

Integrating Public Health and Computer Science Theoretical Perspectives for Developing Tailored Health Messages

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Abstract

In this paper, we review current approaches employed by both public health and computer science to develop tailored persuasive messages to foster health-related behavior change. It is based on this review that we propose an integrated framework for merging public health and computer science approaches. We believe that such a framework can lead to new methods to extend current tailoring research. Our method for analyzing persuasive health messages, influenced by this integrated framework, is presented as an example.

Introduction

Advances in technology have made it easier to tailor persuasive messages to communicate an individual's disease risks, thereby assisting him or her in making personal decisions about health-care choices (Rimer and Glassman, 1999). Tailored messages focus on individual factors important in behavioral change that are typically not included in messages targeting the general population (De Vries and Brug 1999). Thus, a tailored message is designed to reach a specific person, is based on characteristics that are unique to that person, is related to an outcome of interest, and is derived from an individual assessment (Kreuter, Farrel, Olevitch and Brennan 2000).

Over the past several years, efforts to improve health have led to the growing use of tailored persuasive messages to foster health-related behavioral change (Voelker 1994; Champion Foster and Menon 1997; Kreuter, Strecher and Glassman 1999). Several of these systems are described in a special issue of Patient Education and Counseling, which also includes a review article by Strecher that summarized projects in the area of tailored print communication. Although Strecher concludes his review article on a positive note, in fact the experiments he reviews do not unambiguously demonstrate the effectiveness of short stand-alone tailored messages (Strecher 1999).

In subsequent publications, investigators examined variations in the way different investigations applied tailoring principles in an effort to explain the limited effects of print based tailored interventions (Skinner, Campbell,

Rimmer, Curry et al. 1999; Abrams, Mills and Bulger 1999; Rakowski W 1999; Orleans 1999). These investigators, primarily from the discipline and thematic perspectives of public health, looked at tailoring depth, amount of existing content, print and quality. They neglected, however, to consider how the technological methods employed, as well as the theoretical frameworks upon which these methods are based, could have adversely affected the persuasiveness of the messages generated.

In this paper, we examine current approaches employed by both public health and computer science. A review of these approaches provides the rationale for integrating the theoretical perspectives, thematic views, and experiences from both public health and computer science communities. It is based on this review that we propose an integrated framework for merging public health (PH) and computer science approaches to developing persuasive tailored messages. We believe that such a framework can lead to new methods to extend current tailoring research. Our method for analyzing persuasive health messages, influenced by this integrated framework, is presented as an example.

Public Health (PH) Approach to Tailoring

Kreuter et al identifies a five-step approach that has been employed in most, if not all, tailoring systems developed in the PH domain (Figure 1). Step 1 pertains to identifying the high-level goal that the tailoring system will be developed to influence. In public health, this goal is typically to change a health behavior. Step 1 is also when the determinants of that behavior are analyzed. Behavioral scientists understand that behavior is not caused by a single determinant, and they typically rely on socio-cognitive theories to assist in identifying the determinants for a given behavior. Examples of these models include Health Belief Model (Rosenstock 1974), Social-Cognitive Theory (Bandura 1986), and Transtheoretical Model (Prochaska and Diclemente 1988). A paper questionnaire, telephone interview, or data obtained from existing sources, such as medical records is used to assess each person's status on these determinants. (Step 2). Once these determinants are

assessed, text is written for each determinant and each possible response option (Step 3). Next in this process (Step 4) is assembling these text chunks into a final health document (Step 5).

Figure 1: The Tailoring Process in PH

- (1) Analyzing the problem to be addressed and understanding its determinants
- (2) Developing an assessment tool to measure a person's status on these determinants
- (3) Creating tailored messages that address individual variation of determinants of the problem
- (4) Developing algorithms and a computer program that link responses from the assessment into specific tailored messages
- (5) Creating the final health communication

The developer of a tailoring system using this process faces two challenging requirements. The first challenge is acquiring the expert knowledge needed to author the content, that is, the pieces of text that the system uses to generate the tailored communication. The second challenge is assembling the pieces of text into a structured document that is coherent, cohesive and effectively persuasive.

