Journal of Nonverbal Behavior (2025) 49:171–203
https://doi.org/10.1007/s10919-024-00477-6

ORIGINAL PAPER

# Vocal Speed and Processing of Persuasive Messages: Curvilinear Processing Effects

**Joshua J. Guyer[1] · Thomas I. Vaughan-Johnston[2] · Leandre R. Fabrigar[3] · Borja Paredes[4] · Pablo Briñol[4] · Minqian Shen[3]**

Accepted: 17 November 2024 / Published online: 3 December 2024


**Abstract**
Most work on indicators of vocal confidence (and social influence work more broadly) examines linear relationships between variables. However, in some domains curvilinear (i.e., accelerating or decelerating) relationships may provide greater clarity in understanding human speech patterns. We review mixed past work on vocal speed as a case study, wherein faster vocal speed has been shown both to bolster and inhibit persuasion (e.g., by impairing processing). Across six total studies ($N_{\text{total}}=3{,}958$), we show that faster speed initially increases perceived source confidence and message processing but eventually the increase attenuates or reverses. Correspondingly, vocal speed has a decelerating relationship to participants' processing of persuasive messages, as revealed by two main processes: argument quality effects on attitudes, and the correspondence between thought valence and attitudes. The present work highlights the potential value of high-powered examinations of curvilinear relationships in non-verbal phenomenon for which speed is likely to play a role.

**Keywords** Attitudes · Curvilinearity · Elaboration likelihood model · Source confidence · Vocal speed

## Introduction

Popular media often advises the public how to present themselves to communicate effectively (e.g., Fagan, 2019; Neill, 2016; Ni, 2019), including advice regarding optimal posture, facial expressions, word choice, and how people should vocalize their message. However, the scientific versus anecdotal basis for this advice is often questionable, and where evidence does exist, it is often unclear or largely inconsistent. For example, although a large body of research has examined the persuasive influence of rate

✉ Thomas I. Vaughan-Johnston
thomasvaughanjohnston@gmail.com

[1] Department of Human Science and Technology, IE University, Segovia, Spain

[2] Department of Psychology, Cardiff University, Cardiff, UK

[3] Department of Psychology, Queen's University, Kingston, Canada

[4] Department of Psychology, Universidad Autónoma de Madrid, Madrid, Spain

of speech, researchers disagree on whether fast talkers are more persuasive than slow. Furthermore, it remains unclear whether faster voices stimulate more or less processing of persuasive messages, which as we explain helps guide understanding of when faster voices help or hinder persuasion.

On the one hand, empirical evidence suggests that faster talkers are often associated with qualities that may be advantageous to a persuasive appeal, including higher credibility (Buller & Anne, 1988; Miller et al., 1976; Street & Brady, 1982; Street et al., 1983) more confidence (Brown et al., 1985; Guyer et al., 2018; Jiang & Pell, 2014; London, 1973; Scherer et al., 1973), and enhanced competency-based evaluations, such as intelligence, objectivity, and knowledge (e.g., Buller & Aune, 1988; Giles & Street, 1985; Gunderson & Hopper, 1976; Smith et al., 1975), although a ceiling effect may exist (Street & Brady, 1982). Additionally, some researchers have argued that the persuasive impact of vocal speed can also be linked to increases in processing (Kim et al., 2019). Taken together, several studies indicate that increasing one's speech rate can enhance persuasion (e.g., Apple et al., 1979; Chebat et al., 2007; Hausknecht & Moore, 1986; LaBarbera & MacLachlan, 1979; MacLachlan, 1979; Mehrabian & Williams, 1969; Miller et al., 1976; Moore et al., 1986; Nickell & Pinto, 1984; Smith & Shaffer, 1991, 1995).

On the other hand, other evidence indicates that increasing one's speech rate can undermine persuasion, negatively affect evaluations of the speaker, and reduce message processing. For example, research has shown that faster talkers are sometimes perceived as more condescending (Schlinger et al., 1983), and less polite, kind, and dependable (Brown et al., 1985), qualities that may be disadvantageous to a persuasive appeal. The negative consequences of rapid speech rate on persuasion have been linked to a reduction in message recipients' scrutiny of the persuasive message (e.g., Lautman & Dean, 1983; O'Connell et al., 1989; Smith & Shaffer, 1991, 1995). Research by Moore et al. (1986) supported a reduced processing explanation by demonstrating that the effects of rapid speech on persuasion are moderated by argument quality, such that persuasion is reduced in response to strong arguments but enhanced in response to weak arguments (see also Smith & Shaffer, 1991). However, in these few cases in which vocal speed's implications for message processing have been considered, they generally evaluate only a narrow range of vocal speeds.

A third group of studies have found no direct evidence that fast talkers enjoy a general persuasive advantage over slow talkers (e.g., Gunderson & Hopper, 1976; Wheeless, 1971; Woodall & Burgoon, 1983). Taken together, researchers disagree on whether a rapid speech rate enhances, reduces, or has no significant impact on the attitudes of message recipients. A variety of methodological factors may contribute to this apparently disparate collection of findings. For instance, some studies have varied speech rate by asking speakers to talk fast or slow (e.g., Brown et al., 1985; Miller et al., 1976), whereas others have asked speakers to speak confidently or doubtfully (e.g., Jiang & Pell, 2014; Scherer et al., 1973), or faster/slower (e.g., Rodero, 2020). Others have combined audio and visual stimuli (e.g., Gunderson & Hopper, 1976; Woodall & Burgoon, 1983), or altered rate by compressing audio files (e.g., Hausknecht & Moore, 1986; Moore et al., 1986; Smith & Shaffer, 1991, 1995). These methods pose potential interpretative challenges. First, instructing speakers to talk fast or slow may inadvertently affect other voice properties (e.g., volume, pitch), confounding the intended induction. Second, combining audio and visual stimuli may distort persuasion effects due to various visual cues. Finally, compressing audio files may alter voice parameters, potentially affecting naturalness. The present research explicitly sought to overcome these methodological limitations by digitally manipulating speech rate so that other prosodic elements remained unchanged.

Furthermore, prior research often focuses on examining the link between no more than one or two levels of speed. This is an additional methodological concern that we address in the present data. Given the mixed data regarding the exact nature of the relationship between speech rate and persuasion, this leaves open the possibility that the relation between these variables may be more nuanced than previously thought. For example, although it might be tempting to conclude that faster speech rate is disadvantageous to people advancing a strong argument and advantageous to those advancing a weak argument (e.g., Moore et al., 1986; Smith et al., 1995), prior research has only focused on the impact of an increased speech rate on the relative advantage of strong (vs weak) arguments at the high end of the speech rate spectrum. Thus, further attention to a fuller range of plausible human speech rates may test the boundary conditions of these findings. The current paper considers several novel possibilities:

1. That there is a curvilinear relation between speech rate and the relative persuasiveness of strong over weak arguments: an increasing speech rate enhances the relative persuasiveness of strong (over weak) arguments at the low end of the speech rate spectrum but decreases the relative persuasiveness of strong (over weak) arguments at the high end of the speech rate spectrum. This implies that recipient elaboration of message content (i.e., message processing) plays an important role in both the timing and the extent to which speech rate impacts attitudes.
2. If it is the case that speech rate has a curvilinear effect on recipient attitudes, one way to test this hypothesis would be to examine whether recipient elaboration of the message content – and various factors that might influence elaboration (e.g., self-reported motivation and ability to process, and perceived speaker confidence), serve as mechanisms that could help account for the impact of speech rate on recipient attitudes toward the persuasive message.
3. Within the attitudes literature, researchers have employed several methodologies to test the extent to which individuals are engaged in careful message processing, such as by manipulating the argument quality of a message and then assessing the differential impact of both strong and weak arguments on recipients' attitudes toward the message, and by testing the correspondence between recipients' thoughts and attitudes toward the message (Cacioppo & Petty, 1981; Rucker et al., 2011). Vocal speed may influence both of these signals of processing.

Thus, the present research was designed with three goals in mind: we explicitly examined (1) an unprecedented range of speech rate to probe the possibility of curvilinear dynamics, (2) the mechanisms by which speech rate might influence elaboration, with downstream effects on persuasion (e.g., motivation and ability to process, and perceived speaker confidence), and (3) the moderating role of argument quality and thought direction. In sum, the present research sought to identify when and why vocal speed can increase or decrease message-relevant processing, with consequences for persuasion.

## Applying a Theoretical Framework to Understand Speech Rate

Although many studies have shown that changes in speech rate reliably influence persuasion, comparatively little research has investigated the underlying mechanisms responsible for this process. Few attempts have been made to resolve this gap by applying an explicit theoretical framework to help researchers predict when and why nonverbal signals such as speech rate affect persuasion (but see Briñol & Petty, 2009; Guyer et al., 2021). We propose that vocal speed will be best understood by drawing upon a theoretical framework known as the Elaboration Likelihood Model (ELM; Petty & Briñol, 2012; Petty & Cacioppo, 1986). The ELM is a conceptual framework that describes a discrete set of psychological processes by which a given variable can affect attitudes and behavior. Importantly, the emergence of these processes is a function of where an individual falls on the elaboration continuum (i.e., from low to high), which is determined by an individual's ability and motivation to carefully process information. The term elaboration refers to the extent to which a message recipient carefully processes information in a persuasive appeal. In the attitudes literature, elaboration is typically assessed using the number and/or proportion of relevant thoughts a person generates in response to a persuasive message (e.g., Petty & Cacioppo, 1979b). Other techniques used to assess thinking include assessing the correspondence between thoughts and attitudes, and testing attitude-behavior correspondence (Cacioppo & Petty, 1981; Rucker et al., 2011).

