Available online at www.sciencedirect.com

ScienceDirect

Journal of Pragmatics 121 (2017) 147–161

journal of PRAGMATICS

www.elsevier.com/locate/pragma

The sound of (in)sincerity

Karyn Fish [a,1], Kathrin Rothermich [a,b,*], Marc D. Pell [a,1]

[a] McGill University, School of Communication Sciences and Disorders, Montreal, QC, Canada
[b] East Carolina University, Department of Communication Science and Disorders, Greenville, NC, USA

Received 10 February 2017; received in revised form 6 October 2017; accepted 7 October 2017
Available online 6 November 2017

Abstract

In social life, humans do not always communicate their sincere feelings, and speakers often tell 'prosocial lies' to prevent others from being hurt by negative truths. Data illuminating how a speaker's voice carries sincere or insincere attitudes in speech, and how social context shapes the expression and perception of (in)sincere utterances, are scarce. Here, we studied the communication of social, other-oriented lies occurring in short dialogues. We recorded paired questions (*So, what do you think of my new hairdo?*) and responses (*I think it looks really amazing!*) using a paradigm that elicited compliments which reflected the true positive opinion of the speaker (sincere) or were meant to hide their negative opinion (insincere/prosocial lie). These Question–Response pairs were then presented to 30 listeners, who rated the sincerity of the person uttering the compliment on a 5-point scale. Results showed that participants could successfully differentiate sincere compliments from prosocial lies based largely on vocal speech cues. Moreover, sincerity impressions were biased by how the preceding question was phrased (confident or uncertain). Acoustic analyses on a subset of utterances that promoted strong impressions of sincerity versus insincerity revealed that compliments perceived as being sincere were spoken faster and began with a higher pitch than those that sounded insincere, while compliments rated as insincere tended to get louder as the utterance unfolded. These data supply new evidence of the importance of vocal cues in evaluating sincerity, while emphasizing that motivations of both the speaker and hearer contribute to impressions of speaker sincerity.

Keywords: Speech processing; White lies; Compliments; Sincerity; Prosody; Prosocial lies

1. The sound of (in)sincerity

Natural language abounds with indirectness, assumptions, and implicature; listeners assign meaning to utterances without guarantee that their interpretation is the one intended by the speaker (Green, 1996; Pexman and Zvaigzne, 2004). During interpersonal communication, both verbal and nonverbal cues supply important information about speakers' emotions, attitudes, beliefs, and cognitive states that reveal their intentions (Arndt and Janney, 1991; Wilson and Wharton, 2006). Of special interest here are vocal (*prosodic*) cues in speech, such as dynamic changes in utterance pitch, loudness, tempo, pauses, and voice quality (Cheang and Pell, 2008). These cues are critical for deriving the speaker's underlying affective and cognitive disposition in the context of a verbal message, and thus, for interpreting non-literal meanings (Cheang and Pell, 2009; Jiang and Pell, 2015; Pell et al., 2011).

* Corresponding author at: Communication Sciences and Disorders, College of Allied Health Sciences, East Carolina University, 3310 AD Health Sciences Bldg, 600 Moye Blvd., MD 668, Greenville, NC 27858, USA.
E-mail address: rothermichk17@ecu.edu (K. Rothermich).
[1] McGill University, School of Communication Sciences and Disorders, 2001 McGill College, 8th Floor, Montreal, QC H3A 1G1, Canada.

https://doi.org/10.1016/j.pragma.2017.10.008
0378-2166/

The ways that vocal cues are used to communicate *(in)sincerity* in speech have received little empirical attention to date. When an utterance's content (i.e., the literal semantic meaning of the utterance) matches other cues that mark the speaker's true beliefs or attitudes, it may be described as *sincere*, whereas *insincere* utterances diverge somehow from the speaker's true evaluation of a situation. In many social interactions, speakers' prosody provides critical insight into the reality of their thoughts and feelings to the listener—for example, revealing their sincere or insincere intent when giving a compliment (*I think you look really amazing!*). In this study, we investigate the role of speech prosody in judging that a speaker giving a compliment is being sincere or insincere, a context in which insincerity is associated with the telling of 'prosocial lies'. Although there are various ways for speakers to be insincere in daily communication (e.g., sarcasm, teasing, bluffing), a focus on prosocial lies can begin to illuminate the psycho-acoustic, perceptual, and social dimensions of (in)sincere forms of communication.

Little research has focused specifically on the communication of sincerity, but there is a rich adjacent literature on deception and the perception of lies, a form of insincere speech in which speakers attempt to conceal their true attitudes or beliefs when uttering a remark. Lies have been characterized as fact- or feeling-based, and can be self- or other-oriented (DePaulo et al., 1996). While many self-serving lies are harmful and told for one's own benefit (''high-stakes''), *prosocial lies* about feelings, preferences, attitudes, and opinions are designed to reap psychological rewards, such as closeness and respect, and to avoid hurt feelings (DePaulo et al., 1996, 2003). They also can prevent harm to another's positive self-image or *face* (Brown and Levinson, 1978). Expressing insincere opinions in the form of prosocial lies has been described as a form of communicative competence or ''social lubricant'' (Bryant, 2008; Saxe, 1991). Indeed, these insincere remarks are perceived as so innocuous that they are often grouped with compliments, courtesies (Ekman and O'Sullivan, 2006), and politeness behaviour (e.g., Talwar et al., 2007).

In the literature on deception (unrestricted to prosocial lies), meta-analyses provide clues about the nonverbal indicators of insincerity during social interactions (DePaulo et al., 2003; Sporer and Schwandt, 2006; Zuckerman et al., 1979). Despite speakers' attempts to hide that they are lying, auditory and visual cues that accompany the production of prosocial lies, such as changes in voice pitch or facial expressions, tend to ''leak out'' (Buller and Aune, 1987; Villar et al., 2013). Focusing on the auditory modality, lies seem to be associated with increases in vocal pitch, increased speech disturbances (filled or unfilled pauses), and a delayed response latency. At the same time, lies tend to have a shorter message duration (Sporer and Schwandt, 2006) and slower speech rate when compared to truthful (sincere) utterances (Vrij et al., 1996). Elevated pitch when lying has been associated with tentativeness, revealing that the speaker is uncertain about the utterance's content (Holmes, 1984; Jiang and Pell, 2017).

However, there seems to be a poor correspondence between the cues shown by empirical work to actually signal deception and those that are widely perceived to be associated with lying by the general public (Anderson et al., 1999; Vrij and Semin, 1996). For example, based on cross-cultural investigations, it is commonly believed that ''avoidance of eye contact'' is the predominant cue to deception, when in reality, eye contact (or lack thereof) does not appear to provide a true indication of lying (Anderson et al., 1999; Bond et al., 1990; Cheng and Broadhurst, 2005; Vrij and Semin, 1996). One study comparing the beliefs held by prisoners, law-enforcement officials (professional lie detectors), and college students (with no experience or training) reported that students and professional lie detectors hold similar misconceptions regarding the indicators of deception—for example, both groups falsely believed that liars shift body position and avoid gaze more than truth-tellers. Only prisoners, whose daily survival might depend upon lie perpetration and detection, showed significantly higher accuracy in their beliefs regarding the cues to deception (Vrij and Semin, 1996).

Explicit lie detection may be poor because many individuals overlook nonverbal/paralinguistic cues when judging lies (Ekman et al., 1991), instead over-relying on verbal cues, which tend to be easier for speakers to control than nonverbal cues in the context of deception (DePaulo et al., 1982; O'Sullivan et al., 1985). Furthermore, individual differences can influence the perception of lies, such as speaker personality (Riggio et al., 1987), culture (Bond et al., 1990), and behaviour (O'Sullivan, 2003), and listener social/emotional intelligence (Riggio et al., 1987). These and other factors could alter sensitivity to cues that mark deception in many social contexts (O'Sullivan, 2005), and by extension, (in)sincerity. It has also been proposed that there is a general ''truth bias'' in interpersonal communication, with truthful statements being correctly identified as true more often than lies are recognized as false (McCornack and Parks, 1986).

Other contextual factors seem to guide how humans communicate and perceive (in)sincerity from speech. For example, the proportion of self- versus other-oriented lies told between two people is known to be influenced by the sex and the level of intimacy of interlocutors. Intimate relationships are associated with increased other-oriented (protective) lies, whereas people tell more self-centred lies to strangers (DePaulo and Kashy, 1998). Research shows that women are more frequently the *targets* of other-oriented lies, such as insincere compliments, especially in female-female dyads (DePaulo et al., 1996; Camden et al., 1984). Uttering an insincere compliment may serve to reduce social distance and strengthen interpersonal solidarity for females (Holmes, 1988; Wolfson, 1981), and recent evidence shows that prosocial lying can increase trust when compared to truth-telling (Levine and Schweitzer, 2015). In light of these ideas, the context of soliciting, uttering, and interpreting sincere versus insincere compliments involving two female friends was of keen interest in our study.