PH has employed the most obvious method of acquiring expert knowledge for message content, directly asking experts to write it. The experts (e.g., health educators, behavioral scientists, etc.) write the content used for tailoring informed by a variety of socio-cognitive theories. To provide an illustration of how theory can inform the expert in writing content, we draw upon Fishbein's guidance for applying the Integrative Model of Behavioral Prediction, which was developed to inform health communications that are intended to change behavioral intentions (Fishbein 2003).

if strong intentions to perform the behavior in question have not been formed, the model suggests that there are three primary determinants of intention: the attitude toward performing the behavior, perceived norms concerning performing the behavior, and one's self efficacy with respect to performing the behavior. It is important to recognize that the relative importance of these three psychosocial variables as determinants of intention will depend upon both the behavior and the population being considered. Thus, for example, one behavior may be primarily determined by attitudinal considerations while another may be primarily influenced by feelings of self-efficacy. Similarly, a behavior that is attitudinally driven in one population or culture may be normatively driven in another. Thus, before developing communications to change intentions, it is important

to first determine the degree to which that intention is under attitudinal, normative, or self efficacy control in the population in question

Thus, the theory informs the expert whose goal is to influence intention to focus their writing on one or more psychosocial constructs. Knowing which construct to use depends on both the behavior and the population or individual being considered. Empirically derived principles of good communication provide further guidance in selecting constructs.

Beyond this, the public health literature is disappointingly scant in providing guidance on writing content for tailoring system. As stated, expert authoring typically relies on behavior change theories as well as empirically derived principles. However, this assumes that experts have the ability to integrate theoretical knowledge with actual practice. Findings from one of the few publications in the public health literature that examined this assumption raise concern. Kline (2000) examined the extent to which theoretical knowledge is integrated in communications that focus on breast self-examination (BSE). The goal of the study was to quantify and describe the inclusion of four message variables: severity, susceptibility, response efficacy, and self-efficacy. Inclusion of these constructs, which are from the Health Belief Model, was an indicator used to measure the potential strength of the persuasive arguments in BSE pamphlets. The study found that messages rarely included communication that addressed these constructs and thus the persuasive arguments for BSE in these pamphlets were determined to be very weak.

Even beyond acquiring knowledge to inform the content of the message, techniques in guiding the assembly of message fragments (i.e. chunks of text) into a structured and cohesive document are necessary. Structure in this regard refers to optimally combining the chunks of text into paragraphs and sentence structures. Simply pasting pieces of text together is unlikely to result in a coherent smooth document, unless the author carefully ensures that every possible combination of texts is coherent and smooth. Even when the author engages in this laborious task, the issue of persuasiveness remains. Communication studies emphasize the role that structure plays, because although the understanding of a message decreases gradually as the same semantic information is presented in a less and less structured way, the persuasive effects vanish rapidly (Bettinghaus and Cody 1987). In order to guide the structure of assembling these chunks of text into a final document, one also needs a theory to describe how to assemble messages in a coherent sequence and explain why certain multi-argument structures are more persuasive than others. While such theories are not considered in the PH five-step tailoring process, they have been prominent to the tailoring process employed among computer science researchers.

Approaches to Tailoring in Computer Science

Because of the limitations of existing tools and techniques, several of the more experimental projects attempt to use more complex techniques, taking ideas from computer science. Bental reviews many of these projects that have investigated using these more advanced techniques for generating tailored patient information (Bental, Cawsey, and Jones 1999). For example, Piglit uses computational techniques to create tailored information for diabetes patients, given information in their medical record (Binstead, Cawsey and Jones 1995). Other projects using similar techniques are Migraine, Healthdoc and OPADE (Carenini, Mittal and Moore 1994; Hirst, DiMarco and Hovy 1997; DeCarolus, de Rosis, and Grass 1996).