Low elaboration usually occurs when people's motivation and/or ability to think are low. This can occur either through a low-effort evaluation of the merits of an argument (e.g., examining less information or the same amount but less carefully), or through less resource demanding processes that include the use of heuristics (Chaiken, 1987), classical conditioning (Staats & Staats, 1958), or self-perception (Bem, 1972). Low elaboration conditions reduce the likelihood that individuals will carefully examine and process available information.

High elaboration tends to occur when motivation and ability to think are high. Under these conditions, the ELM proposes that individuals tend to carefully examine the quality of the information, which activates different psychological processes by which persuasion occurs. For example, under high elaboration conditions, a variable such as speech rate can influence attitudes by (a) serving as an argument used to evaluate the merits of the attitude object, or (b) biasing the direction of thoughts (i.e., favorable vs. unfavorable) toward the attitude object, or (c), affecting how much people rely on their thoughts generated about the attitude object by increasing or decreasing their confidence and/or liking for their own thoughts (i.e., the self-validation process).

Finally, most relevant to the present research, in the middle of the elaboration continuum, when thinking is not constrained to be either high or low by other factors, a variable (e.g., speech rate) can affect recipients' motivation and/or ability to process, influencing the degree to which they scrutinize message content given more moderate elaboration conditions (e.g., if it is unclear whether the recipient should process more). Such conditions include situations when the topic's personal relevance to recipients is not explicitly specified, recipients are not specifically distracted or encouraged to pay very close attention to a message, and so on (see Petty & Cacioppo, 1986, Vaughan-Johnston et al., in press, for other moderators).

## Potential Mechanisms Driving Processing across Speech Rate

Within the literature investigating how rate of speech influences persuasion, researchers typically have employed two levels (e.g., baseline 180 Words Per Minute / WPM vs. faster 220 WPM, Smith & Shaffer, 1995) of speech rate. Rather than focusing on two discrete points of contrast, we argue that investigating a broader spectrum of speech rate might be more informative. Indeed, comparing only two levels of speed is limiting because it is not clear that we would necessarily expect speech rate to exert a continuous effects on ability and motivation to process all the way across the range of natural human speech rates.

First, a listener's ability to process a persuasive message may change as a speaker's rate of speech increases. Receiving messages in audio and/or visual channels can sometimes overwhelm recipients' ability to process what they are hearing, with subtleties of the speaker's voice affecting the likelihood of this occurring (Potter, 2000; Potter et al., 2019; Rodero et al., 2017). For instance, very slow speech may have a negative impact on a person's ability to process message content because slow speech requires sustained attention for a much longer amount of time, thus potentially eliciting fatigue in the listener. Increasing speech rate to a moderately fast pace may alleviate the negative effects of fatigue on a listener's ability to maintain sustained attention. At the upper end of the speed continuum, however, rapid speech reduces listeners' ability to process the message (Moore et al., 1986; Smith & Shaffer, 1991). Consistent with this finding, research has shown that relative to normal rates of speech, rapid speech can reduce message recall as well as attention to the message content (Chattopadhyay et al., 2003; Hausknecht & Moore, 1986; Moore et al., 1986; Schlinger et al., 1983). Consequently, if voices become too rapid for most listeners to easily follow, it may undermine listeners' ability to thoroughly process the message. Additionally, in one past study, curvilinear effects were noted such that memory of ad content was remembered best at moderate (vs slow and fast) vocal speeds (Rodero, 2020). Since remembering a message's detail will often facilitate thoroughly thinking through its arguments, this supports that vocal speed may affect ability to process in a curvilinear fashion.

Second, from a motivational perspective, very slow speech may elicit boredom, which might then undermine the listener's desire to carefully process a message. Increasing speech rate to a moderate pace may alleviate the negative effects of boredom on a listener's motivation to attend to the message content, consequently increasing processing and thus enhancing the persuasive benefit of strong over weak messages. Similarly, listeners may interpret slow speakers as lacking confidence (Jiang & Pell, 2014; Scherer et al., 1973), undermining processing because unconfident speakers may be perceived as providing information of lesser value (Smith & Clark, 1993). At the upper end of the speed continuum, however, *very* fast speech may trigger perceptions of speaker anxiety (Guyer et al., 2018) or self-doubt, reducing listeners' motivation to listen closely if information from a self-doubting source is seen as being of lesser value.

Taken together, various factors may differentially influence amount of processing as rate of speech moves from extremely slow to extremely fast. For example, motivation and ability to process may increase processing to a certain point. However, we propose that at some inflection point, faster speeds may actually undermine to what extent people can and want to engage in message scrutiny. Therefore, to investigate these complex interrelationships, instead of comparing only two levels of speed, the present research will compare vocal speed across multiple levels.

## Consequences of Processing for Persuasion

The effects on processing described in the previous subsection have important implications for persuasion, suggesting that the effects of vocal speed on persuasion may be more complex when a broader spectrum of vocal speeds is considered. As noted, we predict that the relative advantage of strong (vs. weak) arguments should be relatively small at slow speech rates, increase up to a point, and then reduce as speech rates rise above a "normal" rate. We propose that this happens because of the curvilinear effects of vocal speed on motivation and ability that were unpacked in the previous subsection. This is because both motivation and ability affect the degree to which people elaborate the central merits of the arguments that they hear.

When people think more carefully about messages, at least two effects should occur (also see Petty & Cacioppo, 1986). First, strong arguments should be more persuasive than weak arguments, and this relative difference should increase the more people elaborate on the arguments in the message. See Fig. 1, which tracks the proposed persuasiveness of strong (top line) versus weak (bottom line) messages. The relation between these messages' persuasiveness forms a "diamond shape": least discrepancy at very slow and very fast speeds, more discrepancy at moderate speeds. Second, as elaboration increases, people should use their thoughts more to form attitudes, thus, thoughts and attitudes should correspond more closely (Chaiken, 1980; Petty & Cacioppo, 1979b, 1999; Vaughan-Johnston et al., in press). The shape of this interaction is also modeled by Fig. 1: the top line tracks the attitudes of people with mostly pro-message thoughts, and the bottom line the attitudes of people with mostly counter-message thoughts.

The different processes just described are also referred to as *multiple roles of variables* (see Petty & Cacioppo, 1986; Petty & Wegener, 1998). Poignantly, these indicators of increased processing do not always entail more persuasion. When recipients are exposed to weak messages, or when they generate a preponderance of counter-message thoughts, more processing is expected to reduce persuasion (i.e., in Fig. 1, note that persuasion is minimized given a weak argument or counter-message thoughts at moderate/slightly fast speeds, that is, when processing would be expected to be maximized).

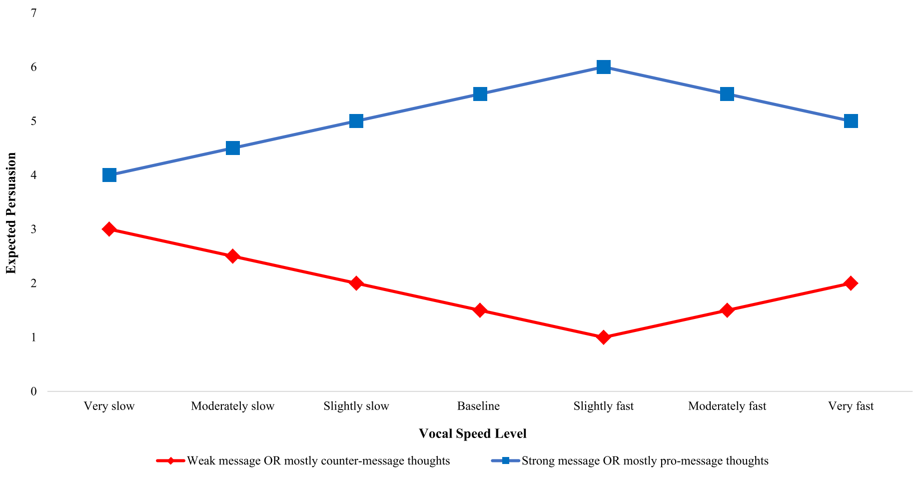



**Fig. 1** Proposed relation of vocal speed to message-relevant processing, and persuasion by weak and strong arguments. *Note* The above are hypothetical results. Higher scores indicate more expected persuasion. The persuasive difference between weak (red line, diamonds) and strong (blue line, squares) messages initially increases and then decreases from very slow to very fast speeds. The same is expected of the persuasive difference between people having mostly counter-message thoughts versus those having mostly pro-message thoughts, so the same hypothetical plotted points characterize both expected relations (compare Fig. 3a, b, 5)

### Goals of the Present Research

Prior research has yielded mixed results regarding the persuasive benefits of speech rate, with theorists providing evidence in favor and against a persuasive advantage for fast talkers. We propose that this debate can be reconciled through: (1) attention to vocal speed's curvilinear dynamics, often impossible in prior research given that typically only two levels of this variable were examined, (2) attention to psychological mechanisms linking vocal speed with persuasion (i.e., elaboration), and (3) the moderating role of argument quality. Using the Elaboration Likelihood Model as our conceptual lens, we tested whether motivation (i.e., self-reported and by assessing perceived speaker confidence) and/or ability (i.e., self-reported and via argument quality effects on post-message attitudes) might account for proposed curvilinear effects of speech rate on processing (e.g., as revealed by probing the persuasive advantages of strong over weak messages).