The social motives leading to a sincere versus insincere expression of an opinion are also important (Seiter and Bruschke, 2007). The act of giving a compliment is inherently social, requiring both a sender and a receiver; it is therefore important to understand the antecedents that prompt a speaker to deliver a compliment in a certain manner. For example, if a compliment is prompted by an explicit request for an opinion, it might be perceived differently than if the same compliment is offered spontaneously. A compliment may also be interpreted and uttered differently after a casual, confident request (i.e., someone is merely curious about her friend's opinion) versus an uncertain request (i.e., one expressing feelings of apprehension and a desire for reassurance), influencing the extent to which the compliment is perceived as sincere or as having been given to strengthen the asker's confidence. Buller and Burgoon (1996) have argued that the interaction between sender and receiver is crucial for understanding interpersonal deception. People often refrain from providing explicit negative feedback to others (Blumberg, 1972; DePaulo and Bell, 1996; Swann et al., 1992), particularly negative evaluations of friends or romantic partners (Blumberg, 1972; Felson, 1980; Lemay et al., 2013). The frequency of lies told to close friends has been linked to interpersonal variables such as attachment anxiety (Ennis et al., 2008). Thus, the relationship between the deceiver and the deceived and the underlying *motive* for telling lies—whether to promote affiliation, benefit others, or protect privacy needs—is an important factor to take into account (Seiter et al., 2002). Here, like much of the research on lying, we focus on behaviours associated with the *producer* of sincere or insincere compliments, not on the *recipient* of the compliment. Nonetheless, our design considers aspects of the broader social context for communicating (in)sincerity by manipulating the form of the question prompting a compliment (confident versus uncertain), allowing new insights about the interpersonal context that governs this behaviour.

1.1. Current objectives

In this study, we examined how (in)sincerity is communicated during simulated interpersonal exchanges involving two female friends, to characterize how vocal cues differentiate utterances that reflect a speaker's true positive evaluation of the listener (sincere) or their attempt to hide a negative evaluation (insincere/prosocial lie). To account for attitudes held by both interlocutors, auditory recordings of question–response conversations were created in which one person solicits an opinion in a confident or uncertain manner, and a second person responds with a sincere or insincere compliment. These conversations were first used to gather perceptual data on utterances expressing sincere or insincere opinions in relation to the social context, and then to examine the link between perceptual ratings of (in)sincerity and the acoustic form of utterances that strongly bias these impressions. Although the laboratory setting cannot entirely replicate the natural environment, a number of steps were taken to simulate factors that underlie the elicitation of compliments in real life (e.g., defining the motives and true opinions of the giver and receiver of the compliment; see below). Note that by tightly controlling the linguistic context for expressing compliments, our study is very useful for highlighting how prosody functions in different settings; however, this approach is unlikely to capture the full range of vocal and/or linguistic strategies speakers use when communicating (in)sincerity in natural discourse (Caffi and Janney, 1994), which remains a goal for future work.

Based on the above literature, we expected that insincere compliments (prosocial lies) would be difficult for listeners to accurately detect overall. However, we predicted that by looking at utterances perceived to be highly sincere versus insincere, acoustic analyses would reveal differences in the acoustic properties of these two expressions, such as higher pitch values and a slower speech rate for insincere utterances when compared to sincere ones. We also predicted that the social context for eliciting the compliment (confident versus uncertain request) would influence sincerity impressions, i.e., compliments judged to be sincere following confident questions would be less likely to be perceived as such following uncertain questions.

2. Methods

The study had two phases: the goal of the first part (*Stimulus Elicitation Study*) was to construct a set of Question-and-Response pairs, ending in a compliment that expressed a sincere or insincere attitude. In the second part (*Perceptual-Acoustic Study*), we gathered perceptual and acoustic data on the recordings to determine how perceived speaker sincerity is associated with underlying prosodic features in speech (using a subset of the elicited stimuli containing utterances reliably perceived as sincere/insincere). Informed written consent was obtained for all participants who were compensated $10 CAD per hour for their involvement.

2.1. Stimulus elicitation study

2.1.1. Materials

Two types of written stimuli were constructed for the study: (a) Question–Response pairs; and (b) eliciting Contexts. Contexts were simply employed as prompts to enhance the naturalness of Questions and Responses when recorded by

Table 1
Example of Questions and Responses for the item ''Bikini'' during the stimulus elicitation study.

Attitude	Question	Response	Prosody
Confident	''*So, what do you think of how this bikini looks on me?*''	''*It looks really beautiful on you*''	Sincere
			Insincere
Uncertain	''*Do you think this bikini looks disgusting on me?*''		Sincere
			Insincere

the actors (see below). Question–Response pairs, especially the form of the Response (or compliment), were of primary interest in data analysis.

a) Question–Response pairs depicted a short conversation between two female friends, in which the ''Asker'' asks the ''Responder'' for her opinion about something, in either a confident or uncertain manner, and the Responder replies with a sincere or insincere compliment (Table 1). This design yielded four unique Response conditions as a combined function of the attitude of the Asker (confident, uncertain) and of the Responder (sincere, insincere). Regardless of the question or response type, the wording of the Response for any given item was identical.

Responses consisted of 16 short compliments (each 9–11 syllables in length), each produced by four different female Responders. Responses were designed to directly answer the question without evading the issue at hand (i.e., not violating Grice's maxim of relation). Conversational themes reflected typical scenarios where people use prosocial lies: *Appearance* (e.g., hairstyle, bikini, glasses); *Creative acts* (painting, cooking); *Interpersonal Acts* (hosting a party, making a presentation, etc.); and *Third Parties* (i.e., someone in a close relationship with the Asker or Responder, such as a boyfriend, mother). Two question types were constructed to elicit a sincere and insincere Response for each compliment (16 sets total): For *confident* questions, the Asker was merely curious about her friend's opinion; these had the general pattern, ''*So, what do you think of my. . .?*''. For *uncertain* questions, the Asker was feeling anxious and seeking reassurance from the Responder about the topic in question; these took the form of ''*Do you think my [item] looks/is/was [negative attribute, e.g., ugly, boring, disgusting]?*''. In total there were 32 questions (16 confident, 16 uncertain). The full list of items is furnished in the Appendix.

b) Contexts were designed to help speakers produce the Questions and Responses as naturally as possible, by describing real-world situations corresponding to differences in Asker (confident, uncertain) and Responder (sincere, insincere) attitudes. As shown in Table 2, contexts provided explicit details about the topic and how confident the actor felt about the item (for Askers) or their true opinion about the item and the evaluations being asked of them (for Responders). Contexts prompting confident questions emphasized that the Asker openly wondered what her friend thought of an attribute, whereas contexts prompting uncertain questions emphasized the Asker's lack of self-confidence in relation to the compliment's target attribute. To elicit sincere versus insincere responses, scene-setting details formulated for each item were followed by a description of the Responder's true opinion (i.e., why she loved or hated the attribute in question). Insincere contexts also highlighted the Responder's motivation for lying by including the phrase, ''*But you don't want to hurt your friend's feelings*''. In total there were 64 contexts (16 items $\times$ 2 Question types (confident, uncertain) $\times$ 2 Response types (sincere, insincere)).

2.1.2. Speakers

Five female speakers (mean age = 23.8 years; SD = 5.3) were recruited to produce the Questions and the Responses; they responded to an ad ''on expressing meaning in language'' and were naïve to the detailed purpose of the study. All were native English speakers with unmarked North American accents and lay acting experience. One speaker produced all of the questions (the ''Asker''), whereas four different women each produced all of the compliments (the ''Responders''). Given our primary focus on the form of Responses and how they were perceived, recruiting four speakers to serve as Responders allows greater generalizability of the data by accounting for possible individual differences in speaking style. Only females were recruited because they are more frequently the deliverers and recipients of other-oriented protective lies (i.e., insincere compliments), especially when interacting with other females (DePaulo and Bell, 1996; Erat and Gneezy, 2012). It has also been suggested that female-female dyads are generally more intimate and emotionally supportive than those including men, and that women often prefer to protect others' feelings instead of telling the truth (e.g., MacGeorge et al., 2003). In turn, intimate relationships have been associated with increased prosocial lie telling (DePaulo and Kashy, 1998), justifying why we focused here on conversations between female friends. A 26-year-old male speaker was also recruited to record the ''Contexts'' that were employed during Question and Response recording sessions.

Table 2
Example of contexts to elicit the item ''Bikini'' during the stimulus elicitation study.

