



The sound of confidence and doubt[☆]

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ABSTRACT

Feeling of knowing (or *expressed confidence*) reflects a speaker's certainty or commitment to a statement and can be associated with one's trustworthiness or persuasiveness in social interaction. We investigated the perceptual-acoustic correlates of expressed confidence and doubt in spoken language, with a focus on both linguistic and vocal speech cues. In Experiment 1, utterances subserving different communicative functions (e.g., stating facts, making judgments) produced in a confident, close-to-confident, unconfident, and neutral-intending voice by six speakers, were then rated for perceived confidence by 72 native listeners. As expected, speaker confidence ratings increased with the intended level of expressed confidence; neutral-intending statements were frequently judged as relatively high in confidence. The communicative function of the statement, and the presence vs. absence of an utterance-initial probability phrase (e.g., *Maybe, I'm sure*), further modulated speaker confidence ratings. In Experiment 2, acoustic analysis of perceptually valid tokens rated in Experiment 1 revealed distinct patterns of pitch, intensity and temporal features according to perceived confidence levels; confident expressions were highest in fundamental frequency (f_0) range, mean amplitude, and amplitude range, whereas unconfident expressions were highest in mean f_0 , slowest in speaking rate, with more frequent pauses. Dynamic analyses of f_0 and intensity changes across the utterance uncovered distinctive patterns in expression as a function of confidence level at different positions of the utterance. Our findings provide new information on how metacognitive states such as confidence and doubt are communicated by vocal and linguistic cues which permit listeners to arrive at graded impressions of a speaker's feeling of (un)knowing.

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1. Introduction

We constantly evaluate what we perceive is true and what we (or others) say is correct. Imagine you are having a conversation with a friend, and when they ask you what places you visited during your vacation last summer, you experience the “tip-of-the-tongue” phenomenon and a feeling of uncertainty; this exemplifies the effects of a speaker's “feeling of (un)knowing” on communication, or one's evaluation of the evidence for a statement, that occurs routinely in social situations. Humans possess a unique capacity to encode a variety of emotive and social meanings in speech, including the expression of confidence and doubt, which are often decoded by listeners through an inferential process that weighs evidence from available verbal cues (e.g. linguistic phrases and constructions) and non-verbal cues (e.g. tone of voice,

Caffi and Janney, 1994; Pell, 2007; Sammler et al., 2015; Wilson and Wharton, 2006; Body and facial expression, Swerts and Kraemer, 2005; Carney et al., 2010). *Confidence* is reflected in external cues that provide evidence of the correctness or truth value of a speaker's statement and the reliability of a person (London et al., 1970a; 1970b; London et al., 1971; Scherer et al., 1973). In contrast, *doubt* (*lack of confidence*) is marked by cues that supply signs of untrustworthiness or lack of credibility; at times, these cues can also represent an indirect strategy to signal one's negative attitude or hesitation to commit oneself to a particular fact or opinion (Jokinen, 2010; Kuhlen et al., 2015).

If we are to understand how attributions about a speaker's feeling of knowing guide interpersonal communication, it is of great importance to identify what verbal and vocal cues are systematically relevant for expressing confidence and doubt and which are essential for listeners to distinguish mental states of “feeling of (un)knowing” (Brennan and Williams, 1995; Kimble and Seidel, 1991; Monetta et al., 2008; Pell, 1997; Scherer et al., 1973; Smith and Clark, 1993). The present study addressed this question by investigating how different levels of expressed confidence are encoded and decoded by the speaker-listener for utterances with different social functions (e.g., stating facts, making judgments), and

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how these communicative processes are influenced by speaker and listener characteristics.

1.1. Perceptual-acoustic correlates of confidence and doubt

Evidence from perceptual studies argues that expressed confidence is communicated in an important manner through a speaker's tone of voice, or speech *prosody*—i.e., changes in pitch and temporal parameters that make speech sound doubtful, certain, authoritative, submissive, etc. In addition, confidence is conveyed by the speaker's choice of linguistic structures (e.g., modal adverbs or probability phrases, such as *maybe*, *definitely*). Relevant studies have examined confidence-bearing expressions generated in a spontaneous question-response format (Brennan and Williams, 1995; Smith and Clark, 1993; Kimble and Seidel, 1991) or utterances elicited in a more controlled (but less natural) recording paradigm followed by a decoding procedure (Monetta et al., 1998; Pell, 1997; Scherer et al., 1973). The form of materials studied to date is limited to factual responses to trivia questions (Brennan and Williams, 1995; Kimble and Seidel, 1991; Smith and Clark, 1993), legal arguments (London et al., 1971; Scherer et al., 1973), or short utterances that could be spoken in daily interactions (Monetta et al., 2008; Pell, 2007). In general, results of these studies suggest that speakers use different types of vocal cues to convey their confidence level in speech (Kimble and Seidel, 1991; Scherer et al., 1973) and that listeners are relatively adept at making judgments about the speaker's expressed confidence from these cues in subsequent perceptual tests (Monetta et al., 1998; Pell, 1997; Scherer et al., 1973).