## Overview

We present two main experiments, the latter preregistered. We then present an integrative data analysis (IDA) that additionally includes four additional experiments. In each, we examined whether speech rate has linear and/or curvilinear effects on processing, and the consequences of processing for persuasion (i.e., determining the attitudes that listeners form).

## Experiment 1

Experiment 1 was designed to examine a hypothesized curvilinear relationship between speech rate and message processing, with downstream consequences on persuasion. We examined processing in two main ways (also see footnote 4): (1) by measuring the extent to which strong arguments produced more persuasion than weak arguments, and (2) by measuring the correspondence between thought valence and persuasion. We predicted that speech rate would moderate the effect of argument quality on persuasion, producing a curvilinear pattern on attitudes and thought valence-attitude correspondence, both indicating message processing.

### Method

#### Participants and Design

Undergraduates ($N = 332$) from a Canadian university were randomly assigned to conditions in a 4 (Vocal Speed: $-35\%, -15\%, +10\%, +13\%$) X 2 (Argument Quality: strong versus weak arguments) between-participants factorial design. All experimental sessions were completed in a university laboratory for course credit. We halted data collection at the end of the first academic semester in which at least 40 participants/cell had been obtained. Although demographic data were not collected for this study, participants were sampled from the same population as other studies conducted in our lab during the same semester with the following demographic patterns: 22.7% men, 76.6% women, 0.4% non-binary/other, and 0.1% prefer not to answer; 70.8% white, 12.3% East Asian, 7.3% mixed, 4.2%

south Asian, 3.3% other, 1.5% black, 0.7% Hispanic; $M_{age} = 18.1$, $SD_{age} = 1.1$. We report all manipulations, measures, and exclusions in these studies. Verbatim materials are available in SOM-1; data and code are available on OSF at https://osf.io/5gwcb/?view_only=8658ddf8b0fe4d4fa43aca131cd99996.

## Procedure and Materials

Participants listened to an audio passage through headphones. The passage was delivered by a woman speaker who discussed a policy to be applied in unspecified regions of the participants' country, offering tuition reduction for students working part-time. Importantly, no information indicated if the participants' own university was considering the program, intended to foster more message relevance ambiguity. Consequently, we expected a baseline level of moderate processing for participants. Prior research has shown that when the personal relevance of a message is ambiguous versus high or low, it is easier to detect the elaboration-influencing effects of a variable (Petty & Cacioppo, 2016).

After listening to the audio recording, participants responded to several questions about the speaker's manner of delivery. Although our focus was on questions about the speaker's vocal speed (1 = *Extremely slow*, 7 = *Extremely fast*) and confidence (1 = *Not at all confident*, 7 = *Very confident*), we also included distractor items intended to mask our hypothesis, such as the clarity of the speaker's voice, the complexity and organization of their message, and the speaker's apparent sex, height, and accent. In all cases a 1–7 scale was used. Next, participants indicated their attitude towards the university service plan. Lastly, participants completed a thought-listing task, listing up to 10 thoughts that came to mind while listening to the audio recording, then rated the favorability of each thought as either positive, negative, or neutral to the topic. Finally, participants were debriefed regarding the purpose of the experiment.

**Independent Variables** *Vocal Speed* The messages were recorded by the same woman speaker, then digitally edited using PRAAT® (Boersma & Weenik, 2022). We digitally manipulated the speaker's speech rate into four levels without impacting other vocal characteristics (e.g., pitch, intonation). Two conditions decreased speed by 35% (113 WPM) and 15% (148 WPM) from the baseline, whereas two conditions increased speed by 10% (192 WPM) and 13% (197 WPM) from the baseline rate. Given that the natural baseline speech rate of this particular speaker was relatively fast, it was easier to slow down rather than speed up the speech while maintaining a natural-sounding voice. Beyond that, there is nothing special about these particular four speed levels, and indeed we sampled over seven total levels of vocal speed between this and the remaining five datasets (Experiment 2, Supplementary Experiments 1–4).

*Argument Quality* Participants were randomly assigned to listen to a message that contained either strong or weak arguments in favor of a university service plan. In both conditions, the plan was explained as having students receive reduced tuition fees in exchange for becoming part-time staff members. However, the *strong arguments* version provided compelling reasons that would be convincing to most students: the policy (i) would have favorable consequences for student experience (e.g., the money raised by the policy would produce a "greater number of smaller classroom sessions" and "quality of services"), (ii) was supported by student groups, (iii) described importantly good consequences (making the educational experience better), and so on. In contrast, the weak arguments version was designed to be unconvincing for those paying sufficient attention: the policy (i) would have consequences that most students dislike ("substantial reduction in leisure time"), (ii) was supported by administration but not students, and (iii) described superficial benefits (e.g., cosmetically improving campus) and had a cost-cutting tone. Generally, then, strong arguments were those that a typical student would find persuasive assuming they were paying attention, and weak arguments might sound superficially appealing but on close examination a student should generally reject them. These messages were adapted from Baker and Petty (1994), who validated each argument to be strong or weak based on pilot testing in which strong (weak) arguments prompted predominantly positive (negative) reactions to the proposal (also see Clark et al., 2008; Wegener et al., 1995, who also successfully used these passages to test argument quality).[1]

More favorable evaluations of strong (versus weak) arguments signals message-relevant processing (Petty & Cacioppo, 1986). For people to be differently affected by strong and weak persuasive messages, they have to carefully attend to and think about the content of the information (see Cacioppo & Petty, 1981; Rucker et al., 2011; Petty & Cacioppo, 1986 for an extended discussion of this technique). That is, the more careful attention people pay to the information provided, the bigger the difference strong versus weak messages have on people's attitudes. Importantly, the arguments selected were pre-tested in previous research and were shown to produce the appropriate pattern of cognitive responding. That is, the strong arguments elicited mostly favorable thoughts and the weak arguments elicited mostly unfavorable thoughts when people were instructed to think carefully about them.

**Dependent Variables** *Speaker confidence* Conforming to past research on speaker confidence judgments derived from listening to audio stimuli (Guyer et al., 2018; Vaughan-Johnston et al., in press), we had participants rate the speaker's confidence on a single item rated from 1 (*Not at all confident*) to 7 (*Very confident*).

*Attitudes* Participants reported their attitudes toward the university service plan using eight items from the Crites et al. (1994) validated scale of attitudes (e.g., "positive," "dislike," each rated from 1 = *not at all* to 7 = *definitely*). Final scores were created by reverse coding the negative items, then averaging the scores across all items. Item ratings were highly correlated ($\alpha = 0.89$), thus averaged to form one overall attitude index.

*Thought Listing/Rating Task* After listening to the messages, participants were given the opportunity to list up to 10 thoughts that they had about the topic while listening to the message (e.g., Cacioppo & Petty, 1981). Next, participants rated each thought as positive, negative, neutral, or irrelevant, as it applied to the university service plan.

[1] This conception of argument quality is consistent with the Elaboration Likelihood Model, in which argument quality is a technique designed to reveal the amount of thinking participants are engaging in. Therefore, it is not a problem for our research that participants in the 'strong' versus 'weak' message likely perceive a substantively different quality of the policy. After all, if the best thing an advocate can say for a policy is a weak argument, a reader is likely to assume the policy does not have many compelling merits and therefore is more likely to generate unfavorable thoughts in response to that proposal. This is by design, because the point is merely that only someone thinking carefully about the 'weak' message will realize this: because both messages superficially sound reasonable, people who cannot or will not engage in message-relevant elaboration are likely to accept them equally.

## Results

### Manipulation Check: Perceived Vocal Speed

For this and most remaining analyses (complete statistics in Table 1) we conducted regression analyses using the following steps. First, we treated Vocal Speed as a continuous measure because the objective difference in speech rate (measured in words per minute) between each level of vocal speed was interval level data. Thus, the vocal speed levels −35%, −15%, +10%, and +13% were coded as the continuous values −0.35, −0.15, 0.10, and 0.13. Second, we centered Vocal Speed. Third, we created a squared term of this centered Vocal Speed variable, named Vocal Speed Curvilinear. Fourth, we ran regression equations with each dependent variable (column titles in Table 1) regressed onto the linear and curvilinear vocal speed variables, argument quality (weak = -0.5, strong = +0.5), and the interaction terms of both linear and curvilinear vocal speed multiplied by argument quality.[2]

We predicted and found a main effect of linear vocal speed (see Table 1, column 1). Objectively faster voices were perceived as faster by listeners ($p < 0.001$). Unexpectedly, we detected an interaction effect with argument quality ($p = 0.025$), indicating a robust effect of objective vocal speed on perceived vocal speed among weak arguments, $B = 6.87$, $t(326) = 15.86$, $p < 0.001$, which slightly increased among strong arguments, $B = 8.24$, $t(326) = 19.27$, $p < 0.001$. Because the manipulation check was successful at each level of argument quality, and subsequent studies did not replicate this pattern, we do not discuss this effect any further.