I) Asker	
Common beginning	
You are going to the beach with your friend and you are wearing your new bikini for the first time. You both lay your towels down on the sand and then proceed to take off your clothes, revealing your bathing suits.	
Confident	**Uncertain**
You think that the bathing suit looks fine on you but you are wondering what your friend thinks about it so you look at her and ask,	You feel incredibly self-conscious in the bikini and want some reassurance from your friend, so you look at her uneasily and ask,
II) Responder	
Common beginning	
You are going to the beach with your friend. Although you have a good idea of what your friend's body looks like from seeing her in her clothes, you have never seen her in a bathing suit and you don't know what style bathing suit to expect her to be wearing. You both lay your towels down on the sand and then proceed to take off your clothes, revealing your bathing suits.	
Sincere/confident	**Sincere/uncertain**[a]
Your friend looks fantastic in her bikini. Her body is toned yet feminine and the vibrant colour of her bikini contrasts nicely against her tanned skin. She looks so good that she deserves all of the approving looks aimed her way. So when she looks at you and asks, ''QUESTION'', you respond,''	Your friend looks fantastic in her bikini. Her body is toned yet feminine and the vibrant colour of her bikini contrasts nicely against her tanned skin. She looks so good that she deserves all of the approving looks aimed her way. So when she looks at you uneasily and asks, ''QUESTION'', you respond,
Insincere/confident[a]	**Insincere/uncertain**
Your friend looks terrible in her bikini. The straps of the elastic are tied too tightly, causing her flesh to ripple and fold, and the pale colour of her bikini blends in with her pasty white skin. She looks so bad that she is getting attention for all the wrong reasons. But you don't want to hurt your friend's feelings so when she looks at you and asks, ''QUESTION'', you respond	Your friend looks terrible in her bikini. The straps of the elastic are tied too tightly, causing her flesh to ripple and fold, and the pale colour of her bikini blends in with her pasty white skin. She looks so bad that she is getting attention for all the wrong reasons. But you don't want to hurt your friend's feelings so when she looks at you uneasily and asks, ''QUESTION'', you respond

[a] *Note*: These contexts were not recorded by the actor during the recording session, but were instead created as digital composites, using components from the sincere/confident and insincere/uncertain recordings.

2.1.3. Recording procedure

All materials were digitally recorded in a sound-attenuated booth using a head-mounted microphone connected to a Tascam HD-P2 Portable Stereo Audio Recorder. Stimuli were elicited and recorded in three stages. First, all contexts were read aloud by the male ''narrator'' and recorded during a single session; the narrator was instructed to read each context, displayed on a laptop monitor, with a neutral-yet-engaging tone of voice and was provided constructive feedback by the examiner. These recordings were transferred to a PC and edited to isolate the onset and offset of each context. Questions were then recorded during a second session by the female speaker who played the ''Asker''. She was told to imagine that she was interacting face-to-face with a female friend and to visualize each situation as the context unfolded. Each trial consisted of the following event sequence: (1) a title slide displayed on a computer monitor summarizing the theme of the trial (e.g., ''Painting''); (2) a slide showing the target Question to be produced; and (3) auditory presentation of the Question-prompting context recorded by the male speaker, played through the computer speakers. When prompted by the narrator, the Asker produced the Question in a manner consistent with the context, speaking into a head-mounted microphone connected to a digital recorder. Confident and uncertain questions were recorded in separate blocks, allowing the Asker to successfully adopt self-assured and uncertain frames of mind during the procedure. Prior to producing confident sounding questions, she was explicitly told that she felt confident and was only curious about her friend's opinion; before uncertain trials, she was told that she felt insecure and wanted her friend's reassurance. The Question recordings were then edited to mark their acoustic onset/offset and inserted at the end of the compliment-prompting contexts to facilitate production of the Responses at the third recording stage.

Finally, each of the four Responders was recorded during a separate session using the same set-up and visualization instructions as above. First, each Responder produced the 16 compliments in a ''neutral tone of voice'' prior to being exposed to any biasing contexts; this block served to familiarize Responders with the target stimuli and established an acoustic baseline for each speaker for analyses of sincere/insincere expressions. The Responders then completed a series of randomized trials with the following sequence: (1) a slide with the visual title/theme; (2) a slide showing the Response target; (3) auditory presentation of the context; and (4) auditory presentation of the Question. Immediately after the question, they produced the target compliment in a contextually-appropriate manner. Whenever Responders were unhappy with their performance, the trial was repeated from the beginning (no additional feedback was provided by the examiner). Responses elicited in each of the four conditions (Sincere-Confident, Sincere-Uncertain, Insincere-Confident, Insincere-Uncertain) were edited to identify their acoustic onset/offset and then combined with their eliciting Question to create short dialogues for use in part two of the study.

2.2. Perceptual-acoustic study

The goals of part two of the study were: (1) to gather data on how listeners judge the sincerity of Responders when listening to Question–Response pairs constructed in the Elicitation Study; and (2) to extract acoustic parameters from a subset of utterances that were strongly perceived to be sincere or insincere, to establish underlying acoustic differences related to these perceived meanings.

2.2.1. Materials

The 256 Question–Response pairs recorded in the stimulus elicitation phase (4 actors × 16 items × 2 sincerity conditions × 2 security conditions) were used. Stimuli were first normalized to a peak amplitude of 70 dB to control for inter-speaker differences in recording levels across sessions; they were then presented in the pairs in which they were elicited, in the form of ''short conversations'', separated by 750 milliseconds (ms) of silence between the Question and Response. Studies suggest that an inter-turn silence of this duration is unlikely to provide sufficient information for listeners to determine Responder attitudes based on the duration of the inter-stimulus pause (Roberts et al., 2006).

Listeners. Thirty young adults with good hearing (15 male/15 female; mean age = 21.9 years; SD = 2.5; mean education = 16.6 years; SD = 2.1) were recruited via McGill University's online classified ads to rate the recorded stimuli. None of the listeners reported familiarity with individuals recorded in the elicitation study.

2.2.2. Sincerity rating task

Listeners were tested individually in a quiet laboratory, seated in front of a computer. They were informed that the study was about how ''meanings are expressed in language'' and that they would hear Question–Response exchanges between two female friends, casual friends of equal status. In each case, the first friend asks the second friend for her opinion, and the second friend replies with a compliment. Participants were told to listen carefully to each interaction and then *judge how much the Responder really meant the compliment* on a 5-point scale ranging from −2 (insincere) to +2 (sincere). Each participant listened to all of the 256 Question–Response pairs, presented by SuperLab software through circumaural headphones, while facing a blank screen. All stimuli were fully randomized and presented in different orders across participants (i.e., there was not a single randomized order). Trials were distributed in different blocks, with full randomization of items within blocks and blocks within the experiment. Participants responded by clicking on a scale that appeared at the offset of the Response, which automatically recorded their decision. These ratings were used to analyze the effects of different question and response types on perceived speaker sincerity, and to identify a subset of utterances strongly perceived as conveying sincere versus insincere attitudes to guide detailed acoustic analyses.

2.2.3. Acoustic analyses

For the acoustic analyses, only a subset of stimuli reliably perceived as sincere/insincere (based on participants' ratings) were selected; restricting acoustic analyses to a subset of the stimuli ensured that any acoustic differences observed between sincere and insincere utterances were likely to reflect parameters associated with the perception of these meanings in the voice, and were not artefacts of the elicitation paradigm or of analyzing stimuli that did not promote a consistent impression of either meaning. Regardless of the (in)sincerity intended by the speakers, compliments from either group rated as *sincere* (i.e., score of +1 or +2) by at least 60% of the listener group, with less than 25% ratings in the insincere range (−1 or −2), were coded as valid exemplars of perceived sincerity, whereas the opposite but corresponding criteria were applied to identify valid items labelled as *insincere*. In total, this yielded 58 sincere (Mean rating = 0.81, SD = 1.08) and 51 insincere (Mean rating = −0.92, SD = 1.14) compliments that conveyed relatively unambiguous perceptual impressions of (in)sincerity, which were subjected to acoustic analyses using Praat speech analysis software (Boersma, 2002).