Most of these projects have built their systems using Natural Language Generation (NLG) methods. NLG systems are computer software systems that produce texts in English and other human languages, often from non-linguistic input data (Reiter and Sripanda 2003). NLG systems, like most linguistic systems, need substantial amounts of knowledge. The basic idea in most of these systems is: to represent explicitly information about the patient (as a 'user model'); to represent general rules about communication; and to automatically 'generate' text from some database of health related information, given the rules and user model. Achieving this, with only limited knowledge of how humans tailor their communications, is complex. In practice, even the systems that have this approach as their goal need application-specific rules, and need to incorporate human-authored text into the output.

Most frequently the tailoring systems developed using NLG draw on theories of argumentation to inform the structure of persuasive arguments that are fitting to the goal of promoting behavior change. The NLG community has fully embraced the understanding that the same semantic information can be conveyed through a variety of text, paragraph, and sentence structures, and that a multi-argument structure is critical to developing communications in a domain as complex as health behavior change.

Two types of knowledge acquisition (KA) techniques are: 1) working with experts in a structured fashion, such as structured interviews, think-aloud protocols, sorting, and ladder grids; and 2) learning from data sets of correct solutions (such as text corpora) (Scott, Clayton and Gibson 1991; Provost, Buchanan, Clearwater and Lee 1993). The latter are currently very popular in natural language processing and are used for many different types of knowledge, ranging from grammar rules to discourse (Jurafsky and Martin 2000). There are of course other possible KA techniques as well, including the approach used in the PH tailoring process which is to simply ask experts how to write the texts in question.

Reiter used this direct approach in preliminary stages of developing the STOP, an NLG system to tailor smoking cessation letters based on the Stages of Change Model

(Reiter, Cawsey, Osman and Roff 1997). When experts were asked to write example smoking cessation letters based on a Stages-of-Change tailoring questionnaire, they found that the specific example letters produced had a different structure from the "general" structure that the experts had initially proposed. After the investigators pointed out this fact to the experts, they subsequently attempted to revise the general structure to more closely conform to the example letter that they had actually written, in other words, to combine their "theoretical" and "practitioner" knowledge. It was relatively straightforward for the experts to state theoretical knowledge, or to use their practitioner knowledge to produce example letters, but attempting to integrate the two types of knowledge was far more difficult. This is a common finding in knowledge acquisition, and it is partially due to the fact that it is difficult for experts to introspectively examine the knowledge they use in practice (Anderson 1995). Thus rather than relying on acquiring expert knowledge directly as a sole method, computational tailoring systems have given prominent attention to argumentation theories, which focus on persuading people to change their beliefs and desires. Mainly, the interest is on the rhetorical structure of arguments, and as a consequence, in the structure of rhetorical argumentative discourse.

An Integrated Framework

Applying persuasive argumentation theories to tailored communication for behavioral change has been complex. Some of the computational tailoring systems (e.g., Daphne) have attempted to combine theories of argumentation with behavioral theories, realizing that if the aim of an intervention is to induce people to modify their behavior, specific theories of how and why people change behavior to guide the advising process is necessary. These interventions have used Stages of Change and the Health Belief Model in addition to linguistic and argumentation theories to develop their tailoring systems (Grasso 1998). However, most of the computational tailoring systems have not combined theories of argumentation with behavioral theory and those that have were difficult to move into real world environments primarily due to the complexity of using NLG techniques to generate multi-argument structures in domains as complex as health behavior. Additionally, there is very little in the way of reusable NLG resources (grammars, lexicons, etc), which means that most NLG developers still have to more or less start from scratch.

The non-linguistic ('PH-approach') tailoring approach has other limitations. This approach is done by manipulating character strings; the user writes a program which includes statements such as 'include X if condition Y is true and Z otherwise. The key difference between this approach and NLG is there is no attempt to represent the text in any logical structure. Because persuasive health messages do appear to have a logical structure, as species

of argumentation from consequences, argumentation theories are needed to ensure that the persuasive message conforms to the logical structure of a sound argument. Without a logical structure, it tends to be presumed that the message recipient is not very rational, and that they are more influenced by emotional appeals than by logical reasoning. The contrast between the public health approach that relies on constructs from behavior theory to write text that appeals to emotion and the computer science approach that uses theories of argumentation to inform a logical structure for reasoning is misleading. In fact, persuasive health messages would never work unless the respondents were highly rational in calculating and perceiving how their actions will bring about or thwart goals that are important to them. Once the emotion is channeled within the logical framework of practical reasoning base, the argument leads the respondent to a particular conclusion. This may explain the variability found in Stretchers review on the effectiveness of tailored health messages. The emotional and logical components of persuasive health messages are inextricable combined. A simple appeal to emotion may have a psychological impact, but its impact in changing behavior may be random and hard to predict.

