Likert scales unless indicated otherwise. Means and standard deviations are provided in Table 1.

Attitudes were measured with six items using semantic differentials such as "Progesterone is harmful/beneficial" ($\alpha=.93$). *Risk beliefs* were measured with five items such as "The scientific evidence shows that progesterone is risky for females" ($\alpha=.87$). In addition to manipulating the message condition (lay vs. scientific message), *ability* was measured with self-assessed scientific literacy including items such as "Understanding scientific articles about breast cancer is easy" ($\alpha=.88$). *Motivation* was measured in terms of four items assessing participant involvement with environmental links to breast cancer, including items such as "All in all, the ways that the environment impacts my risk for breast cancer is important in my life" ($\alpha=.80$). *Heuristic processing cues* were measured with eight semantic differential questions to assess source credibility, with the stem "I felt the source of this

message was..." followed by, for example, "inexpert/expert, uninformed/informed" ($\alpha=.96$). *Perceived message quality* (PMQ) was measured with five items including, "I felt the message was credible" and "I felt the message was informative" ($\alpha=.89$). *Systematic processing* was measured by the correct number of responses to 10 knowledge items based on the message with true/false and multiple choice response options. The message translations and the accompanying knowledge questions were developed in partnership between the scientists who made the discoveries and the authors of this paper (messages provided in Appendix). Confirmatory factor analysis demonstrated that measurements were single factors as specified, except for the knowledge index.

Analysis

To answer the research questions and test hypotheses, path analysis using maximum-likelihood estimation in AMOS was used to examine risk beliefs as a predictor of negative attitudes about progesterone, as well as message processing as predictors of risk beliefs, and motivation and ability variables as predictors of message processing. Testing all the variables in a single model demonstrates how all the predictors and two outcome variables (risk beliefs and attitudes) operate in tandem. In addition, after testing the a priori model, potentially better-fitting models were tested in an iterative fashion with the goal of discovering which structure of relationships best represented the data.

Results

The model, with the configuration of variables as specified according to the HSM, did not show good fit when tested (Fig. 1) (RMSEA=.141; GFI=.933); thus, other configurations of the variables were investigated. In an attempt to determine a model with a better fit, the heuristic and systematic processing variables were moved from serving as mediators to exogenous variables in the model. A model showed good fit in which risk beliefs predicted attitudes, while risk beliefs were predicted by message condition, involvement, and perceptions of heuristic cues (RMSEA=.057; GFI=.994) (Fig. 2). Given that the original model was not retained due to poor overall fit, the first three research questions and hypothesis were not assessed or supported given their paths' absence in the retained model.

Hypothesis 2 predicted that perceptions of heuristic processing cues and systematic processing would predict risk beliefs. Consistent with the first part of H2, perceptions of heuristic processing cues predicted risk beliefs, with greater perceptions of source credibility predicting greater risk beliefs ($\beta=.123, p<.05$) and greater PMQ predicting greater risk beliefs ($\beta=.087, p<.05$). Contrary to the second part of H2, however, systematic processing (knowledge) did not predict risk beliefs.

Hypothesis 3 predicted that risk beliefs would predict negative attitudes about progesterone. Consistent with H3, risk beliefs predicted negative attitude, such that greater risk beliefs predicted stronger negative attitudes about progesterone ($\beta=.565, p<.05$).

While not specified by the research questions and hypotheses, in the final retained model, message literacy condition ($\beta=.155, p<.05$) and involvement (motivation) ($\beta=.204, p<.05$)

both predicted risk beliefs. Specifically, those reading the higher literacy message, and those with greater involvement, had greater risk beliefs.

Discussion

This study offers implications for health education message design. The findings are discussed in terms of prior research and practical message implications. First, this study demonstrates the value of the HSM for understanding message processing about environmental determinants of breast cancer, and it adds to prior literature using the HSM for similar messages about other environmental determinants. The findings are consistent with a prior study in terms of motivation and perceptions of heuristic message cues being significant predictors of risk beliefs about PFOA [12].

In relation to prior studies, our findings regarding ability are mixed. Prior research [12, 15] reported greater knowledge scores among people reading lower literacy level messages about risks for breast cancer, whereas the model in the present study has the higher level message as a predictor of knowledge. Furthermore, research has reported [12] that those with greater confidence in scientific ability had greater knowledge scores after reading messages about PFOA, while that was not the case in this study. Perhaps this is due to the fact that progesterone is a widely known topic for which people already had many preconceived ideas about risk, while PFOA is a less known environmental risk factor. Individuals' greater familiarity with progesterone may make it less important to provide simple messages. The difference of findings between this study and prior research underscores the importance of studying various breast cancer risk topics so practitioners are better equipped to write effective, targeted messages.