Following Pell et al. (2009), five acoustic parameters measuring *global* differences in the form of sincere/insincere utterances were extracted from each valid sincere, insincere, and neutral utterance produced by each speaker. Acoustic measures were: mean fundamental frequency (f0) and fundamental frequency range (both in Hertz, Hz); mean amplitude and amplitude range (both in decibels, dB); and speech rate (in syllables/second). Range (variation) measures were computed by subtracting the corresponding minimum from the maximum value of each utterance. F0 measures were visually inspected and manually corrected for each speaker to mitigate automatic extraction errors. In addition to global measures, visual comparison of sincere and insincere compliments appeared to reveal more local differences between the initial phrase (''I think/I found'') and the main part of the utterance (e.g., ''You look really amazing'') that might not be captured by focusing exclusively on whole-utterance measures (see Fig. 1). As the vast majority of items had this syntactic structure, we extracted the five acoustic measures separately for the first and second portion of each utterance to further qualify prosodic differences corresponding to perceived sincerity and

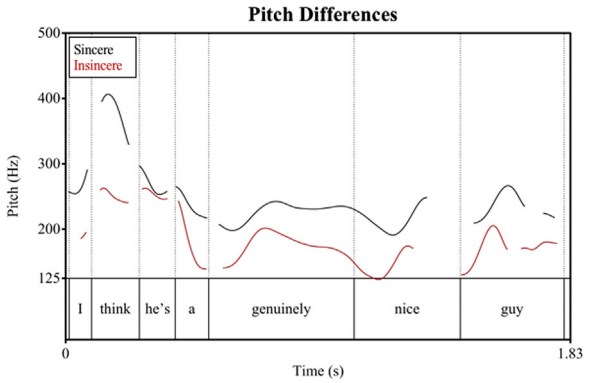

Fig. 1. Visual display of sincere and insincere compliments and local pitch differences between the initial phrase (''I think'') and the main part of the utterance (''he's a genuinely nice guy'').

insincerity, allowing analyses of both global and more local (phrase-level) acoustic features.[2] Before entering the acoustic data into statistical models, all f0 and amplitude measures were normalized to correct for inter-speaker differences in vocal characteristics unrelated to sincerity expression, allowing meaningful differences to be investigated when data for the four speakers were combined.[3]

3. Results

3.1.1. Perceptual measures

The mean sincerity ratings of compliments presented in each of the four Question–Response conditions are shown in Fig. 2. Listeners were instructed to rate sincere compliments with positive ratings and insincere compliments (prosocial lies) with negative ratings; one can see from the distribution of scores that the elicitation paradigm was generally successful in producing compliments that were perceived as sincere or insincere, as intended. Statistical tests confirmed that compliments intended as sincere received a significantly higher proportion of positive than negative ratings ($t(29) = 7.00$, $p < .0001$), whereas insincere compliments received a higher proportion of negative than positive ratings ($t(29) = 4.13$, $p = .001$). The mean sincerity ratings for all items were then entered into a 2 × 2 (Question × Response type) repeated-measures ANOVA. As expected, this analysis produced a significant main effect for Response type ($F(1, 29) = 123.12$, $p < .0001$, partial $\eta^2 = .81$), with insincere compliments receiving lower mean sincerity scores than sincere compliments overall. This pattern was informed by a Question × Response type interaction ($F(1, 29) = 22.88$, $p < .0001$, partial $\eta^2 = .44$). Tukey's post hoc comparisons ($p < .05$) revealed that while higher ratings were always assigned to sincere versus insincere compliments, this difference was mitigated by uncertain questions. When Askers were simply curious about the Responder's opinion (confident question), listeners rated sincere replies as sounding more sincere, and insincere utterances as sounding less sincere, than identical compliments following an appeal for social reassurance (uncertain question). These patterns are displayed in Fig. 2.

3.1.2. Acoustic measures

Measures of the five acoustic parameters of interest—mean fundamental frequency (Meanf0), fundamental frequency range (f0Range), mean amplitude (MeanAmp), amplitude range (AmpRange), and speech rate (SpeechRate)—are

[2] Two items (''acting'' and ''cooking'' in the Appendix) were subsequently excluded from acoustic analyses due to their distinct syntactic structure, which hampered comparison of local measures. The initial portion was always composed of the first two words (*I think, I had, I found, It looks*).

[3] Each f0 or amplitude measure extracted from an utterance (mean, min, max) was expressed as the relative distance from a single anchor point calculated for each speaker, based on stable vocal characteristics in the *neutral* condition. Individual mean, min, and max f0/amplitude values for sincere and insincere tokens were always compared to the mean minimum f0 or mean minimum amplitude of all neutral utterances produced by the corresponding speaker. Range values were then calculated from the *normalized* min and max values within speakers. See Pell et al. (2009) for complete details and a rationale for this approach.

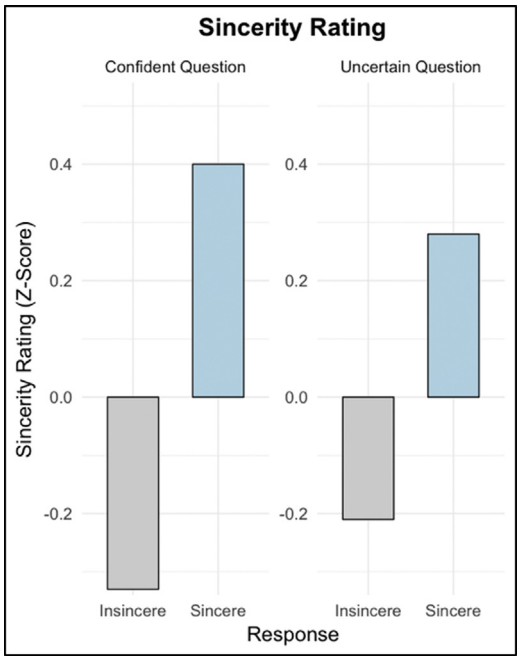

Fig. 2. Z-scores of sincerity ratings by Question and Response.

Table 3
Mean (standard deviation) of five major acoustic parameters extracted from critical constituents of the compliment (initial phrase, main phrase) according to the Question and Response type. Each measure was first z-normalized within each of the four speakers prior to averaging in reference to neutral utterances produced by the same speaker.

		Confident question		Uncertain question	
		Sincere response	Insincere response	Sincere response	Insincere response
Meanf0	Initial phrase	.86 (.21)	.68 (.16)	.84 (.15)	.64 (.19)
	Main phrase	.44 (.12)	.44 (.15)	.49 (.19)	.47 (.17)
	Full utterance	.65 (.27)	.56 (.19)	.67 (.24)	.55 (.20)
Rangef0	Initial phrase	.57 (.34)	.46 (.36)	.57 (.37)	.42 (.30)
	Main phrase	.97 (.35)	1.07 (.37)	.98 (.27)	1.04 (.39)
	Full utterance	.77 (.40)	.76 (.47)	.77 (.38)	.73 (.47)
MeanAmp	Initial phrase	.38 (.05)	.38 (.05)	.39 (.05)	.36 (.05)
	Main phrase	.35 (.03)	.37 (.03)	.34 (.03)	.37 (.04)
	Full utterance	.37 (.04)	.37 (.04)	.36 (.05)	.37 (.05)
RangeAmp	Initial phrase	.38 (.07)	.41 (.09)	.40 (.10)	.40 (.09)
	Main phrase	.53 (.07)	.56 (.08)	.55 (.08)	.53 (.07)
	Full utterance	.45 (.10)	.48 (.11)	.47 (.12)	.47 (.10)
SpeechRate	Initial phrase	7.59 (1.29)	5.90 (1.23)	7.07 (1.23)	6.06 (1.58)
	Main phrase	6.44 (.78)	5.00 (.77)	5.77 (.77)	5.10 (.78)
	Full utterance	7.01 (1.21)	5.45 (1.21)	6.42 (1.21)	5.58 (1.32)

provided in Table 3 for the subset of 109 compliments that were reliably perceived as sincere (n = 58) or insincere (n = 51) by the majority of listeners (see section 2). Recall that each acoustic measure was extracted both on the initial phrase (e.g., ''I think/I found'') and the main body of the compliment (e.g. ''absolutely delicious/you look really amazing''), allowing insight into whether acoustic cues were marked locally within particular syntactic constituents or more globally throughout the utterance. Values of the five dependent measures were entered into a MANOVA with repeated measures on Question (confident, uncertain), Response (sincere, insincere), and Utterance Position (initial phrase, main utterance).

The MANOVA revealed a statistically significant difference in the combined acoustic measures according to the sincerity of the Response ($F(5, 206) = 14.18$, $p < .001$, Wilk's $\Lambda = 0.744$, partial $\eta^2 = .26$), Utterance Position ($F(5, 206) = 94.84$, $p < .001$, Wilk's $\Lambda = 0.303$, partial $\eta^2 = .70$), and the interaction of these factors ($F(5, 206) = 94.84$, $p < .001$, Wilk's $\Lambda = 0.869$, partial $\eta^2 = .13$). Focusing on acoustic effects linked to the expression of (in)sincerity in the Response, follow-up tests showed that sincere versus insincere attitudes had a significant overall effect on Meanf0 ($F(1, 210) = 18.35$, $p < .001$, partial $\eta^2 = .08$) and SpeechRate ($F(1, 210) = 60.15$, $p < .001$, partial $\eta^2 = .22$). Overall, compliments perceived to be sincere displayed a higher mean pitch and were uttered significantly faster than those perceived as insincere (i.e., prosocial lies). Question type was not found to influence Responses' acoustic dimensions (all *p*'s involving Question > .202).