### Perceived Confidence

We regressed perceived confidence onto the same predictors previously noted, anticipating a positive linear effect of vocal speed on perceived confidence, attenuated by a curvilinear reverse-U function (i.e., the effect of manipulated vocal speed on perceived confidence diminishes then reverses as speed increases). No main effect of argument quality nor interactions emerged. Importantly, we observed both a positive linear effect, and more importantly, a negative curvilinear effect of vocal speed. As seen in Fig. 2b, the curvilinear pattern shows a relatively strong positive link between faster vocal speed and confidence at lower levels of vocal speed (left half of figure). However, the positive effect of vocal speed on perceived confidence attenuates as speed increases, ultimately reversing when comparing very fast versus moderately fast speech.[3]

[2] Simonsohn (2018) has argued for use of the "two lines" test to probe for U-shaped or reverse U-shaped functions, rather than quadratic terms. In the present case we are less concerned with identifying specifically U-shaped functions and more interested in demonstrating that the relation of vocal speed to processing itself differs across levels of vocal speed, for which quadratic functions suffice. However, in SOM-6 we conduct the two lines task and an equivalent to test curvilinear interactions. 9 of 10 tests (vocal speed relating to motivation, ability, confidence; vocal speed moderating argument quality on attitudes) were consistent. However, the thought/attitude correspondence showed partially different results, as we report there.

[3] An ANOVA with vocal speed and argument quality as the independent variables and ratings of vocal confidence as the dependent variable confirmed a significant main effect of vocal speed, $F(3, 324) = 103.00$, $p < .001$, partial $\eta 2 = .49$. Pairwise comparisons between each level of vocal speed were made using the LSD test. As expected, ratings of speaker confidence increased in a roughly linear fashion as speech rate increased from very slow ($M = 2.95$, $SE = .13$), to moderately slow ($M = 4.70$, $SE = .13$), $p < .001$, to mod-

**Table 1** Effects of argument quality, and linear and curvilinear vocal speed, on Experiment 1 dependent variables

| Independent variable | Perceived speed | | | | Perceived confidence | | | | Post-persuasion attitude | | | | Thought favorability | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *P* | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *p* | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *p* | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *p* |
| Argument quality (AQ) | .24 | −.16, .64 | 1.19 | .235 | −.19 | −.68, .30 | −.78 | .438 | 2.10 | 1.60, 2.61 | 8.18 | <.001 | .72 | .45, 1.00 | 5.22 | <.001 |
| Vocal speed | 7.56 | 6.96, 8.16 | 24.82 | <.001 | 4.55 | 3.81, 5.28 | 12.12 | <.001 | 2.13 | 1.37, 2.89 | 5.50 | <.001 | .34 | −.08, .76 | 1.59 | .112 |
| Vocal speed curvilinear | .05 | −4.40, 4.50 | .02 | .983 | −12.67 | −18.15, −7.19 | −4.55 | <.001 | −3.71 | −9.37, 1.95 | −1.29 | .198 | .67 | −2.42, 3.76 | .43 | .669 |
| AQ X vocal speed | 1.37 | .17, 2.57 | 2.25 | .025 | −.37 | −1.84, 1.11 | −.49 | .626 | −.45 | −1.98, 1.07 | −.58 | .561 | −.37 | −1.20, .47 | -.86 | .391 |
| AQ X vocal speed curvilinear | −.53 | −9.42, 8.36 | −.12 | .907 | 1.42 | −9.54, 12.37 | .25 | .799 | −17.40 | −28.72, −6.08 | −3.02 | .003 | .12 | −6.06, 6.30 | .04 | .970 |
| Model fit | $R^2=.72$, $F(5, 326)=165.00$, $p<.001$ | | | | $R^2=.47$, $F(5, 326)=58.83$, $p<.001$ | | | | $R^2=.36$, $F(5, 326)=36.14$, $p<.001$ | | | | $R^2=.26$, $F(5, 303)=20.96$, $p<.001$ | | | |

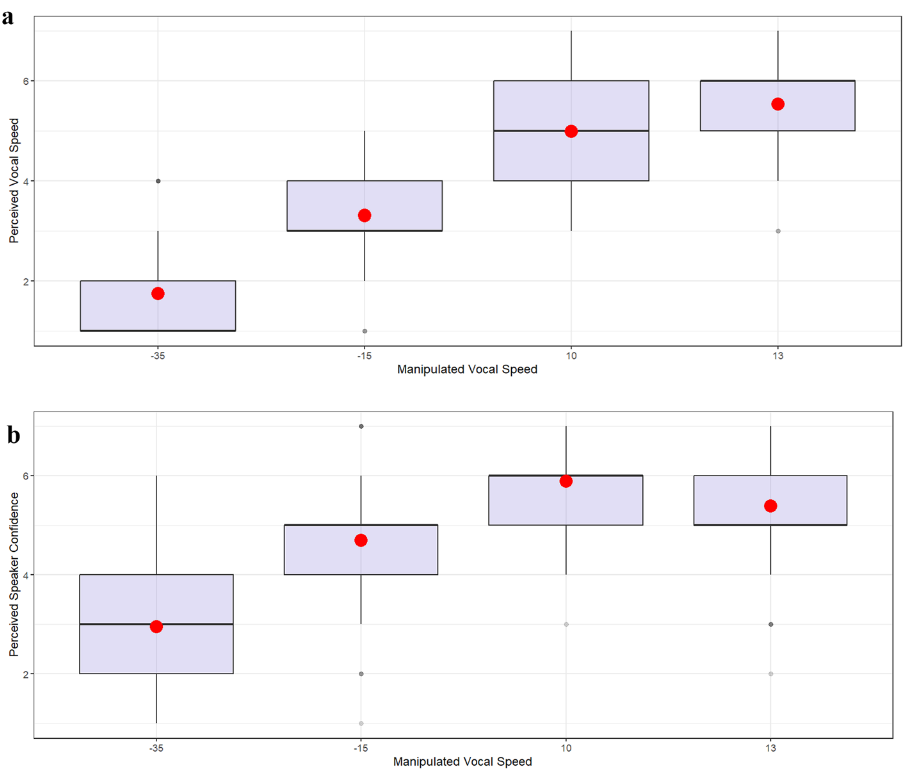



**Fig. 2** **a** Relation between manipulated vocal speed and perceived vocal speed. **b** Relation between manipulated vocal speed and perceived confidence. *Note* Figures created using ggplot2 in R. Red dots represent means, thick black lines represent medians

## Persuasion Effects

Under conditions of moderate elaboration, the ELM suggests that the effects of a variable (i.e., vocal speed) on persuasion are driven by the amount of processing. That is, if the recipient is carefully processing the message, then the quality of the arguments should have a substantial impact on the recipient's attitude. However, if the recipient is not carefully processing, then the effect of argument quality on the recipient's attitude should be comparatively weak. Thus, to test amount of processing effects, this analysis regressed attitudes onto the same predictors noted previously.

We predicted and found a two-way interaction between curvilinear vocal speed X argument quality such that the magnitude of the argument quality effects on attitudes changed as a function of vocal speed (see Fig. 3a). Weak arguments are represented

Footnote 3 (continued)

erately fast ($M = 5.89$, $SE = .13$), $p < .001$. However, consistent with our hypothesis, ratings of speaker confidence decreased when comparing a very fast ($M = 5.39$, $SE = .13$), relative to a moderately fast speaker, $p < .01$. This pattern supports our prediction that speech rate does not affect perceptions of speaker confidence in a linear fashion.

by red cells and strong arguments are represented by blue cells. Confirming the success of our argument quality manipulation, strong arguments generated more persuasion than weak (see Table 1). As shown by the vocal speed X argument quality interaction, this persuasion effect is weakest given very slow speech, $F(1,\ 324) = 10.62$, $p = 0.001$, $\eta_\rho^2 = 0.03$, increases given moderately slow speech, $F(1,\ 324) = 58.44$, $p < 0.001$, $\eta_\rho^2 = 0.15$, slightly attenuates given moderately fast speech, $F(1,\ 324) = 37.26$, $p < 0.001$, $\eta_\rho^2 = 0.10$, and further attenuates given very fast speech, $F(1,\ 324) = 21.89$, $p < 0.001$, $\eta_\rho^2 = 0.06$. This pattern explains the interaction of curvilinear speed X argument quality: increasing vocal speed initially enhanced the effect of argument quality on persuasion (i.e., when comparing very slow to moderately slow speech), after which each increase further attenuated this effect (i.e., from moderately slow to moderately fast to very fast speech).

Alternatively considered, for weak arguments we observed no curvilinear effect of vocal speed, $B = 4.99$ [-3.71, 13.69], $t(162) = 1.13$, $p = 0.259$, which makes sense because the processing challenges posed as a curvilinear function of vocal speed should not make weak messages any less persuasive and could even make them more persuasive. However, given strong arguments, the curvilinear effect of speed was significantly negative, $B = -12.41$ [$-19.74$, $-5.08$], $t(126) = -3.06$, $p = 0.001$. This is consistent with the idea that strong messages are initially benefitted by faster vocal speeds, but are eventually undermined by excessive vocal speed. As seen in Fig. 3a, this "diamond" shaped interaction illustrates the expected processing effect, revealing an initially modest difference between strong versus weak arguments on attitudes, which increases towards the middle of the speed range, then later narrows when speech rate becomes too fast.