We have reviewed both public health and computer science approaches to develop tailored messages, and it is our contention that a more integrated approach is necessary. The integrated approach we propose takes the view that persuasive health messages have both a logical component and an emotional component, and thus require theories of both argumentation and health behavior to

inform their development. We propose in Table 1 a framework to merge public health with linguistic and argumentation theories needed to inform the logical component of persuasive health messages.

Table 1: An Integrated Framework for Merging Public Health, Linguistic and Argumentation Theories

	Public Health (Content)	Computer Science (Form)	Integrated System (Content + Form)
Theory (KR)	Social-Cognitive Models (e.g., HBM)	Discourse Structure (e.g., RST)	Persuasive Strategies
Methods (KA)	Empirically derived principles	Linguistic Analysis	Empirically derived principles conveyed by Linguistic analysis

Several conjectures, based on our review, motivate this integrated approach to tailoring. First, knowledge about the specific domain, knowledge about how individual behavior is influenced by beliefs, attitudes and knowledge about how argumentation techniques can be used all have a crucial role in producing persuasive messages. Second, knowledge about the specific domain and about how individual behavior is influenced by emotions, beliefs, attitudes and knowledge is best obtained from public health, socio-cognitive theories and principles of health communication whereas theories of argumentation and persuasive structure are best obtained from linguistic and argumentation theories.