Elaboration of the Response × Utterance Position interaction specified that for some acoustic cues, their location in the utterance influenced how sincere/insincere Responses were perceived, with significant effects on Meanf0 ($F(1, 210) = 14.06$, $p < .001$, partial $\eta^2 = .06$), f0Range ($F(1, 210) = 4.55$, $p = .034$, partial $\eta^2 = .02$), and MeanAmp ($F(1, 210) = 10.52$, $p = .001$, partial $\eta^2 = .05$). Pairwise comparisons indicated that compliments perceived as sincere versus insincere were produced with a higher mean f0 on the initial evidentiality phrase (*I think. . .*, $p < .001$), although no differences were noted in the main utterance that followed ($p = .71$). Variability in pitch (f0Range) also tended to be greater in the initial phrase of utterances perceived as sincere versus insincere, although this effect was marginal ($p = .062$). At the same time, compliments perceived to be insincere were significantly higher in mean amplitude (i.e., louder; $M = 67.61$, SD = 1.35) than sincere compliments in the main body of the utterance *(. . .you look really amazing*, $M = 67.10$, SD = 1.16; $p = .004$), although not in the initial phrase ($p = .09$). As noted above, speech rate was significantly faster when speakers were perceived as sincere versus insincere and this effect was significant in both parts of the utterance ($p < .001$), suggesting that articulation rate exerts a more global effect on impressions of (in)sincerity.[4]

In a final step, we performed a discriminant function analysis to estimate how the acoustic measures predicted perception of the group of 58 sincere versus 51 insincere utterances. Given that the position of acoustic cues informed impressions of speaker sincerity in our initial analyses, we entered ten acoustic measures as separate predictors (5 measures × 2 utterance positions). The discriminant analysis produced a significant canonical function (Wilk's $\Lambda = 0.44$, $F(9,99) = 14.06$, $p < .0001$) that correlated positively with SpeechRate (initial phrase, $r = .46$, $p = .001$; main utterance, $r = .29$, $p < .0001$) and MeanAmp (initial phrase, $r = .49$, $p < .001$; main utterance, $r = .28$, $p < .01$), as well as with the Meanf0 of the initial phrase ($r = .34$, $p = .02$) and the f0Range of the initial phrase ($r = .31$, $p = .05$). Overall, contributions of the acoustic parameters in this model led to accurate classification of 88% (51/58) of sincere utterances and 86% (44/51) of insincere expressions.

4. Discussion

Our experiment sought to shed light on the vocal (paralinguistic) cues that contribute to the perception of sincere and insincere communications. Our main goal was to determine whether impartial judges could use prosodic information to perceptually distinguish between sincere and insincere compliments (i.e., prosocial lies) when exposed to short verbal interactions between two friends. Our secondary goal was to explore whether the social context for interpreting the compliment (i.e., attitude of the Asker) influenced how speech prosody was used to rate speaker sincerity. Finally, we examined how compliments that produce strong impressions of speaker sincerity or insincerity differ at the acoustic level, to inform how sincerity judgements may be linked to specific acoustic cues provided by speakers.

4.1. Perception of speaker sincerity

In daily life, we can be insincere for a number of different reasons; however, most research touching on insincerity has focused on antisocial lies, or lies told to benefit oneself at the expense of another person. Considerably less work examines prosocial lies, which are told to spare another's feelings, for example when giving a compliment even when you do not mean what you say. Prosocial lies are of interest because of their prevalence in social communication and high significance for relationship management.

Although there is little work focused broadly on the perception of sincerity from speech (Rigoulot et al., 2014), research on lie detection underscores that this ability is difficult and often does not deviate far from chance performance in experimental tasks (Anderson et al., 1999; Cheng and Broadhurst, 2005; Crossman and Lewis, 2006; DePaulo and Pfeifer, 1986; Forrest et al., 2004; O'Sullivan, 2003). Here, focusing uniquely on the perception of ''low-stakes'' social lies,

[4] In an exploratory analysis, global acoustic measures of confident versus uncertain Questions were also analyzed and compared. Only the mean amplitude of the two question types differed, with confident questions ($M = 57.5$, SD = 2.16) being significantly louder than uncertain ones ($M = 55.5$, SD = 1.95; $F(1,26) = 6.575$, $p < 0.05$).

we found that when participants explicitly rated the sincerity of utterances, they could use vocal cues to discriminate subtle differences between sincere versus insincere compliments for a large number of tokens that possessed the same linguistic structure; this argues that prosodic cues supply meaningful information to listeners forming impressions of speaker sincerity. It has been noted that people tend to be better at detecting insincerity (lies) when they are impartial third-party observers, as they were in this study, than when they are personally interacting with the speaker expressing sincere or insincere statements. Our data also reveal that impressions of the speakers from their vocal cues are modulated to some extent by how the compliment-eliciting question is asked (see below). In demonstrating that sincere statements and prosocial lies can often be differentiated from vocal cues in speech, our findings should be interpreted in light of these various factors.

In addition to a speakers' voice, our data show that the social *context* in which identical compliments are spoken—in this case, the attitude of the Asker who receives the compliment—alters the perception of speaker sincerity. While listeners consistently assigned higher ratings to sincere versus insincere remarks, perceived differences in speaker sincerity from vocal cues were more robustly differentiated when the prompting question was ''confident'' and did not seek social reassurance, than when it was ''uncertain'' and expressed self-doubt about the object of the compliment. Listeners tended to believe sincere compliments somewhat less, and prosocial lies more, when the Asker was seeking reassurance from the speaker, emphasizing that both conversational partners influenced the direction and outcome of impressions formed by the exchange. These findings underscore that listeners incorporate pragmatic information about the Asker in their interpretation of how sincere a speaker sounds, re-affirming other work that has reported context-related effects on the formation of interpersonal impressions from speech (e.g., Jiang and Pell, 2016a,b; Van den Brink et al., 2012).

Previous work looking at the contexts in which compliments are delivered has mostly concentrated on how recipients respond to compliments, not what they say to instigate them (Farghal and Al-Khatib, 2001; Golato, 2002; Mursy and Wilson, 2001; Tang and Zhang, 2009). One reason that our participants may have been less likely to believe truthful compliments when they followed uncertain questions is that they felt that these compliments were being delivered out of duty, not because of truly-held opinions. According to Brown and Levinson's (1978) theory of politeness, one role of compliments in interpersonal relations is for the speaker to show care for the addressee's positive face by supporting the hearer's positive self-image, minimizing the repercussion of face-threatening acts (see Holmes, 1988). In certain instances, seeking a friend's approval (i.e., posing an uncertain question) could be considered a face-threatening act, because it leaves the Asker vulnerable to insult and rejection; by providing positive feedback, the Responder allows the Asker's positive face to be restored and maintained. In our design, listeners may have inferred that sincere compliments following uncertain, more face-threatening questions were motivated primarily by the desire to protect the Asker's positive self-image; this may have caused them to temper their ratings of these items when compared to identical compliments following confident questions (review Fig. 2).

4.2. Vocal cues associated with perceived (in)sincerity

In the second part of our study, those expressions that were reliably perceived as sincere or insincere were subjected to acoustic analyses to draw a link between (in)sincerity impressions and underlying speaker cues. We found that combined changes in speech rate, mean fundamental frequency, and vocal amplitude differed systematically between sincere and insincere remarks. When compared to sincere speech, compliments perceived to be insincere were associated with lower pitch at the onset of the utterance, were louder as the utterance unfolded, and had a slower speech rate throughout (as well as tending to have less pitch variation). Our observation that compliments judged to be sincere were uttered more quickly throughout the utterance was particularly salient, in keeping with research exemplifying that speech rate is slower during lying compared to truth-telling (Vrij et al., 2001; Ebesu and Miller, 1994; Fiedler and Walka, 1993; Rockwell et al., 1997; Spence et al., 2012; cf. Sporer and Schwandt, 2006). It has been suggested that insincere utterances are produced more slowly due to associated feelings of guilt, or in some instances, due to the higher cognitive load associated with deception and on-line attempts to construct a lie, which impact speaking rate (Burgoon and Qin, 2006). As our utterances were elicited in a controlled environment, it is not possible to directly link these (or related) factors to the observed rate changes in the present stimuli; however, it remains possible that speakers partially *enacted* these distinctions based on general experience or lay attitudes about how quickly individuals express sincere versus insincere attitudes in speech. This claim awaits further study that focuses on factors contributing to the *production* of prosocial lies in finer details and in more naturalistic settings.

Some of the vocal cues signalling sincerity were tied to the underlying sentence structure of the compliment, in particular the phrase ''*I think/I found*'' which often serves as an 'evidentiality device' in interpersonal communication (Caffi and Janney, 1994). The initial phrase was selectively marked by higher mean pitch (and more pitch variation) in utterances that listeners interpreted as being sincere; at the same time, the main content of the utterance (*. . .you look really amazing*) was spoken more softly (lower mean amplitude) when speakers were viewed as sincere. Amplitude

measures have been studied relatively little in the related literature and existing results are mixed: for example, Mehrabian (1971) reported *decreased* intensity in those trying to deceive, whereas other research points to an *increase* in intensity or intensity range in deceivers versus truth-tellers, at least in certain conditions (Buller and Aune, 1987; Rockwell et al., 1997). In studies focused on lie detection, it has been claimed that deceivers increase their range of loudness in order to make their voices sound more normally expressive (Scherer, 1978), a process that could add further to the cognitive load imposed on speakers as they construct prosocial lies in spontaneous discourse. Speaking more loudly is also known to promote impressions of greater confidence and believability in what a speaker is saying (Barr, 2003; Jiang and Pell, 2015), a claim that is supported by an exploratory acoustic analysis showing that confident questions were produced with a louder voice when compared to uncertain questions (see footnote 2). Possibly, differences in speech intensity as an utterance unfolds are (unconsciously) provided by a speaker to reinforce that the expressed but *insincere* opinion is true to the listener.