One set of studies have focused on the behavioral correlates of a speaker's perception of their own confidence, or feeling of knowing/unknowing, while speaking. Kimble and Seidel (1991) presented trivia questions to respondents and recorded their verbal response to each multiple-choice question, as well as their subsequent confidence rating to their response. They found that answers associated with higher ratings of feeling of knowing occurred more quickly following the question and tended to be louder; the more certain a responder felt, the louder was the response. Using a similar paradigm, Smith and Clark (1993) attempted to disentangle two types of responses that reflect a speaker's feeling of *unknowing*: answers that occur following a hesitation and non-answers to the question (*I don't know*). As the speaker's feeling of knowing decreased, the shorter was the delay of non-answers, although the delay of answers was longer. Moreover, answers associated with lower feeling of knowing more frequently used rising intonation, added fillers (e.g., *uh*, *uhm*), and explicit linguistic hedges (e.g., *Perhaps*). In Brennan and Williams (1995), verbal responses to trivia questions were rated by an independent group of listeners who were naïve to both the question and to the speaker's subjective feeling of knowing when the response was produced; when the feeling of *another's* knowing was judged as lower, utterances tended to exhibit rising intonation and longer onset latencies. Together, these studies provide useful clues about how expressed confidence is produced and interpreted from speech cues; however, it can be argued that the metacognitive states communicated in question-answer trivia statements do not adequately capture how expressed confidence is communicated in daily life, where utterances assume a variety of social functions beyond statements of world knowledge (for example, expressing intentions and opinions).

Other studies have focused on how listeners perceive another speaker's confidence using "expression elicitation – decoding" paradigms. Scherer and his colleagues (1973) asked a speaker to read texts of legal argument, written with phrases that linguistically marked confidence (e.g. *obviously*) or doubt (e.g. *I don't know*), in a confident or unconfident voice; they then asked female lis-

teners to judge the speaker's confidence and confidence-related characteristics (e.g. expertise, legal competence). Utterances produced in a confident voice were associated with increased loudness, faster speech rate, and less frequent insertion of short pauses regardless of the type of text. Interestingly, the confident voice exhibited a higher pitch when the text included doubtful linguistic phrases, whereas the unconfident voice was associated with longer between-utterance pauses in the condition when the text included confident phrases. Analyses on an independent group of listeners revealed that both linguistic and vocal cues were associated with increased speaker confidence ratings. Results of this study argue that listener impressions of speaker-intended confidence levels are linked to a core set of vocal cues used conjointly by the speaker-listener. In addition, these findings suggest that confidence-related lexical and prosodic information frequently interact; for example, the speaker may use confidence-related vocal cues, such as pitch and between-utterance pauses, only when the relevant level of confidence is absent in the lexical channel (Scherer et al., 1973).

However, the generalizability of this study is put into question due to its use of only one speaker who read one formally-written text (legal argument), and because only female judges were used (Scherer et al., 1973). Moreover, these and other results only shed light on a limited degree to which speakers conventionally express their relative feeling of knowing; as suggested by Jokinen (2010), a speaker's confidence or doubt is signaled along a continuum from the most positive to the most negative attitude, or the lowest to the highest commitment to what is said. This means that studies that inform the perceptual-acoustic characteristics of expressed confidence should include conditions where the speaker-listener communicate an intermediate level of confidence/doubt that falls between the two extremes on the continuum, as has been successfully accomplished in certain work (Monetta et al., 2008; Pell, 2007).

1.2. Role of verbal and vocal cues in encoding and decoding speaker confidence

To further disentangle how listeners process verbal (lexical) vs. vocal confidence cues in speech at the neural level, patients with selective lesions in the right hemisphere and healthy aging controls were asked to judge statements expressing confidence produced by four male English speakers. Utterances communicating three levels of confidence (low, moderate, high) were evaluated in two separate conditions: in the first, a lexical probability phrase preceded the main utterance expressed with vocal confidence (LEX+VOC condition); in the other, English-like "pseudo-utterances" (e.g., *The plackter jobbored the tozz*) were produced to vocally express the three confidence levels (VOC condition). In both conditions, high confidence was characterized by a decreased mean f₀, less variable f₀ range and increased speech rate. Right hemisphere-damaged patients were less able than controls to differentiate high vs. moderate confidence when only vocal information was available (VOC), although both groups could rate these distinctions when both vocal and verbal information was available (LEX+VOC). Ratings implied that the prosodic cue was generally more informative than lexical cues in signaling the speaker's confidence level (especially high confidence), and that lexical information was used mainly when prosodic decoding mechanisms were impaired (see also Monetta et al., 2008 for data on Parkinson's disease). These data underscore that accurate perception of speaker confidence often depends on the interplay of verbal and vocal cues, which can be differentially weighted by certain listeners (Jiang and Pell, 2016a,b). However, it is still unclear how the perceptual outcomes are supported by acoustic underpinnings separating low to high expressed confidence.

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