Figure 2: Graphical depiction of statement types in health messages

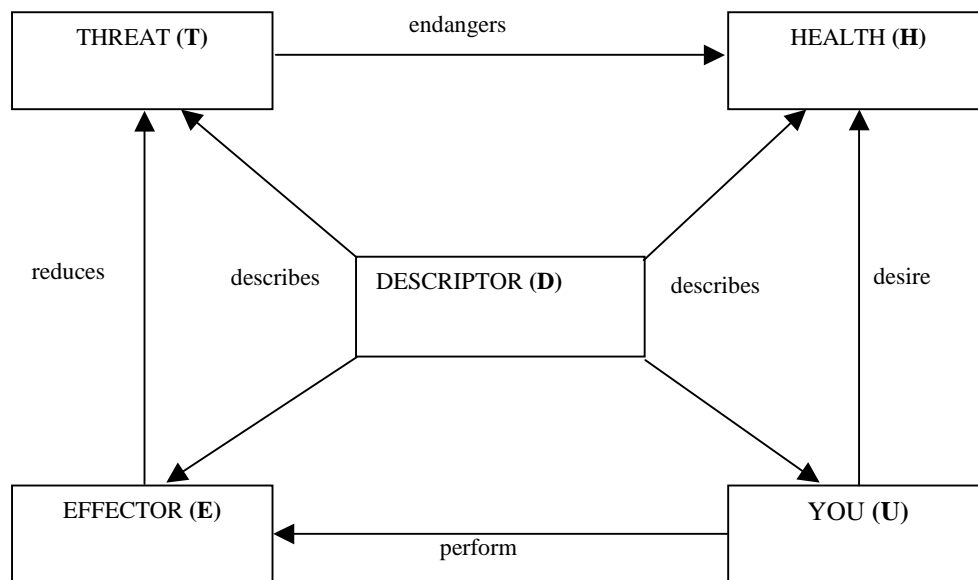


Figure 3: Discourse analysis of a persuasive health message

ID	Type	Parent	Sentence	Paraphrase
1.0	UE	2.0	Empower Yourself!	<you> empower yourself
2.0	UE		Learn Your Cholesterol Number	<you> learn cholesterol number
3.0	UE-	4.0	Should you be concerned about your blood cholesterol number?	you are concerned about cholesterol number
4.0	UE	2.0	YES!	you are concerned about cholesterol number
5.0	TH	4.0	High blood cholesterol increases your chances for coronary heart disease.	cholesterol increases CHD
6.0	TH	4.0	Coronary heart disease is a disease of the blood vessels of the heart that causes a heart attack.	CHD causes heart attack
7.1	TH	4.0	It is the number one killer	heart attack is killer
7.2	DU	7.1	Among African Americans.	<if you are> African American
8.1	UE	2.0	You can take steps	you can take steps
8.2	EH	8.1	to protect your heart!	taking steps protects heart
9.0	UE	8.1	Read this brochure.	<you> read brochure
10.1	UE	8.1	Improve your cholesterol level or keep it at the right level	<you> improve your cholesterol
10.2	ET	10.1	to help reduce your risk of getting heart disease.	improving cholesterol reduces heart disease

Our research seeks to integrate the theories shown in this framework. We have begun to create a collection (corpus) of persuasive health messages and analyze their structure.

The methods of analysis synthesize several existing approaches. We employ discourse analysis to determine the structure of the sentences in each message (Harris 1952). Figure 2 shows a graphical rendering of the types of statements that we have identified, e.g. “threat endangers health” and “effector reduces threat”. We also draw on rhetorical structure theory (Mann and Thompson 1988) and the theory of argumentation (Toulmin 2003) to connect these statements into a hierarchical structure that represents how the statements support and refute each other. Figure 2 shows an example of our analysis combining these techniques. Our major innovation over prior methods is to use public health theory to guide the analysis by incorporating theories of behavioral change to label blocks of text and to define relationships between them.

The procedure for analyzing the message that is shown in Figure 3 is as follows: The text is organized into a table with columns ID, Type, Parent, Sentence and Paraphrase. The Text in each row of the table consists initially of sentences that terminate with a period. An ID is assigned to each sentence sequentially, starting at 01.0. Complex sentences containing conjunctions and other connective

phrases are broken into clauses on separate lines and given distinct IDs using the decimal point (e.g. 7.1 and 7.2). The paraphrase column rewords the sentence or clause into a simple declarative sentence form (subject, verb, object). For example, *Read this brochure* becomes *You read brochure*. The Type column is assigned based on the categories of words related in the paraphrase. For example, sentence 7.1 *It is the number one killer* is paraphrased as *Heart attack is a killer (heart attack endangers life)*, which relates a threat (*heart attack*) and a health state (*life*). This statement therefore is type TH (threat endangers health). Clause 10.2 *to help reduce your risk of getting heart disease* is paraphrased as *improving cholesterol reduces heart disease*, which has type ET: effector (*improving cholesterol*) reduces threat (*heart disease*).

The Parent column shows how statements support or refute each other. Statement 10.2 supports 10.1, which supports 8.1, which supports 2.0, the conclusion statement *Learn your cholesterol number*. We expect this analysis to reveal that preventive health messages are arguments in which the adoption of a health behavior and the supporting arguments are formed from the constructs in the model. Our aim is to establish the structure that constitutes well-formed arguments in persuasive health messages, a step that is preliminary to our more long-term

research goal of developing a computer assisted authoring tool for generating effective persuasive health messages in real world settings.

Conclusions

The complexity of generating persuasive health messages provides a fertile ground to employ novel computer assisted tailoring approaches. An integrated framework such as the one we suggest can guide empirical investigations of how to incorporate theories across public health and computer science disciplines to inform the production of effective messages for tailoring. We have provided an example of a method, grounded in this framework, for understanding arguments that are informed by socio-cognitive, linguistic and argumentation theories. We believe this work is necessary given that persuasive health messages appear to include not only the component of emotion, attitudes and beliefs as gathered from public health theory, but also a normative or logical structure that has not yet been systematically studied. Applying the method we describe to better understand both of these components as they are intricately intertwined, is a first step in our future research which is to develop a computer assisted tool for generating tailored persuasive health messages. It is our hope that this research will facilitate the next generation of tailored persuasive health messages in real world settings.

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