In contrast to our work, earlier studies report an increase in mean pitch for *insincere* as opposed to sincere utterances (DePaulo et al., 2003; Sporer and Schwandt, 2006; Villar et al., 2013; Vrij and Semin, 1996). Also, deceptive speech has been characterized as having greater pitch variation than truthful speech (Anolli and Ciceri, 1997; Rockwell et al., 1997), whereas our analysis implies the opposite trend (however, note that both effects in our data were restricted to the initial phrase). While it seems likely that a speaker's pitch often serves as a vital cue for evaluating (in)sincerity (combined with other vocal cues), variability in this literature implies that the acoustic markers of sincerity and deception tend to vary across contexts and individual speakers (Qin et al., 2004). Of note, it has been argued that the acoustic form of insincere/deceptive speech can be influenced by multiple factors: the purpose of the lie (e.g., to save face versus to avoid punishment); the extent to which the lie had been prepared and rehearsed; the communication modality (telephone versus face-to-face); characteristics of the lie's recipient (e.g., a friend versus stranger); and possibly, one's own meta-knowledge about which prosodic features are associated with deception (for example, believing that pitch increases during lying, DePaulo et al., 2003; Villar et al., 2013). Clearly, more research will be needed to understand the impact of these variables on acoustic profiles associated with sincere/insincere communication and with different types of lies (e.g., prosocial versus self-serving lies).

In one study, Kirchhübel and Howard (2013) concluded that truth-tellers and liars cannot be reliably differentiated based on acoustic measures of the speech signal (e.g., pitch, pitch range, amplitude). However, our data argue that the voice of speakers who tell prosocial lies can at times betray their true, insincere attitude to the listener. This observation is interesting given that (psycho) physiological reactions to low-stake lies, and associated effects on the voice, are likely to be quite different in nature and intensity when compared to high-stake lies that have been the object of study in the literature to date. According to the Arousal Theory, liars are more stressed and anxious than truth-tellers and experience emotions such as fear, guilt and 'duping delight' (Ekman, 2009; Zuckerman et al., 1981), whereas people producing prosocial lies are less influenced by emotion and are usually motivated by interpersonal affiliation or the desire to be polite (Bryant, 2008). Thus, it is likely that prosocial lies primarily tax cognitive control behaviours as the speaker attempts to present a sincere and natural demeanour, while suppressing or controlling behaviours that they associate with lying. Paradoxically, it would appear that these control behaviours sometimes produce detectable vocal indications of the speakers' insincere opinions, which are qualitatively different than when speakers are unfettered by the need to conceal their negative attitudes to the listener.

4.3. Limitations and future directions

Results in this study relate to interactions between casual female friends, a group that is reported to employ feelings- and other-centred lies to the greatest extent (DePaulo and Bell, 1996) and to deliver/receive the greatest number of compliments in daily life (Holmes, 1988; Yu, 2005). It is not known how sincerity impressions would change if our judges were told that the conversations they heard involved best friends, romantic partners, or casual work acquaintances, or if the Asker and/or Responder had been male, as pointed out in recent work looking at context effects on a broader range of social intentions expressed in conversation (Rothermich and Pell, 2015). Moreover, it has been shown that compliment use and interpretation varies significantly around the world (Jaworski, 1995; Wolfson, 1981; Yu, 2005). Given research demonstrating that listeners are generally poor at cross-cultural sincerity perception (e.g., Bond et al., 1990; Cheang and Pell, 2011; Cheng and Broadhurst, 2005), it seems probable that the specific cues that promote impressions of sincerity in speech also vary according to an individual's cultural background. Caution should therefore be exercised in generalizing our results beyond native English-speaking participants until further data are collected. In future work, a larger number of speakers will also be needed to confirm the robustness of prosodic cues that promote impressions of sincerity in a given sample.

In terms of methods, our stimulus elicitation procedure was designed to control the linguistic form of vocal expressions while allowing responses to flow naturally from detailed contexts, mitigating the need for actors to rely on preconceived ideas about how to deliver sincere and insincere compliments (Anderson et al., 1999; DePaulo et al., 2003). By having

actors imagine themselves in particular social situations, we sought to simulate the true-to-life motivations that underlie sincere and insincere remarks in everyday conversations, a process that appeared to be successful in generating stimuli that encoded the target intentions of our study. Nonetheless, it cannot be discounted that preconceived ideas about the cues for expressing sincerity may have influenced actors' depictions and/or that Responders delivered compliments in a somewhat artificial or stereotypical manner, affecting the way that sincere compliments and prosocial lies are described in our study. It is also likely that similar conversations extracted from naturalistic stimuli would exhibit greater variability in linguistic choices, which could impact differently on the vocal form of utterances, that are not captured here. At the same time, DePaulo et al. (2003) have noted that laboratory-induced lies are not as dissimilar to natural, everyday lies as one might think; in many situations, people feel as though they have no option but to lie in order to protect themselves or the feelings of others, meaning that the small lies of daily life are sometimes prompted in a similar manner to lies that are explicitly instructed and elicited in the laboratory. Nonetheless, future studies that build upon our work could benefit by studying sincere and insincere remarks extracted for spontaneous language samples, for example, by extracting these tokens from podcasts (Truesdale and Pell, submitted for publication), allowing the current results to be generalized more broadly and in more ecological speaking contexts.

5. Conclusion

Our study establishes that a speaker's sincerity can often be inferred from prosodic cues accompanying speech, such as differences in speech rate (sincere > insincere), pitch (sincere > insincere), and loudness (sincere < insincere) as speakers utter a statement. As speakers' intent when uttering prosocial lies is typically to *conceal* their true opinions, these data imply that speakers' goals are not always achieved due to an apparent ''leakage'' of cues to the listener via the vocal channel. Possibly, even when a listener detects that the speaker is insincere, uttering an unambiguous, positive statement while *attempting* to overlook obvious vocal cues that would contradict the linguistic message, provides the same psychological rewards (Brown and Levinson, 1978; DePaulo et al., 2003) and fulfils the intended role of these expressions as a ''social lubricant'' (Bryant, 2008). The manner in which vocal cues bias sincerity impressions also depends on the phrasing of a sentence and its pragmatic context; our data show that listeners take into account the presumed *motivation* behind the statement (e.g., speaker–hearer attitudes), underscoring the importance of the conversational environment in which the utterance takes place. The effects of these interpersonal variables on the communication of sincerity and deception have not yet been subjected to adequate scrutiny and call for new studies.

Another way to advance knowledge of how a speaker's true beliefs or opinions are detected from speech, and to specify the role of vocal cues in utterance interpretation, is to use time-sensitive measures such as event-related potentials (ERPs). Recently, Rigoulot et al. (2014) presented a subset of the current stimuli to a group of listeners who rendered an explicit judgement of how sincere the speaker sounded while the encephalogram was recorded. When on-line neurocognitive responses to sincere versus insincere statements were compared, the authors reported significant differences in the P600 wave in right frontal regions from the onset of the compliment; P600 amplitudes were greater when speakers were judged to be sincere versus insincere, and this neural response significantly predicted participants' accuracy when judging the sincerity of vocal expressions. As P600-like effects are thought to index on-line processes for *updating* a mental representation of speaker meaning and intentions (e.g., Brouwer and Hoeks, 2013), these results begin to establish the time course for using prosodic cues in speech to render decisions about whether a speaker is being sincere (Rigoulot et al., 2014). Additional studies that use similar on-line methodologies to illustrate how a speaker's beliefs and mental states are inferred, and which show how this information is incorporated into a coherent mental representation of speaker meaning as speech is processed (e.g., Jiang and Pell, 2015; Regel et al., 2010), seem especially promising to extend our present conclusions about the psycho-acoustic properties of speaker sincerity perception.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Funding

This research was supported by the National Sciences and Engineering Research Council of Canada (Discovery Grant RGPIN-2016-04373) and a James McGill Professor Award to M.D. Pell.