Practical Implications for Message Design

Certain characteristics of messages can influence levels of perceived breast cancer risk about progesterone. Notably, high literacy level messages were more effective at increasing risk perceptions regarding progesterone than the low literacy messages. Therefore, it may not always be best to reduce educational messages to the lowest possible literacy level, especially when the risk topics are commonly known. In other words, for some risk factors, there may be a greater level of familiarity and understanding, which may give the audience a stronger knowledge base for thinking about and interpreting messages.

Additionally, messages for which participants had greater perceptions of source credibility and overall PMQ were related to higher risk perceptions. These findings are consistent with prior research [12]. Regardless of how important the risk information might be, people will not perceive it as risky if the message does not appear to be from a high quality source. Furthermore, the findings about greater involvement with environmental links to breast cancer as a predictor of risk beliefs demonstrates how motivation to think about a message can shape risk perceptions. Thus, message designers may also write and target messages differently depending on the motivation level of various audience segments, or messages may be designed to increase involvement/motivation.

Finally, as expected, risk beliefs can influence people's negative attitudes about progesterone and breast cancer. This is not surprising given that attitudes are highly correlated with behaviors [22]. If behavior change is the ultimate goal, it is important for progesterone education materials to focus on risk beliefs as a means to influence negative attitudes.

One important issue here is the set of findings from the high and low literacy message conditions. Prior literature has reported greater knowledge scores among those in the lower literacy level message condition [12, 15]; however, the final retained model here was not consistent with the message condition predicting knowledge scores. Rather, in this study, people in the higher literacy message condition had greater risk perceptions. The familiarity of the audience with the message topic in this study, in comparison with the more novel message topics in prior research, could be one reason why people in the higher literacy condition had greater risk beliefs. Another explanation of these results from the high literacy message could be due to a heuristic, or mental shortcut, related to message complexity (i.e., that more complex messages must be better).

Limitations

One limitation is that attitude about progesterone was measured very generally rather than measuring an attitude about a specific behavior relating to progesterone. Further, as this was a relatively highly educated group of participants, the high literacy messages may not have been too difficult for them to grasp. An additional limitation is that there were not actual measures of heuristic processing, simply the antecedents of each. Therefore, it is not surprising that the model that showed good fit revealed these as predictors and not mediators; future tests of the HSM on this topic should incorporate such heuristic and systematic processing assessments.

Conclusion

Guided by the HSM [8], this research examined how ability, motivation, and message processing influence risk beliefs and negative attitudes about progesterone among women who read messages about progesterone exposure. Higher literacy level messages led to greater risk perceptions than lower literacy level messages. Additionally, those with greater motivation to think about the messages also felt there were greater risks of breast cancer from progesterone. Greater perceptions of source credibility and message quality were also related to greater risk beliefs among participants, with greater risk beliefs predicting strong negative attitudes about progesterone. As this study shows, for educational messages about progesterone exposure and its relationship to increased breast cancer risks, higher literacy level messages may be more effective at increasing risk perceptions than more simple messages with the same information.

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Appendix

Higher Literacy Level Message Condition

Progesterone and Inflammation

Development and growth of the normal mammary gland requires tissue remodeling to allow for duct elongation and penetration of the ducts into the surrounding mammary tissue. The tissue remodeling processes are carried out by certain white blood cells. The process by which white blood cells migrate into a tissue is termed inflammation. The migration of white blood cells is regulated by small secreted proteins called chemokines. We have made the new discovery that progesterone induces both the production of chemokines and the migration of white blood cells into the mouse mammary gland; in other words, it induces inflammation in the mammary gland. Inflammation and its associated migration of white blood cells is a normal process that can assist in the development of the mammary gland, just as in other contexts it can help fight infections. One of the white blood cells that migrate to the mammary gland is called the macrophage. Macrophages can become activated to fight infections by engulfing and killing invading bacteria, or they can become activated to build blood vessels and remodel growing tissue. When the macrophage enters the growing gland, it becomes activated to help remodel the cells of the gland into the structure of ducts that characterizes the mature mammary gland and helps to establish the blood vessels that supply nutrients to the gland. These same macrophages that progesterone brings to the mammary gland have also been implicated in the development of tumors, including breast cancer, where the macrophages help the tumor to grow and develop the blood vessels that supply the tumor with nutrients. Thus, the ability of progesterone to stimulate the migration of white blood cells, such as macrophages, to the mammary gland (inflammation) presents a novel mechanism where progesterone can both promote normal mammary gland development and potentially promote the growth of tumors.