## Thought-Attitude Consistency Effects

Several distinct patterns can indicate increased processing, one of which is the greater effect on attitudes of strong versus weak arguments. An additional indicator of increased processing is shown when people exhibit greater reliance on their message relevant thoughts when forming an overall attitude towards a topic. That is, thought favorability should have a stronger correlation with one's attitude when people think more versus less carefully. To test this possibility, we centered thought favorability scores, then created interaction terms of thought favorability X vocal speed and thought favorability X curvilinear vocal speed. We then regressed attitudes on these interactions, and on all the main effects that contribute to the interaction terms.[4]

We found a main effect of linear vocal speed indicating faster voices prompted more positive attitudes, $B = 0.02$ [0.01, 0.03], $t(303) = 4.14$, $p < 0.001$, and a main effect of thought favorability indicating that people who had positive thoughts also liked the topic more, $B = 156.67$ [121.50, 189.82], $t(303) = 8.97$, $p < 0.001$. More importantly, we found the anticipated interaction of curvilinear vocal speed and thought favorability onto attitudes, $B = -0.08$ [$-0.16$,$-0.01$], $t(303) = -2.18$, $p = 0.030$. For visual simplicity, in Fig. 3b we dichotomized participants into those with relatively positive thoughts (blue cells) versus relatively negative thoughts (red cells). Paralleling the curvilinear vocal speed X argument quality interaction in Fig. 3a, we see a similar "diamond" shaped curvilinear pattern, indicating that although positive versus negative thoughts tend to prompt more

[4] We divided thought favorability scores by 100 to make the unstandardized regression coefficients more interpretable, but this does not affect any inferential tests (i.e., $t$ scores and $p$ values remain identical if this change is not implemented).

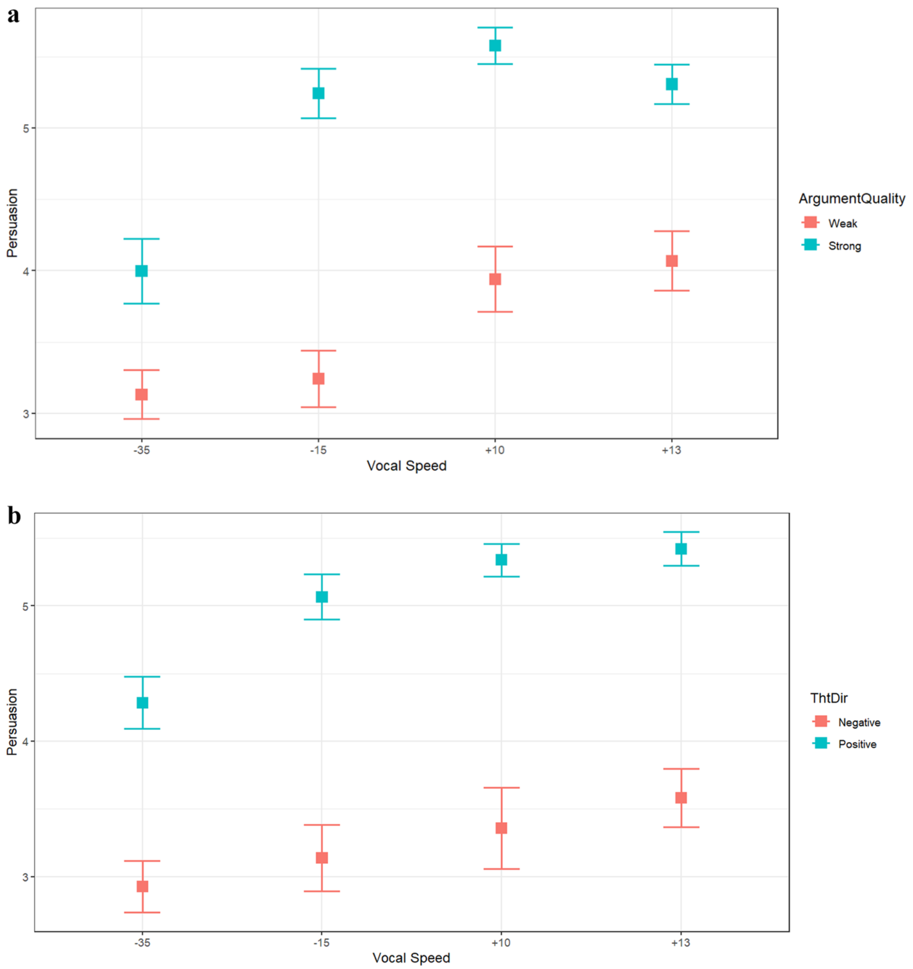



**Fig. 3** **a** Relation between manipulated vocal speed and persuasive effect of argument quality. **b** Relation between manipulated vocal speed and thought-attitude correspondence

favorable attitudes, this effect is attenuated at very slow and very fast speeds and is more pronounced at moderately slow and moderately fast speeds.[5]

[5] As we noted above, participants coded whether each of their thoughts were relevant to the message. We might also expect a greater proportion of thoughts to be message-relevant among people who engaged in thoughtful message elaboration. Regressing "proportion of message relevance" (conceptual range 0% to 100%) on the same predictors indicated above shows a positive influence of vocal speed, $B = .26$ [.06, .46], $t(323) = 2.53$, $p = .012$, and a negative curvilinear effect of vocal speed, $B = -2.19$ [-3.67, -.71], $t(323) = -2.91$, $p = .004$. Indeed, the proportion of relevant thoughts per condition shows a curvilinear distribution: starting at a modest 56.4% at -35% speed, increasing to 76.4% at -15% speed, to 81.4% at + 10% speed, and slightly reducing to 75.0% at + 13% speed. As expected, neither effect was moderated by argument quality, $ps > .091$. We also conducted several additional checks, all of which aligned with expectations, as documented in SOM-5.

### Confidence as Mechanism

Given the curvilinear relationship between vocal speed and perceived confidence, we tested whether perceived confidence might account for vocal speed's curvilinear processing effects. We therefore re-ran the moderation of argument quality and moderation of thought-attitude correspondence analyses with confidence included as an additional moderator of argument quality in the first analysis, and of thought favorability in the second analysis, alongside linear and curvilinear vocal speed in both analyses. Neither of these analyses supported mediation of the moderation, because (1) perceived confidence did not significantly moderate argument quality's effect on attitudes, $t(324)=1.56$, $p=0.119$, nor did it moderate thought favorability's relation to attitudes, $t(324)=0.90$, $p=0.369$; and because (2) curvilinear vocal speed continued to moderate argument quality's effect on attitudes, $t(324)=-2.69$, $p=0.008$, and thought favorability's relation to attitudes, $t(324)=-2.10$, $p=0.037$, despite the inclusion of the interactive term of confidence X argument quality in each model. We examine this more thoroughly in the integrative data analysis.

### Discussion

By investigating a broader spectrum of speech rate than prior research, the results of Experiment 1 provided the first empirical demonstration of a curvilinear relationship between speech rate and message processing, with downstream consequences for persuasion. We provided evidence for this curvilinear relationship through two analyses. First, we demonstrated a curvilinear effect of manipulated argument quality on attitudes as a function of speech rate. Specifically, whereas an increase in speech rate (i.e., 113 WPM to 148 WPM) initially enhanced the difference between strong and weak arguments on attitudes, subsequent increases (i.e., 148 WPM to 192 WPM to 197 WPM), attenuated this effect. Second, we observed a curvilinear relationship between thought-favorability and attitudes, with a more pronounced relationship was observed in the middle of our speech rate continuum (i.e., 148 WPM and 192 WPM), which was attenuated at both very slow (113 WPM) and very fast (197 WPM) rates of speech. Taken together, these data suggest that message processing can both increase and decrease as a function of accelerating rate of speech. Moreover, our data suggests this curvilinear pattern also extends to the relationship between rate of speech and perceptions of speaker confidence. However, perceived confidence did not account for the curvilinear effect of vocal speed on processing, leaving unresolved the question regarding which mechanisms might account for this relationship.

## Experiment 2

The results of Experiment 1 provided initial evidence for a curvilinear relationship between vocal speed and processing, with downstream consequences for persuasion. However, against expectations, perceived speaker confidence did not mediate this relationship. Thus, Experiment 2 had two main goals. First, we sought to replicate the curvilinear effects of vocal speed on message processing. Second, we tested several potential mediators of this relationship.

Having uncovered a curvilinear relationship in Experiment 1, we wanted to create the most efficient test of this effect, thus condensed the design of Experiment 2 to three levels of manipulated vocal speed crossed with a strong versus weak argument quality manipulation; the most parsimonious design capable of detecting a curvilinear interaction. Note that in the IDA we will also consider a much broader range of vocal speeds. Furthermore, we included multiple measures of perceived ability and motivation to test the potential mediating role of these variables on message processing. In addition to measuring attitudes, we also measured behavioral intentions to test whether a similar curvilinear pattern emerged on this variable. Additionally, Experiment 2 included a baseline (unmodified) vocal speed condition, to more thoroughly assess moderate speech rate. Finally, we removed the thought listing/rating measures used in Experiment 1 to examine whether differences in processing would still emerge even when participants did not explicitly engage in a process designed to stimulate thinking. Importantly, we preregistered the design, sampling plan, and analyses for Experiment 2 https://osf.io/pq6tz.

