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Cognition and interpersonal communication: The effect of voice quality on information processing and person perception

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ABSTRACT

Against the backdrop of cognitive load theory (CLT) it was tested if irregular voice increases processing demands on working memory (WM). An experiment was designed to expose *N* = 54 participants to expository text delivered with a modal and a creaky human voice. Working memory capacity was measured by a secondary task on the visual modality. Listening to a creaky voice quality consumes more cognitive capacity as indicated by the significant decrease in secondary task performance; also, retention of information was found to be impaired. Results are explained within the framework of CLT and implications for professional communication are discussed.

1. Introduction: cognition and interpersonal communication

Processes in interpersonal communication, such as social cognition, the forming of a first impression, and impression management involve the perception of speech, and, therefore, voice. In particular, voice characteristics have an impact on whether a person is perceived to be likeable or attractive, but also on the assessment of authority and credibility (Aronson, Wilson, & Akert, 2013; Knapp, Hall, & Horgan, 2013). In addition, voice also carries state and trait information about the speaker, such as age and gender, and emotionality (Laukkanen, Vilkman, Alku, & Oksanen, 1997; Scherer, Ladd, & Silverman, 1984) and health. Voice is also critical in providing information about covered and implicated attitudes of a speaker e.g., the tone of voice in ironic speech, social status and roles. Given that voice characteristics simultaneously affect both person perception and information processing, we take a closer look at how (undesirable) voice characteristics have an impact in interpersonal communication situations (Knapp et al., 2013; Siegman, 1987; Zuckerman & Driver, 1989; Zuckerman & Miyake, 1993).

Cognitive models of information processing suggest that messages are processed in multiple steps which comprise selection, organization, and integration of information (Mayer, 2005). In the case of listening, this extends to information from verbal and nonverbal signals which are conveyed both through the ears (e.g., linguistic information and paralinguistic information such as speech rate, pauses, accent) and through the eyes (e.g., hand and face gestures, pictures; Imhof, 2010b).

The mental unit which is considered the bottleneck of information processing, is working memory (WM; Baddeley, 1986, 1998; Mayer & Moreno, 2003). Working memory provides the cognitive capacity to select and organize the input, and to integrate information from different sources. WM has limited capacity, so that the relationship between available capacity and the capacity demands put on WM by a specific communication task is critical for efficient processing of information in communication situations (Janusik, 2005). In the following, we will present a theoretical framework which can be used to describe the functions of working memory and which permits to identify variables that are critical for the cognitive load imposed on it in interpersonal communication situations.

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2. Theoretical and empirical background

2.1. Listening within the framework of cognitive load theory

Cognitive load theory (CLT) proposes a model which identifies three different components of cognitive load (Chandler & Sweller, 1991; Paas, Renkl, & Sweller, 2003; Sweller, Ayres, & Kalyuga, 2011): *Intrinsic load* is posed on WM by task difficulty in relation to the learner's prior knowledge and complexity of the material due to element interactivity. Dealing with difficult information, e.g., on a topic for which a learner has only little prior knowledge, consumes a larger amount of resources than information which can be more easily integrated into a rich knowledge structure. The mental operations which are required to actually process the information and to (re-)construct knowledge schemata and mental representations cause the so-called *germane load* of a task. *Extraneous load* is associated with irrelevant information which may result from poor design and confusing presentation of the information. It is typically caused by elements, such as decorative pictures and redundant sounds ("bells and whistles"; Moreno & Mayer, 2000), which distract attention away from the core information. The components of cognitive load function additively, which means that if the sum exceeds available capacity, subsequent performance will deteriorate.

Since capacity of WM is limited, it is critical for efficient information processing that the capacity demands from the different types of cognitive load do not accumulate to an overload on the information processing system. According to Mayer and Moreno (2003), overload occurs when concurrent signals are high in complexity, inconsistent, confusing, or irrelevant. As a result, information processing is affected (Beaman, 2004; Larsen & Baddeley, 2003), perceptual discrimination is impaired (Mattys & Wiget, 2011), retention scores of the presented material are poor (Norris, Baddeley, & Page, 2004), and the probability of constructive problem-solving and transfer is low (Moreno & Mayer, 2000, 2002).

