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Does the signal-to-noise ratio of an interlocutor influence a speaker's vocal intensity?☆

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Abstract

This study investigated whether the signal-to-noise ratio (SNR) of the interlocutor (speech partner) influences a speaker's vocal intensity in conversational speech. Twenty participants took part in artificial conversations with controlled levels of interlocutor speech and background noise. Three different levels of background noise were presented over headphones and the participant engaged in a "live interaction" with the experimenter. The experimenter's vocal intensity was manipulated in order to modify the SNR. The participants' vocal intensity was measured. As observed previously, vocal intensity increased as background noise level increased. However, the SNR of the interlocutor did not have a significant effect on participants' vocal intensity. These results suggest that increasing the signal level of the other party at the earpiece would not reduce the tendency of telephone users to talk loudly

Keywords: Vocal effort; Signal-to-noise ratio; Conversation

1. Introduction

A common annoyance in public places, for example on public transport, is the inclination of other people to talk loudly into mobile phones. This experiment investigated whether this effect is due to compensations made in response to the received speech-to-noise ratio and thus to the sound level of the other party at the ear. In other words, do people shout due to difficulty hearing their interlocutor's voice relative to the level of background noise?

In a noisy environment, individuals are known to adjust their speech in order to be heard. The modifications include speaking more slowly, enunciating more clearly and increasing vocal intensity. The present investigation focussed on the increase of vocal intensity, for which two effects are already established in the literature: individuals increase their intensity when the background noise level increases (The Lombard Effect, Lombard, 1911, as cited in Lane and Tranel, 1971) and when the perceived intensity of their own voice decreases (sidetone compensation). However, the effect of the signal-to-noise ratio (SNR) of the interlocutor appears not to have been examined. The present experiment employed a novel method of controlling the sound level of the interlocutor in a live conversation, so that its possible effect on vocal intensity could be measured.

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1.1. The Lombard effect

Lombard (1911) reported that an increase in ambient noise level resulted in an increase in a speaker's voice level; a phenomenon now known as the Lombard effect. This effect is intuitively appealing; we all have experience of the need to raise our voice in order to be heard over loud noise in a bustling restaurant or bar.

Lane et al. (1970) reviewed 10 studies that have established the Lombard effect quantitatively. These studies measured the rate at which vocal intensity increases as background noise level increases, known as the noise compensation function. If the slope of the noise compensation function is 0 dB/dB, there is no increase in vocal intensity as a function of noise, while 1 dB/dB indicates an increase in vocal intensity that matches the increase in noise. They noted that variations in the function's slope appeared to be determined by the importance of effective communication in the experimental task. The studies that have reported flat noise compensation functions have typically employed tasks that do not demand audible communication. For instance, Dreher and O'Neill (1958) instructed participants to simply read a list of words into a tape recorder. Increase in background noise produced only a small effect on vocal intensity; the slope of the noise compensation function was 0.10 for sentences and 0.11 for words. Korn (1954) reported a noise compensation function of 0.3 by adopting a more interactive method: participants were engaged in conversation and then instructed to read test sentences to their interlocutor. There was however, no requirement for correct transmission of material. Webster and Klumpp's (1962) design demanded effective communication by requiring listeners to repeat what they had heard. They reported a larger noise compensation function of 0.50. If the effect were purely automatic, it would occur to the same degree whether an individual reads sentences alone or is engaged in a conversation with another individual. These findings suggest that the need for intelligible communication with another individual is an important factor influencing the Lombard effect.

This conclusion has been consistently supported in the literature. For instance, Garnier et al. (2010) manipulated both auditory and communicative aspects of their experimental paradigm in which subjects participated in a game. Speech modifications were greatest when cocktail-party noise was played into headphones rather than over loudspeakers and in the interactive condition than in the non-interactive condition. These results suggest that the Lombard effect is a combination of both a communicative adaptation and automatic regulation of voice level. All of the findings discussed above suggest that although the Lombard effect is partly automatic its magnitude is dependent on communicative factors. The effect is greater when an individual is required to transmit speech signals effectively in communication with others.

1.2. Sidetone compensation

A second effect on vocal intensity has been reported in the literature; a speaker modifies their vocal intensity in response to the level at which they hear their own voice. This effect is known as sidetone compensation or the Fletcher effect (Fletcher et al., 1918, as cited in Lane et al., 1970) A related phenomenon has been reported to occur in individuals who have hearing problems; they perceive their own voice to be quiet and compensate for this by speaking loudly (Radley, 1948). Similarly, when a speaker is presenting in a room with low reverberation, their apparent speech level is quiet and they raise their voice in order to be heard effectively by their audience (Pelegrin-Garcia et al., 2011a).

Lane et al. (1970) also evaluated 10 experiments on sidetone compensation. Sidetone compensation showed a similar function to the Lombard effect, but with the inverse slope. Fletcher et al. (1918, as cited in Lane et al., 1970) instructed participants to read monosyllables into a telephone microphone and obtained a sidetone compensation function of −0.25. Noll (1964) used conditions where telephone talkers read prepared passages (and obtained a slightly larger compensation function of −0.33). These two designs did not use tasks that involved interactive communication. McKown and Emling (1933, as cited in Lane et al., 1970), however, monitored live business calls made by telephone company employees and modified sidetone. Increases in sidetone produced decrements approximately half as great in speech level; the slope of the compensation function was −0.49.

The findings above, taken together, suggest that noise and sidetone compensation have the same fundamental purpose: to compensate for reductions in an individual's SNR for their listener and therefore facilitate intelligible communication (Radley, 1948).