## Method

### Participants and Design

Undergraduates ($N=313$) from a Spanish university were randomly assigned to conditions in a 3 (Vocal Speed: −35%; unmodified, i.e., 0% change; and + 15%) X 2 (Argument Quality: strong versus weak arguments) between-participants factorial design. All participants (32.9% men, 66.1% women, 0.3% non-binary/other, and 0.6% prefer not to answer; $M_{age}=19.10$, $SD_{age}=1.42$) completed the experimental materials using their personal computers in exchange for course credit.[6] We followed time-based stopping rules, halting data collection after one week, as per our preregistration information.

### Procedure and Materials

The procedures, materials, and manipulations were identical to Experiment 1 except where explicitly noted otherwise. Participants listened to an audio recording about the same university service plan as Experiment 1, delivered by the same speaker. No thought listing/rating task was used in Experiment 2. After listening to the audio recording, participants indicated their attitude toward the university service plan. Next, participants responded to three questions regarding their behavioral intentions toward the plan. Following this, participants answered several questions about the speaker's manner of delivery, including vocal speed, perceived confidence, and distractor items, all as used in Experiment 1. Participants then responded to three items intended to evaluate their perceived ability to process the message (e.g., "*To what extent were you able to understand what the speaker was saying?*", each rated 1–7; $\alpha=0.77$). Next, we measured participant's perceived motivation to process the message using five items (e.g., "*To what extent did the speaker seem like someone worth listening to?*" each rated 1–7; $\alpha=0.89$), after which they answered the same demographic questions as per Experiment 1.

[6] Based on our preregistered exclusion criteria, we removed six participants, all of whom indicated that their native language was not English, did not pass the Cambridge C2 English Proficiency exam, and self-rated their level of English fluency lower than 4 on a scale of 1–7. Thus, all main text analyses were conducted using a sample of $N=307$, but see SOM-3 for alternative analyses with other (or no) exclusion criteria applied, which generally produced comparable findings.

**Independent Variables** *Vocal Speed* The message was recorded by the same female speaker in both audio versions, then digitally edited using PRAAT®. We digitally manipulated the speaker's speech rate, creating three levels without impacting other vocal characteristics (e.g., pitch, intonation). One condition decreased speech rate by 35% (113 WPM), whereas a second condition increased speech rate by 15% (202 WPM), relative to the speaker's natural baseline (174 WPM).

*Argument Quality* The identical passages were used as per Experiment 1.[7]

**Dependent Variables** *Attitudes* The same attitude measure was used as per Experiment 1. Item ratings were highly correlated (α = 0.95), thus averaged to form one overall attitude index.

*Behavioral Intentions* Participants responded to three items designed to measure their behavioral intentions regarding the university service plan, each rated from 1 = *extremely unlikely* to 7 = *extremely likely*. The questions were: "*How likely is it that you would support the proposed Tuition Reduction Policy you just learned about by…*" (1) "*…voting in favor of this policy if you were given the chance?*", (2) "*…agreeing to write a brief essay that describes the benefits of this program for all IE undergraduates?*", and (3) "*…sharing the positive information you have learned about this policy with other students in your class?*" Item ratings were highly correlated (α = 0.87), thus averaged to form one overall behavioral intentions index.

## Results

### Manipulation Check: Perceived Vocal Speed

As per Experiment 1, we treated Vocal Speed as a continuous measure because the difference in speech rate (i.e., WPM) across conditions was best represented by the specific speed levels used. Thus, the vocal speed levels -35%, unmodified, i.e., 0% change, and + 15% were coded as the continuous values -0.35, 0 and 0.15. We regressed perceived vocal speed onto the same predictors as Experiment 1, predicting and finding only a main effect of vocal speed. As expected, a main effect of vocal speed (see Table 2) indicates that each 10% increment in vocal speed corresponds to 0.58 units of perceived speed difference. This was a linear relationship and was not moderated by argument quality (see Fig. 4a).

### Perceived Speaker Confidence

Replicating Experiment 1, a positive main effect of linear vocal speed emerged, such that faster voices were generally perceived as more confident. However, this pattern was qualified by a negative curvilinear term, suggesting diminishing benefits of increasingly faster vocal speeds (see Fig. 4b).

[7] We also included a measure of the need for cognition (Cacioppo & Petty, 1982) as a possible moderator of our results. However, it did not produce significant results, and we therefore report relevant details in the supplement (SOM-4).

### Persuasion Effects

We observed the predicted two-way interaction between curvilinear vocal speed X argument quality on post-persuasion attitude, thus replicating Experiment 1 (see Table 2). We also found a two-way interaction between linear vocal speed X argument quality. Once again, strong arguments were consistently more persuasive than weak arguments, but the magnitude of the argument quality effects on attitudes (i.e., suggesting changes in processing) changed as a function of vocal speed (see Fig. 5). Although increasing speech rate from -35% (113 WPM) to the unmodified baseline speed (174 WPM) had a non-significant impact on processing, $F(1, 199) = 0.24$, $p = 0.626$, partial $\eta 2 = 0.00$, a significant decrease in processing emerged when speech rate was increased by an additional 15% (202 WPM) from the baseline rate, $F(1, 202) = 5.15$, $p = 0.024$, partial $\eta 2 = 0.03$. Decreased processing is reflected by an attenuation of the difference between strong and weak arguments on attitude.

Alternatively considered, the curvilinear influence of vocal speed on attitudes was non-significant but arithmetically positive among weak arguments, $B = 8.72$ [−1.98, 19.43], $t(150) = 1.61$, $p = 0.109$; it was non-significant but arithmetically negative among strong arguments, $B = -3.97$ [−11.83, 3.88], $t(157) = -1.00$, $p = 0.319$. Thus, increasingly fast vocal speeds if anything had an accelerating persuasion benefit among weak arguments, but they had a decelerating persuasion effect among strong arguments.

### Behavioral Intention Effects

As seen in Table 2, the interaction between curvilinear vocal speed and argument quality on behavioral intentions was non-significant. However, we observed a significant two-way interaction between linear vocal speed X argument quality. As expected, strong arguments produced more behavior intentions than weak arguments. Similar to the persuasion effects observed on attitude, the magnitude of the argument quality effects on behavioral intentions changed as a function of vocal speed, suggesting that changes in processing have similar effects on attitudes and subsequent behavioral intentions.

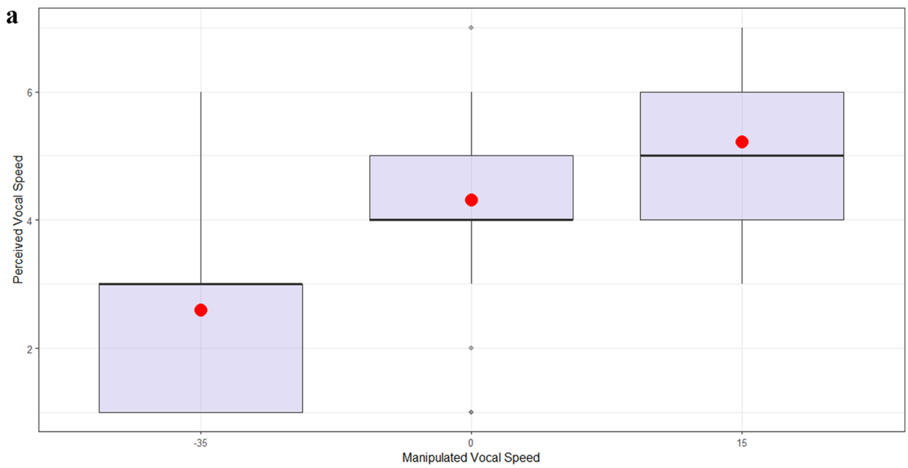
### Mechanisms of Vocal Speed's Curvilinear Effect

Finally, we considered whether motivation and/or perceived ability to process might account for the curvilinear influence of vocal speed on processing. First, we tested our two new mechanism variables, motivation and perceived ability to process, to see if vocal speed was curvilinearly related to either variable. As seen in Table 3, the data revealed a marginal linear effect and non-significant curvilinear effect of vocal speed on motivation to process. This suggests that a faster speech rate induced a modest increase in motivation to attend to the message.