2.2. Components of listening load

Listening is sensitive to WM limitations (Beaman, 2004) and puts a specific challenge on WM, because the sound waves necessarily carry two types of information via the voice. Speech conveys both verbal information and nonverbal information through paralinguistic and extralinguistic characteristics, e.g., about age, gender, health, and emotional state (Belin, Bestelmeyer, Latinus, & Watson, 2011; Kalyuga, 2012; Knapp et al., 2013) of the speaker. This means that in the case of listening, in particular, when discourse comprehension is asked for, the cognitive load on the phonological loop of WM consists of a combined load of both verbal and nonverbal information which is specific for listening tasks and, therefore, we propose to name this *listening load*.

Against the backdrop of *CLT*, instructional designers have looked at ways to reduce cognitive load by controlling extraneous load through appropriate measures (Mayer & Moreno, 2003; Merriënboer, Kirschner, & Kester, 2003). Therefore, empirical evidence is needed as to what exactly causes extraneous load on WM in auditory information processing. Quite consistently, irrelevant sound was found to interfere substantially with processing of acoustic information. Experiments on the *irrelevant sound effect* (ISE) typically use two signals from different sources across or within modalities. The pattern of results reflects an impairment of learning performance (free recall, serial recall, sequence learning) when concurrent but irrelevant background speech or noise were present while speech or sound signals had to be detected (Farley, Neath, Allbritton, & Surprenant, 2007; Klatte, Meis, Sukowski, & Schick, 2007; Larsen & Baddeley, 2003; LeCompte, 1994; Schlittmeier, Hellbrück, & Klatte, 2008; Schlittmeier, Hellbrück, Thaden, & Vorländer, 2008). Martín-Loeches, Schweinberger, and Sommer (1997) conducted a study in which the cognitive load was manipulated within the speech signal by using pronunciation varieties of sounds. They found that irrelevant sound which was produced by the different manners of pronunciation caused a significant ISE in sound detection tasks.

In contrast, the degree of interference was reduced when the irrelevant sound was imparted together with the speech signal and when the experimental stimuli were not only sounds but meaningful words and sentences (Lewis, Vasishth, & van Dyke, 2006). The detrimental effect of the manipulated acoustic signal was absent in a memory task when meaningful speech was used as stimulus material (Tremblay & Jones, 1999; Tremblay, Nicholls, Alford, & Jones, 2000). Sentence comprehension was typically not affected (Davis, Johnsrude, Hervais-Adelman, Taylor, & McGettigan, 2005; Hervais-Adelman, Davis, Johnsrude, & Carlyon, 2008) when a speech signal was manipulated, e.g., by using a voice with reduced intelligibility due to masked or missing sounds. As a result, it has been assumed that irrelevant sound which was immanent to speech could play a different role in the ISE: Because language is semantically redundant and subjects have access to context information which allows them to compensate for the information that they had lost (Davis et al., 2005), subjects make meaning even of disrupted speech. Mattys and Wiget (2011) call this a "strategic bias for communicatively meaningful percepts" (p. 146).

Given the preference of the human information processor for language, it might be plausible to assume that problems with the quality of the speech signal may be overcome or subdued by an automatic language repair mechanism as demonstrated in earlier speech perception experiments (Warren, 1970). These experiments suggest that semantic context effects may exist (van de Ven, Tucker, & Ernestus, 2011), so that an acoustic message comes through as comprehensible in spite of a disrupted signal. However, when the experimental listening task went beyond signal detection or verbatim recall and required extended discourse comprehension, competing acoustic signals have been shown to have a substantial impact on the mental model which resulted from information processing. Baron, David, Brunsman, and Inman (1997) presented subjects in an experiment with a story about a person who had been driving while intoxicated. In the experimental condition, the subjects had to listen to this story while background noise was being played. Results showed that subjects who had to filter information against background noise judged the person in the story more categorically and rigorously, and ignored or failed to process mitigating circumstances and details. This is in line with other findings which showed that an increased cognitive load on the receiver's working memory is very likely to cause a more negatively biased impression of the sender's personality (Baadte & Dutke, 2013).

To sum up: Empirical studies suggest that distracting sounds not only interfere with information processing but also have an impact on the quality of the mental model which a listener constructs from discourse. It seems plausible to assume that irregular signals increase listening load because more distracting and potentially irrelevant information needs to be processed. As a result of this increase in extraneous load, the efficiency of information processing is impeded and, eventually, comprehension and the generation of a mental model are, too.

2.3. Listening load imposed by voice characteristics and person perception

Previous studies have shown the influence of voice quality on person perception in interpersonal communication. A modal and healthy voice typically lead the listeners to associate positive characteristics, such as trust, credibility, and attractivity with the person