When mature women are exposed to progesterone over a long period of time, such as in postmenopausal hormone therapy, their risk of breast cancer is increased. Progesterone seems to be the cancer-promoting factor, since the increase in breast cancer risk is not seen in women who only receive estrogen. The incidence of breast cancer in postmenopausal women has actually decreased with the decreased prescription of hormone therapy that includes progesterone. A plausible mechanism for this negative effect of progesterone is its newly discovered ability to induce an inflammatory state that causes macrophages and other white blood cells to migrate to the mammary gland. The potent effect of progesterone in causing inflammation in the mammary gland calls for examination of the effects of progesterone in the developing pubertal gland. For instance, what are the effects of progesterone when combined with exposure endocrine disruptors or other toxicant or optional exposure to progesterone, such as that in contraceptives? Further studies are warranted to more fully understand the nature of inflammation induced by progesterone and its contribution to development of mammary cancers.

Lower Literacy Message Condition

Progesterone, Inflammation, and Breast Cancer Risk?

Researchers at Michigan State University have been doing experiments on mice to test the impact of progesterone. Progesterone is a hormone made in a woman's ovary that helps to prepare for pregnancy. We have found that progesterone leads to inflammation in the mouse mammary gland (the breast). Inflammation takes place when white blood cells move into a tissue. It is controlled by small proteins called chemokines. Inflammation is normal and can help to develop the breast. We have found that progesterone causes inflammation because it helps make chemokines and moves white blood cells. One of the white blood cells that move to the breast during inflammation is called a macrophage. Macrophages can help build blood vessels and reshape growing tissue. They may also promote the development of tumors, like breast cancer. Macrophages enter growing glands or tumors and help them develop. They also make blood vessels to give nutrients to the gland possibly the tumor. Because progesterone can move macrophages to the breast, it could help grow normal breasts or cancerous tumors. This potential chain of events is shown in the chart below.

When older women are exposed to progesterone for a long time, their risk of breast cancer goes up. This might be because progesterone can cause macrophages to move to the breast. Long-term contact with progesterone can happen in certain kinds of hormone therapy. Some women take hormone therapy after menopause, when a woman's period stops for life. Hormone therapy with estrogen will control menopause side effects. However, if a woman still has her uterus (womb), estrogen can cause cancer of the uterus. This can be controlled by adding progesterone to the estrogen. However, we have found that progesterone can impact the chances of getting breast cancer. This is because the risk does not increase for women taking only estrogen. In fact, as the progesterone link has become known, women are taking less hormone therapy after menopause. Since then, the rate of breast cancer in older women has gone down.

We should test progesterone's impact on growing glands at the time when a woman starts to have monthly periods. Some questions to ask could include:

- What is the effect of progesterone combined with endocrine disruptors (chemicals that act like hormones), or other toxic or bad agents?
- What is the impact of choosing to take progesterone, like in birth control?

More studies are needed to understand inflammation caused by progesterone and how it might help breast cancers to grow.

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Fig. 1.

Model 1 (original model). The message condition was dummy coded with lower literacy message coded as “0” and the higher literacy message coded as “1.” A negative value for the regression means there is relative advantage to the reference category (lower literacy level message) in terms of knowledge scores (systematic processing) [21]

$$\chi^2 (5, N=1,324) = 25.3, p < .05, RMSEA = 0.057, GFI = 0.994$$

Fig. 2.

Model 2 (revised model). The message condition was dummy coded with lower literacy message coded as “0” and the higher literacy message coded as “1.” The positive value for risk beliefs indicates those reading the scientific message (higher literacy level message) had greater risk beliefs [21]

Table 1

Means, standard deviations, and ranges for measures

Variable	Mean	SD	Minimum	Maximum
Independent variables				
Knowledge test (ability)	7.8	1.7	1	10
Self-assessed scientific literacy (ability)	4.483	1.26	2	7
Breast cancer involvement (motivation)	4.01	0.59	2	7
Source credibility (heuristic processing)	5.89	1.11	1	7
Perceived message quality (heuristic processing)	5.41	1.07	1	7
Dependent variables				
Risk beliefs	5.45	0.92	2	7
Attitudes	5.16	1.05	1	7