Regarding the effect of vocal speed on perceived ability to process, here we find that vocal speed had a marginally negative linear effect, but more importantly a significantly negative curvilinear effect, suggesting that faster speech rates reduced participant's perceived ability to process the message. These relations are depicted in Fig. 6a, b. As Fig. 6a reveals, faster vocal speed was very weakly related to motivation to process, showing only a slight increase in motivation when moving from -35% to the baseline 0% and + 15% rates of speech. As Fig. 6b reveals, the significant curvilinear term is reflected by the fact that

**Table 2** Effects of argument quality, linear and curvilinear vocal speed on Experiment 2 manipulation check and dependent variables

| Independent variable | Perceived speed | | | | Post-persuasion attitude | | | | Behavioral intentions | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *p* | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *P* | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *p* |
| Argument quality (AQ) | .19 | − .39, .76 | .65 | .519 | 2.08 | 1.47, 2.68 | 6.71 | < .001 | 1.90 | 1.24, 2.56 | 5.66 | < .001 |
| Vocal speed | 5.81 | 4.90, 6.72 | 12.52 | < .001 | .69 | − .28, 1.65 | 1.39 | .165 | .89 | − .16, 1.94 | 1.67 | .095 |
| Vocal speed curvilinear | 4.46 | − 1.79, 10.71 | 1.41 | .161 | 3.13 | − 3.49, 9.76 | .93 | .353 | 6.42 | − .77, 13.60 | 1.76 | .080 |
| AQ X vocal speed | − .86 | − 2.68, .97 | − .92 | .357 | − 2.43 | − 4.37, − .50 | − 2.47 | .014 | − 2.41 | − 4.51, − .31 | − 2.26 | .025 |
| AQ X vocal speed curvilinear | − 4.37 | − 16.87, 8.12 | − .69 | .492 | − 13.95 | − 27.20, − .71 | − 2.07 | .039 | − 11.22 | − 25.59, 3.16 | − 1.54 | .126 |
| Model fit | $R^2$ = .47, $F$(5, 301) = 54.37, $p$ < .001 | | | | $R^2$ = .29, $F$(5, 301) = 24.86, $p$ < .001 | | | | $R^2$ = .25, $F$(5, 301) = 19.80, $p$ < .001 | | | |



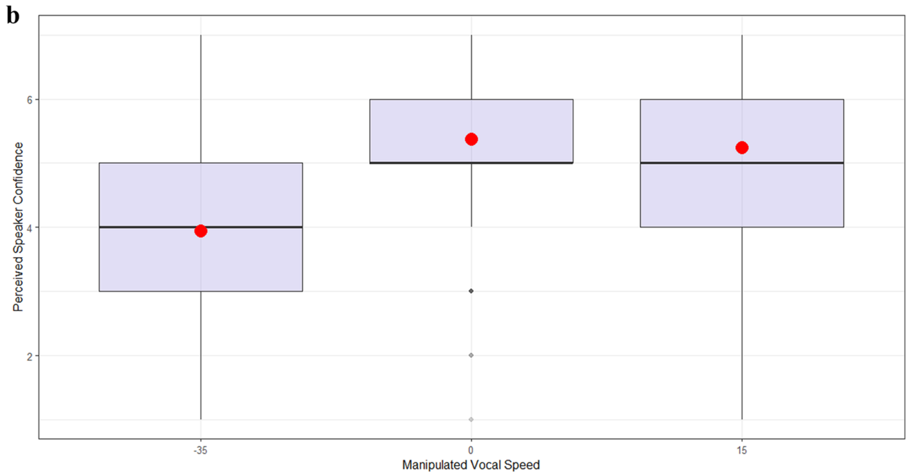




**Fig. 4** **a** Relation between manipulated vocal speed and perceived vocal speed. **b** Relation between manipulated vocal speed and perceived confidence. *Note* Figures created using ggplot2 in R. Red dots represent means, thick black lines represent medians

ability to process if anything weakly increased from -35% to 0% speed, yet was impaired when speech rate increased from the baseline 0% to + 15% speed.

Next, we regressed attitudes onto argument quality, the three mechanisms (confidence, motivation, and perceived ability to process), and interaction terms of argument quality with each mechanism. Only perceived ability to process significantly moderated argument quality's effect on attitudes, $B = 0.39$ [0.17, 0.61], $t(299) = 3.49$, $p < 0.001$, such that the benefit of argument quality on persuasion increased as perceived ability to process increased.[8] Specifically, processing was substantial with strong arguments beating weak arguments by approximately one scale unit given low (1 SD below the mean) ability to

[8] Motivation showed weaker, non-significant interactions with argument quality, $B = -.22$ [-.51, .07], $t(299) = -1.51$, $p = .132$; the same was true for confidence, $B = .20$ [-.02, .42], $t(299) = 1.79$, $p = .075$.

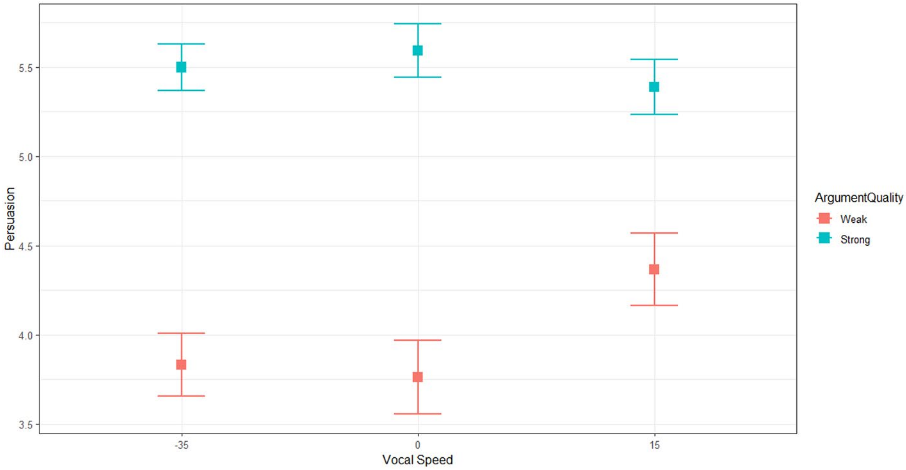



**Fig. 5** Relation between manipulated vocal speed and persuasive effect of argument quality

process, $B = 0.93$, $SE = 0.19$, $t(303) = 4.80$, $p < 0.001$. However, this effect more than doubled to more than two units given high (1 SD above the mean) ability to process, $B = 2.06$, $SE = 0.19$, $t(303) = 10.59$, $p < 0.001$.

The first two steps established that perceived ability to process was uniquely related to curvilinear vocal speed and also demonstrated a parallel moderation effect to curvilinear vocal speed. Finally, we reran the earlier model, regressing attitudes onto linear and curvilinear vocal speed X argument quality, now including perceived ability to process X argument quality as an additional moderator. Curvilinear vocal speed X argument quality was reduced to non-significance, $B = -10.69$ [−24.74, 2.36], $t(299) = -1.61$, $p = 0.108$, whereas the perceived ability to process X argument quality interaction remained significant, $B = 0.41$ [0.20, 0.62], $t(299) = 3.95$, $p < 0.001$. This is consistent with a mediation pattern.

## Deviations from the Preregistration

Our preregistered materials indicated that we would use ANOVA for all critical analyses. However, we decided to use regression to conduct the same analytic goals because this analytical strategy allows us to separate and simultaneously compare linear and curvilinear speed effects. Similar conclusions are reached if ANOVA is employed.[9]

We originally hypothesized linear rather than curvilinear effects of faster speeds on processing for Experiment 2. At the time this experiment was preregistered, we had not conducted our integrative data analysis (see below), thus believed based on early experiments that impaired processing would not consistently emerge until more substantial speed elevations of +25%. However, if all datasets *except* Experiment 2 are combined, curvilinearity effects of vocal speed indeed emerge by as early as +15%; thus, curvilinearity is consistent with the other datasets.

[9] Most crucially, the interaction of argument quality X vocal speed is $F(2, 301) = 3.15$, $p = .044$, $\eta^2_p = .02$; this is represented in regression as the linear, $p = .014$, and curvilinear interaction effects, $p = .039$ (which the ANOVA omnibus interaction folds together).

**Table 3** Effects of argument quality, linear and curvilinear vocal speed on Experiment 2 possible mechanism variables

| Independent variable | Perceived confidence | | | | Motivation to process | | | | Perceived Ability to Process | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *p* | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *P* | *B* | $CI_{LL}$, $CI_{UL}$ | *t* | *p* |
| Argument quality (AQ) | −.32 | −1.06, .42 | −.85 | .399 | .04 | −.56, .64 | .13 | .897 | −.16 | −.80, .48 | −.50 | .617 |
| Vocal speed | 1.94 | .76, 3.12 | 3.23 | .001 | .86 | −.09, 1.81 | 1.77 | .077 | −.94 | −1.96, .07 | −1.82 | .070 |
| Vocal speed curvilinear | −10.42 | −18.51, −2.33 | −2.54 | .012 | −4.52 | −11.05, 2.00 | −1.37 | .173 | −7.93 | −14.91, −.98 | −2.24 | .026 |
| AQ X vocal speed | −1.01 | −3.38, 1.35 | −.84 | .401 | −.51 | −2.42, 1.39 | −.53 | .597 | −.09 | −2.12, 1.95 | −.08 | .934 |
| AQ X vocal speed curvilinear | 4.56 | −11.61, 20.74 | .56 | .579 | 1.55 | −11.49, 14.60 | .23 | .815 | −.05 | −13.99, 13.87 | −.01 | .994 |
| Model fit | $R^2 = .17$, $F(5, 301) = 12.27$, $p < .001$ | | | | $R^2 = .06$, $F(5, 301) = 3.74$, $p = .003$ | | | | $R^2 = .02$, $F(5, 301) = 1.30$, $p = .264$ | | | |