Appendix A

All Questions and Responses used in the study (arranged by theme)

Item	Asker attitude	Question	Response
Appearance			
Bikini	Confident:	*So, what do you think of how this bikini looks on me?*	*It looks really beautiful on you*
	Uncertain:	*Do you think this bikini looks disgusting on me?*	
Glasses	Confident:	*So, what do you think of my new glasses?*	*I think they look really wonderful on you*
	Uncertain:	*Do my new glasses look awful on me?*	
Hairdo	Confident:	*So, what do you think of my new hairdo?*	*I think you look really amazing*
	Uncertain:	*Does my new hairdo look weird on me?*	
Makeup	Confident:	*So, what do you think of this new lipstick colour on me?*	*I think it looks fabulous on you*
	Uncertain:	*Does this new lipstick colour look ridiculous on me?*	
Muscles	Confident:	*So, what do you think of my muscles?*	*I think they look really impressive*
	Uncertain:	*Do you think my muscles are pathetic?*	
Artistic act			
Acting	Confident:	*So, what did you think of my performance?*	*You're a really fantastic actor*
	Uncertain:	*Was my performance in the show horrible?*	
Cooking	Confident:	*So, what did you think of the dinner I cooked?*	*It was absolutely delicious*
	Uncertain:	*Do you think the dinner I cooked was bad?*	
Painting	Confident:	*So, what did you think of the painting I made?*	*I think you're a very talented artist*
	Uncertain:	*Do you think the painting I made is ugly?*	
Poetry	Confident:	*So, what do you think of the poems I wrote?*	*I think you're a really great writer*
	Uncertain:	*Do you think the poems I wrote are lame?*	
Interpersonal act			
Gift	Confident:	*So, what did you think of the gift I got you?*	*I think you made an excellent choice*
	Uncertain:	*Do you hate the present I chose for you?*	
Movie	Confident:	*So, what did you think of the movie I chose?*	*I found it incredibly funny*
	Uncertain:	*Do you think the movie I chose was stupid?*	
Party	Confident:	*So, what did you think of my party?*	*I think it was a really fun night*
	Uncertain:	*Do you think that my party was boring?*	
Presentation	Confident:	*So, what did you think of my presentation?*	*I found it really interesting*
	Uncertain:	*Was my presentation boring?*	
Third party			
Boyfriend	Confident:	*So, what do you think of my new boyfriend?*	*I think he's a genuinely nice guy*
	Uncertain:	*Do you think my new boyfriend seems arrogant?*	
Brother	Confident:	*So, what did you think of your date with my brother?*	*I had an unbelievable time*
	Uncertain:	*Was the date with my brother terrible?*	
Mother	Confident:	*So, what do you think of my mom as a teacher?*	*I think she's phenomenally good*
	Uncertain:	*Do you think that my mom's a bad teacher?*	

References

Anderson, D.E., DePaulo, B.M., Ansfield, M.E., Tickle, J.J., Green, E., 1999. Beliefs about cues to deception: mindless stereotypes or untapped wisdom? J. Nonverb. Behav. 23 (1), 67–89.

Anolli, L., Ciceri, R., 1997. The voice of deception: vocal strategies of naive and able liars. J. Nonverb. Behav. 21 (4), 259–284.

Arndt, H., Janney, R.W., 1991. Verbal, prosodic, and kinesic emotive contrasts in speech. J. Pragmat. 15 (6), 521–549.

Barr, D.J., 2003. Paralinguistic correlates of conceptual structure. Psychon. Bull. Rev. 10 (2), 462–467.

Blumberg, H.H., 1972. Communication of interpersonal evaluations. J. Pers. Soc. Psychol. 23 (2), 157–162.

Boersma, P., 2002. Praat, a system for doing phonetics by computer. Glot Int. 5 (9/10), 341–345.

Bond, C.F., Omar, A., Mahmoud, A., Bonser, R.N., 1990. Lie detection across cultures. J. Nonverb. Behav. 14 (3), 189–204.

Brouwer, H., Hoeks, J.C., 2013. A time and place for language comprehension: mapping the N400 and the P600 to a minimal cortical network. Front. Hum. Neurosci. 7 (758), 1–12.

Brown, P., Levinson, S.C., 1978. Universals in language usage: politeness phenomena. In: Questions and Politeness: Strategies in Social Interaction, pp. 56–311.

Bryant, E.M., 2008. Real lies, white lies and gray lies: towards a typology of deception. Kaleidoscope 7, 23–48.

Buller, D.B., Aune, R.K., 1987. Nonverbal cues to deception among intimates, friends, and strangers. J. Nonverb. Behav. 11 (4), 269–290.

Buller, D.B., Burgoon, J.K., 1996. Interpersonal deception theory. Commun. Theory 6 (3), 203–242.

Burgoon, J.K., Qin, T., 2006. The dynamic nature of deceptive verbal communication. J. Lang. Soc. Psychol. 25 (1), 76–96.
Caffi, C., Janney, R.W., 1994. Toward a pragmatics of emotive communication. J. Pragmat. 22 (3), 325–373.
Camden, C., Motley, M.T., Wilson, A., 1984. White lies in interpersonal communication: a taxonomy and preliminary investigation of social motivations. West. J. Speech Commun. 48 (4), 309–325.
Cheang, H.S., Pell, M.D., 2008. The sound of sarcasm. Speech Commun. 50 (5), 366–381.
Cheang, H.S., Pell, M.D., 2009. Acoustic markers of sarcasm in Cantonese and English. J. Acoust. Soc. Am. 126 (3), 1394–1405.
Cheang, H.S., Pell, M.D., 2011. Recognizing sarcasm without language: a cross-linguistic study of English and Cantonese. Pragmat. Cogn. 19 (2), 203–223.
Cheng, K.H.W., Broadhurst, R., 2005. The detection of deception: the effects of first and second language on lie detection ability. Psychiatry Psychol. Law 12 (1), 107–118.
Crossman, A.M., Lewis, M., 2006. Adults' ability to detect children's lying. Behav. Sci. Law 24 (5), 703–715.
DePaulo, B.M., Bell, K.L., 1996. Truth and investment: lies are told to those who care. J. Pers. Soc. Psychol. 71 (4), 703–716.
DePaulo, B.M., Kashy, D.a., 1998. Everyday lies in close and casual relationships. J. Pers. Soc. Psychol. 74 (1), 63–79.
DePaulo, B.M., Pfeifer, R.L., 1986. On-the-job experience and skill at detecting deception. J. Appl. Soc. Psychol. 16 (3), 249–267.
DePaulo, B.M., Rosenthal, R., Rosenkrantz, J., Green, C.R., 1982. Actual and perceived cues to deception: a closer look at speech. Basic Appl. Soc. Psychol. 3 (4), 291–312.
DePaulo, B.M., Kashy, D.A., Kirkendol, S.E., Wyer, M.M., Epstein, J.A., 1996. Lying in everyday life. J. Pers. Soc. Psychol. 70 (5), 979–995.
DePaulo, B.M., Lindsay, J.J., Malone, B.E., Muhlenbruck, L., Charlton, K., Cooper, H., 2003. Cues to deception. Psychol. Bull. 129 (1), 74–118.
Ebesu, A.S., Miller, M.D., 1994. Verbal and nonverbal behaviors as a function of deception type. J. Lang. Soc. Psychol. 13 (4), 418–442.
Ekman, P., 2009. Telling Lies: Clues to Deceit in the Marketplace, Politics, and Marriage (Revised Edition). WW Norton & Company.
Ekman, P., O'Sullivan, M., 2006. From flawed self-assessment to blatant whoppers: the utility of voluntary and involuntary behavior in detecting deception. Behav. Sci. Law 24 (5), 673–686.
Ekman, P., O'Sullivan, M., Friesen, W.V., Scherer, K.R., 1991. Invited article: face, voice, and body in detecting deceit. J. Nonverb. Behav. 15 (2), 125–135.
Ennis, E., Vrij, A., Chance, C., 2008. Individual differences and lying in everyday life. J. Soc. Pers. Relat. 25 (1), 105–118.
Erat, S., Gneezy, U., 2012. White lies. Manage. Sci. 58 (4), 723–733.
Farghal, M., Al-Khatib, M.A., 2001. Jordanian college students' responses to compliments: a pilot study. J. Pragmat. 33 (9), 1485–1502.
Felson, R., 1980. Communication barriers and the reflected appraisal process. Soc. Psychol. Q. 43 (2), 223–233.
Fiedler, K., Walka, I., 1993. Training lie detectors to use nonverbal cues instead of global heuristics. Hum. Commun. Res. 20 (2), 199–223.
Forrest, J.A., Feldman, R.S., Tyler, J.M., 2004. When accurate beliefs lead to better lie detection. J. Appl. Soc. Psychol. 34 (4), 764–780.
Golato, A., 2002. German compliment responses. J. Pragmat. 34 (5), 547–571.
Green, G.M., 1996. Pragmatics and Natural Language Understanding. Psychology Press.
Holmes, J., 1984. Modifying illocutionary force. J. Pragmat. 8 (3), 345–365.
Holmes, J., 1988. Paying compliments: a sex-preferential politeness strategy. J. Pragmat. 12 (4), 445–465.
Jaworski, A., 1995. ''This is not an empty compliment!'' Polish compliments and the expression of solidarity Int. J. Appl. Linguist. 5 (1), 63–94.
Jiang, X., Pell, M.D., 2015. On how the brain decodes vocal cues about speaker confidence. Cortex 66, 9–34.
Jiang, X., Pell, M.D., 2016a. Neural responses towards a speaker's feeling of (un)knowing. Neuropsychologia 81, 79–93.
Jiang, X., Pell, M.D., 2016b. The feeling of another's knowing: how ''mixed messages'' in speech are reconciled. J. Exp. Psychol. Hum. Percept. Perform. 42 (9), 1412–1428.
Jiang, X., Pell, M.D., 2017. The sound of confidence and doubt. Speech Commun. 88, 106–126.
Kirchhübel, C., Howard, D.M., 2013. Detecting suspicious behaviour using speech: acoustic correlates of deceptive speech – an exploratory investigation. Appl. Ergon. 44 (5), 694–702.
Lemay, E.P., Bechis, M.A., Martin, J., Neal, A.M., Coyne, C., 2013. Concealing negative evaluations of a romantic partner's physical attractiveness. Pers. Relatsh. 20, 669–689.
Levine, E.E., Schweitzer, M.E., 2015. Prosocial lies: when deception breeds trust. Organ. Behav. Hum. Decis. Process. 126, 88–106.
MacGeorge, E.L., Gillihan, S.J., Samter, W., Clark, R.A., 2003. Skill deficit or differential motivation? Testing alternative explanations for gender differences in the provision of emotional support. Commun. Res. 30 (3), 272–303.
McCornack, S.A., Parks, M.R., 1986. Deception detection and relationship development: the other side of trust. Ann. Int. Commun. Assoc. 9 (1), 377–389.
Mehrabian, A., 1971. Silent Messages. Wadsworth, Belmont, CA.
Mursy, A.A., Wilson, J., 2001. Towards a definition of Egyptian complimenting. Multilingua 20 (2), 133–154.
O'Sullivan, M., 2003. The fundamental attribution error in detecting deception: the boy-who-cried-wolf effect. Pers. Soc. Psychol. Bull. 29 (10), 1316–1327.
O'Sullivan, M., Ekman, P., Friesen, W., Scherer, K.R., 1985. What you say and how you say it: the contribution of speech content and voice quality to judgments of others. J. Pers. Soc. Psychol. 48 (1), 54.
O'Sullivan, M., 2005. Emotional intelligence and deception detection: why most people can't ''read'' others, but a few can. In: Riggio, R.E., Feldman, R.S. (Eds.), Applications of Nonverbal Communication. Erlbaum, Mahway, NJ, pp. 215–253.
Pell, M.D., Paulmann, S., Dara, C., Alasseri, A., Kotz, S.A., 2009. Factors in the recognition of vocally expressed emotions: a comparison of four languages. J. Phonet. 37 (4), 417–435.
Pell, M.D., Jaywant, A., Monetta, L., Kotz, S.A., 2011. Emotional speech processing: disentangling the effects of prosody and semantic cues. Cogn. Emot. 25 (5), 834–853.
Pexman, P.M., Zvaigzne, M.T., 2004. Does irony go better with friends? Metaphor Symb. 19 (2), 143–163.
Qin, T., Burgoon, J., Nunamaker Jr., J.F., 2004. An exploratory study on promising cues in deception detection and application of decision tree. In: System Sciences, 2004. Proceedings of the 37th Annual Hawaii International Conference, pp. 23–32.
Regel, S., Coulson, S., Gunter, T.C., 2010. The communicative style of a speaker can affect language comprehension? ERP evidence from the comprehension of irony. Brain Res. 1311, 121–135.

