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Short communication

Latent Semantic Analysis: A new measure of patient-physician communication

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ABSTRACT

Rationale: Patient–physician communication plays an essential role in a variety of patient outcomes; however, it is often difficult to operationalize positive patient-physician communication objectively, and the existing evaluation tools are generally time-consuming.
Objective: This study proposes semantic similarity of the patient's and physician's language in a medical interaction as a measure of patient-physician communication. Latent semantic analysis (LSA), a mathematical method for modeling semantic meaning, was employed to assess similarity in language during clinical interactions between physicians and patients.
Methods: Participants were 132 Black/African American patients (76% women, *M*age = 43.8, range = 18–82) who participated in clinical interactions with 17 physicians (53% women, *M*age = 27.1, range = 26–35) in a primary care clinic in a large city in the Midwestern United States.
Results: LSA captured reliable information about patient-physician communication: The mean correlation indicating similarity between the transcripts of a physician and patient in a clinical interaction was 0.142, significantly greater than zero; the mean correlation between a patient's transcript and transcripts of their physician during interactions with other patients was not different from zero. Physicians differed significantly in the semantic similarity between their language and that of their patients, and these differences were related to physician ethnicity and gender. Female patients exhibited greater communication similarity with their physicians than did male patients. Finally, greater communication similarity was predicted by less patient trust in physicians prior to the interaction and greater patient trust after the interaction.
Conclusion: LSA is a potentially important tool in patient-physician communication research. Methodological considerations in applying LSA to address research questions in patient-physician communication are discussed.

1. Introduction

Patient–physician communication plays an essential role in a variety of patient outcomes, ranging from trust in health care to treatment adherence, and ultimately to health outcomes (Epstein and Street, 2007; Matusitz and Spear, 2014; Ong et al., 1995; Stewart, 1995). The definition of high-quality patient-physician communication differs between two major frameworks: patient-centered communication and relationship-centered communication, with the former placing more focus on the role of physicians in listening to, informing, and involving patients in their care (Institute of Medicine, 2001) whereas the latter places more focus on reciprocal influences between physicians and patients (Roter, 2000). However, both frameworks emphasize the importance of responsiveness between physicians and patients (Beach and Inui, 2006; Davis et al., 2005; Epstein and Street, 2011; Stewart et al., 2003; Suchman, 2006).

There are multiple ways to operationalize responsiveness between a physician and a patient (see Boon and Stewart, 1998; Epstein et al., 2005 for review), including patient and doctor questionnaires about the interaction, observational techniques, and analyses of transcribed

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verbal interactions. Multiple methods are vital in that each method captures a different aspect of the interaction, and each method has its own strengths and weaknesses. Questionnaires are simple and easy to administer and capture the physician and patient perception of the interaction, but are subject to reporting biases (Bourhis et al., 1989). Observational methods may be more objective, but can involve time- and resource-intensive coding of verbal and non-verbal behaviors by at least two independent coders to assess reliability. Further, surveys and observational techniques are top-down approaches that assess only the variables of interest imposed by the researcher on the doctor-patient interaction, as well as the cultural context in which the researcher is working.

In this manuscript, we are proposing that physician and patient responsiveness can be assessed by how similar or coherent the conversation is between the physician and the patient in their interaction using a technique called Latent Semantic Analysis (LSA). LSA allows researchers to quantify the amount of semantic overlap between what a patient and a physician say to each other in a given interaction without having coders read transcripts or watch video-recorded interactions. LSA is a mathematical method for modeling semantic meaning from text (Landauer, 2007; Landauer et al., 1998). In LSA, a group of texts is processed such that each text is represented by a count of each word appearing in the text. Then, principal component analysis (a method used for dimensionality reduction) is used to derive underlying semantic dimensions. Typically semantic meaning in text can be represented using about 300 dimensions, and the meaning of a word is represented by its loading on each of the dimensions. The matrix with each word in a row and dimension loadings in each column is called the "LSA space." One notable characteristic of LSA is that the comparative meaning of two texts is not dependent on using the same words (Landauer, 2007). For example, a patient's and doctor's interaction about diabetes may be judged highly similar even if their conversation uses few overlapping words, provided the words they use have similar meanings based on the principle component analysis. Another characteristic is that it is a data-driven, "bottom-up" approach to deriving meaning, which can enable researchers to generate new theories.

LSA can quantitatively assess the semantic similarity between two texts of any length (single words, phrases, sentences, paragraphs, etc.) by correlating the dimension loadings of the word(s) in each text. Some applications of LSA have included successfully grading content adequacy of student essays (Landauer et al., 2003), diagnosing schizophrenia from patient's language as accurately as experienced psychiatrists (Elvevåg et al., 2007), and (after being trained on text similar to what an American college freshman reads) scoring as well on the Test of English as a Foreign Language as successful U.S. college applicants from non-English-speaking countries (Landauer and Dumais, 1997). Thus far LSA has been limited to assessment of semantic coherence within texts or semantic similarity across texts such as internet search applications. Only one study, to our knowledge, has applied LSA to analyze similarity in meaning between partners in a conversation. Babcock et al. (2014) employed LSA to analyze transcripts of unstructured "getting to know you" conversations between undergraduate students, and found that the semantic similarity between the interaction pairs correlated positively with behavioral ratings of number of intimate self-disclosures, verbal and nonverbal acknowledgements, number and duration of mutual gazes, and participant perception of involvement in the interaction. The authors concluded that latent semantic similarity "develops out of a highly involving interaction between mutually attentive and acknowledging partners in which a lot of verbal information is exchanged" (p. 78). These findings suggest that semantic similarity in the language used by patients and physicians as assessed by LSA can be used to assess responsiveness in the doctor-patient interaction. However, the unstructured "getting to know you" conversations between undergraduates evaluated by Babcock et al. are much different from the structured, goal-directed, and somewhat scripted communication between a physician and patient differing in status, education, and motivation during a clinical interaction.

Thus, the goal of the present paper is to demonstrate the feasibility of applying LSA methods to patient-physician communication research and assess the ability of LSA to detect similarities between what the physician and patient say in a given medical interaction. In addition, we will explore the utility of LSA in this context by presenting some preliminary results showing the sensitivity of semantic similarity to ethnic and gender variables known to affect physician-patient communication (Cooper-Patrick et al., 1999; Street et al., 2008) and using semantic similarity to predict patient outcomes of trust in the physician. Finally, we will make some methodological recommendations for using LSA to study medical interactions and suggest some research questions that can be addressed with this method.

2. Method

2.1. Participants

Participants were 132 low-income, self-identified Black/African American patients (76% women, *M*age = 43.8, *SD* = 14.0, range = 18–82) who participated in clinical interactions with 17 physicians (Mage = 27.1, range = 26–35) as part of a larger study conducted in a primary care clinic in a large midwestern city in the U.S. All physicians were second- or third-year medical residents; there were 8 from India/Pakistan (5 female) who saw 44 patients, 6 from other parts of Asia (3 female) who saw 51 patients, 2 White males who saw 33 patients, and 1 Black female who saw 4 patients. Each physician saw from 1 to 20 (median of 4) patients who participated in the study; each patient participated in only one clinical interaction. Approximately 75% of patients and 83% of physicians approached agreed to participate. For more information about participants and procedures in this study, please see the parent study from which these data were drawn (Penner et al., 2009).

2.2. Procedure

The original study was approved by the Wayne State University Behavioral IRB. The current secondary analysis of the existing de-identified transcript data was approved by the Virginia Commonwealth University IRB as an exempt study (HM14733 approved on Oct. 22, 2012). Patients completed questionnaires including demographic characteristics and previous history with medical interactions, and then participated in their medical appointment, which was video recorded. Following the interaction participants completed questionnaires about their experience in the interaction. Video recorded interactions were professionally transcribed, and transcripts were converted to raw text files and cleaned of special characters and formatting (see Hagiwara et al., 2016). All the words uttered by the patient in the interaction and all the words said by the physician in an interaction were put into separate text files, for a total of 132 patient text files and 132 physician text files.

2.3. LSA methods

In LSA each word's meaning is characterized by its loading on each of the dimensions in the semantic space, or "LSA space". The creation of a semantic space starts with a corpus of training texts, from which a word x text wordcount matrix is created. The rows of the matrix consist of each word in all of the training texts, the columns of the matrix represent each individual training text, and each cell in the matrix consists of the number of times the word in that row occurs in that column's text. The semantic space is created by performing a singular value decomposition (a form of data reduction often referred to as principal component analysis) on this word x text wordcount matrix. This yields three matrices: (1) a text x dimension matrix, giving the positions of the texts in the semantic space; (2) a word x dimension