Riggio, R.E., Tucker, J., Throckmorton, B., 1987. Social skills and deception ability. Pers. Soc. Psychol. Bull. 13 (4), 568–577.
Rigoulot, S., Fish, K., Pell, M.D., 2014. Neural correlates of inferring speaker sincerity from white lies: an event-related potential source localization study. Brain Res. 1565, 48–62.
Roberts, F., Francis, A.L., Morgan, M., 2006. The interaction of inter-turn silence with prosodic cues in listener perceptions of ‘‘trouble’’ in conversation. Speech Commun. 48 (9), 1079–1093.
Rockwell, P., Buller, D.B., Burgoon, J.K., 1997. The voice of deceit: refining and expanding vocal cues to deception. Commun. Res. Rep. 14 (4), 451–459.
Rothermich, K., Pell, M., 2015. Introducing RISC: a new video inventory for testing social perception. PLOS ONE 10 (7), 1–24.
Saxe, L., 1991. Lying: thoughts of an applied social psychologist. Am. Psychol. 46 (4), 409–415.
Scherer, K.R., 1978. Personality inference from voice quality: the loud voice of extroversion. Eur. J. Soc. Psychol. 8 (4), 467–487.
Seiter, J.S., Bruschke, J., 2007. Deception and emotion: the effects of motivation, relationship type, and sex on expected feelings of guilt and shame following acts of deception in United States and Chinese samples. Commun. Stud. 58 (1), 1–16.
Seiter, J.S., Bruschke, J., Bai, C., 2002. The acceptability of deception as a function of perceivers' culture, deceiver's intention, and deceiver–deceived relationship. West. J. Commun. (Commun. Rep.) 66 (2), 158–180.
Spence, K., Villar, G., Arciuli, J., 2012. Markers of deception in Italian speech. Front. Psychol. 3 (453), 210–218.
Sporer, S.L., Schwandt, B., 2006. Paraverbal indicators of deception: a meta-analytic synthesis. Appl. Cogn. Psychol. 20 (4), 421–446.
Swann, W.B., Stein-Seroussi, A., McNulty, S.E., 1992. Outcasts in a white-lie society: the enigmatic worlds of people with negative self-conceptions. J. Pers. Soc. Psychol. 62 (4), 618–624.
Talwar, V., Murphy, S.M., Lee, K., 2007. White lie-telling in children for politeness purposes. Int. J. Behav. Dev. 31 (1), 1–11.
Tang, C.H., Zhang, G.Q., 2009. A contrastive study of compliment responses among Australian English and Mandarin Chinese speakers. J. Pragmat. 41 (2), 325–345.
Truesdale, D., Pell, M.D. The sound of passion and indifference (submitted for publication).
Van den Brink, D., Van Berkum, J., Bastiaansen, M., Tesink, C., Kos, M., Buitelaar, J., Hagoort, P., 2012. Empathy matters: ERP evidence for inter-individual differences in social language processing. Soc. Cogn. Affect. Neurosci. 7, 173–183.
Villar, G., Arciuli, J., Paterson, H., 2013. Vocal pitch production during lying: beliefs about deception matter. Psychiatry Psychol. Law 20 (1), 123–132.
Vrij, A., Semin, G.R., 1996. Lie experts' beliefs about nonverbal indicators of deception. J. Nonverb. Behav. 20 (1), 65–80.
Vrij, A., Semin, G.R., Bull, R., 1996. Insight into behavior displayed during deception. Hum. Commun. Res. 22 (4), 544–562.
Vrij, A., Edward, K., Bull, R., 2001. Stereotypical verbal and nonverbal responses while deceiving others. Pers. Soc. Psychol. Bull. 27 (7), 899–909.
Wilson, D., Wharton, T., 2006. Relevance and prosody. J. Pragmat. 38 (10), 1559–1579.
Wolfson, N., 1981. Compliments in cross-cultural perspective. TESOL Q. 15 (2), 117–124.
Yu, M.C., 2005. Sociolinguistic competence in the complimenting act of native Chinese and American English speakers: a mirror of cultural value. Lang. Speech 48 (1), 91–119.
Zuckerman, M., DeFrank, R.S., Hall, J.A., Larrance, D.T., Rosenthal, R., 1979. Facial and vocal cues of deception and honesty. J. Exp. Soc. Psychol. 15 (4), 378–396.
Zuckerman, M., DePaulo, B.M., Rosenthal, R., 1981. Verbal and nonverbal communication of deception. Adv. Exp. Soc. Psychol. 14 (1), 1–59.

Kathrin Rothermich is an Assistant Professor in Communication Sciences and Disorders at East Carolina University. Her research investigates the behavioural and neural correlates of speech comprehension, with particular interest in the influence of acoustic-phonological aspects in healthy and patient populations. She also examines the social and cognitive processes involved in understanding speaker intentions, including the role of cultural background, interpersonal sensitivity, and anxiety.

Marc Pell has a broad interest in how humans communicate their emotions, attitudes and intentions in speech, in healthy adults and those with acquired disease of the brain (e.g., stroke, Parkinson's disease). Much of his research has studied how a speaker's tone of voice conveys different meanings in spoken language, and how listeners use these cues as a source of pragmatic information for understanding another person's emotions and cognitive state. He holds appointments as James McGill Professor and Director of the School of Communication Sciences and Disorders, Faculty of Medicine, McGill University (Montréal, Canada).

Karyn Fish completed her Bachelor of Science degree in Psychology and is currently a Ph.D. student in the School of Communication Sciences & Disorders at McGill University. She has a broad interest in social cognition and language processing. Her current research investigates how prosody influences the way that listeners understand speaker attitudes such as sincerity.