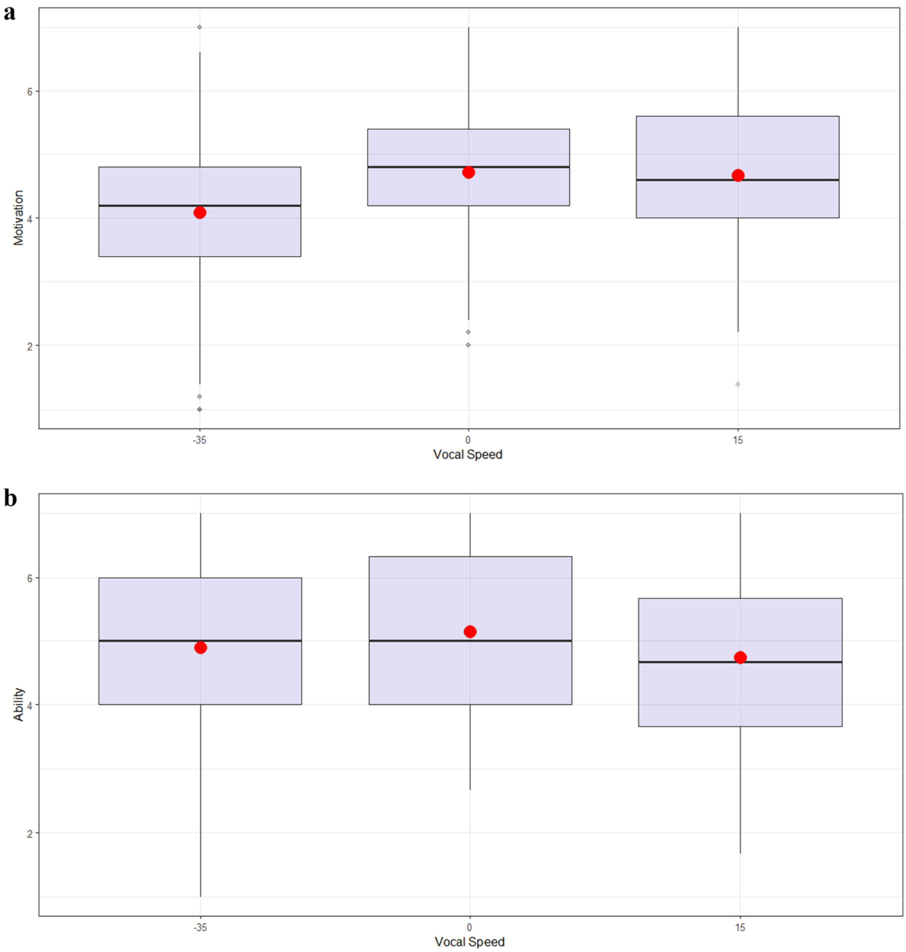



**Fig. 6** **a** Relation between manipulated vocal speed and perceived motivation to process. **b** Relation between manipulated vocal speed and perceived ability to process

## Integrative Data Analysis

Although Experiments 1–2 presented clear and consistent evidence that vocal speed relates curvilinearly to persuasive message processing, these studies leave several points less well explored. First, although they sampled from a broad array of different vocal speeds within the plausibly natural human range (i.e., 113, 148, 174, 192, 197, 202, and 218 WPM), their sampling of participants was modest. Second, although Experiment 2 suggests perceived ability to process is more relevant than perceived confidence or motivation to process in explaining the persuasion effects, it is only a single study, and the effects of motivation and confidence were somewhat inconclusive in the relevant analyses. Similarly, Experiment 2 did not contain thought-listing and thought-rating tasks, so the claim that vocal speed curvilinearly impairs processing in the sense of reducing thought-attitude consistency is again based only on one of the two datasets.

Fortunately, however, we have four supplementary datasets with which to provide high-powered examinations of these issues (see SOM-2 for additional information on their individual procedural characteristics). All six contained strong and weak argument conditions and varied at least three levels of vocal speed (total range: $-35\%$ to $+25\%$). Four experiments contained thought-listing/thought-rating tasks, and all contained at least one measure relevant to mechanisms ($k = 5$ for motivation and perceived ability, $k = 6$ for confidence). Only Experiment 2 contained behavioral intentions so we do not reexamine that here. Although not every experiment jointly supported the target effect, an integrative analysis permits us to examine all of our presented and non-presented data together, to avoid publication bias or cherry-picking "good" datasets. One benefit of including all six datasets is the much greater statistical power obtained by pooling them ($N_{total}$ per analysis = 2,869 to 3,958). We have included figures of several critical relationships because this large sample size permits extremely precise estimates of relationships between key variables (i.e., note the thin error regions in Fig. 7a–c).

For the IDA analyses, we regressed each dependent variable onto linear and curvilinear vocal speed terms, argument quality, their interaction terms (linear speed X argument quality; curvilinear speed X argument quality), and centered dummy variables representing each dataset (see Curran & Hussong, 2009). First, we tested whether the experiments collectively provided support for linear and/or curvilinear effects of vocal speed on message processing. Across almost 4,000 participants, we found no evidence of faster voices increasing or decreasing processing in a linear fashion (i.e., moderating the effect of argument quality on attitudes), $B = -0.28$ [$-0.71$, 0.15], $t(3948) = -1.27$, $p = 0.203$. However, we found support for our key hypothesis that vocal speed exerted a curvilinear effect on processing in the sense of increasing argument quality benefits, $B = -2.56$ [$-4.89$, $-0.23$], $t(3948) = -2.16$, $p = 0.031$.

Second, we tested whether a second form of evidence supported a curvilinear effect on processing: thought-attitude correspondence. We again found no evidence that linearly faster voices increased or decreased processing (i.e., moderated thought valence's relationship to attitudes), $B = -0.13$ [$-0.48$, 0.23], $t(2857) = -0.70$, $p = 0.484$. However, we found clear evidence that vocal speed exerted a curvilinear effect on processing in the sense of thought/attitude correspondence, $B = -2.96$ [$-5.16$, $-1.28$], $t(2857) = -3.25$, $p = 0.001$.

Third, we considered whether there was unique evidence supporting perceived ability to process (rather than confidence and/or motivation) as a mechanism for the curvilinear vocal speed patterns. We detected both a negative linear effect of speed, $B_{ability} = -1.74$ [$-1.95$, $-1.53$], $t(3620) = -16.05$, $p < 0.001$, and a negative curvilinear effect, $B_{ability} = -8.46$ [$-9.62$, $-7.30$], $t(3620) = -14.28$, $p < 0.001$, on perceived ability to process. As Fig. 7a shows, there is a slight tendency for vocal speed to initially facilitate ability to understand messages, when progressing from very slow to average speed voices. However, anything faster than baseline speed begins to have a substantial detrimental effect on perceived ability to understand. This forms a negative (i.e., "reverse-U" shape) curvilinear term that aligns closely with our processing effects noted above.

We also found a positive linear effect of speed on motivation, $B_{motivation} = 0.88$ [0.68, 1.09], $t(3620) = 8.46$, $p < 0.001$, and on confidence, $B_{confidence} = 1.74$ [1.53, 1.96], $t(3953) = 15.77$, $p < 0.001$. Each of these effects, however, were qualified by large negative curvilinear effects, $B_{motivation} = -6.81$ [$-7.93$, -5.69], $t(3620) = -11.95$, $p < 0.001$; $B_{confidence} = -7.28$ [$-8.45$, $-6.11$], $t(3953) = -12.20$, $p < 0.001$. As Fig. 7b–c show, this again occurs because faster speeds initially bolster these variables (increasing motivation and confidence to a point) but have diminishing benefit or even detrimental effects beyond slight elevations of speed.

We therefore next examined whether any of these mechanism variables could substitute (for curvilinear vocal speed) as moderators of argument quality's effect on persuasion. We regressed attitudes onto argument quality, motivation, perceived ability to process, and perceived confidence, and interactions of argument quality X each possible mechanism. We found the expected interaction of argument quality X perceived ability to process, $B = 0.14$ [0.07, 0.20], $t(3615) = 4.20$, $p < 0.001$, suggesting that people who felt highly able to process (+1 SD) showed a larger strong > weak persuasion difference, $B = 1.15$, $t(3615) = 20.00$, $p < 0.001$, compared to those who felt less able to process (−1 SD), $B = 0.80$, $t(3615) = 13.93$, $p < 0.001$. We also found a weaker interaction of argument quality X confidence, $B = 0.08$ [0.01, 0.15], $t(3615) = 2.11$, $p = 0.035$, showing more processing from those who saw the source as more, $B = 1.08$, $t(3615) = 17.04$, $p < 0.001$, versus less confident, $B = 0.87$, $t(3615) = 13.79$, $p < 0.001$. Thus, perceived ability to process and seeing the source as confident were both related to more processing, making them consistent as mediators. Surprisingly, we found a negative interaction of argument quality X motivation, $B = -0.12$ [−0.20, −0.04], $t(3615) = -2.84$, $p = 0.005$, suggesting that if anything high motivation to process (+1 SD) decreased the strong > weak argument benefit, $B = 0.83$, $t(3615) = 12.80$, $p < 0.001$, compared to low motivation to process (−1 SD), $B = 1.12$, $t(3615) = 17.26$, $p < 0.001$. This effect is opposite to the effect of curvilinear vocal speed, eliminating it as a plausible mediator.

Next, we ran regression analyses in which vocal speed (linear and curvilinear) interacted with argument quality in the same analysis in which ability to process (analysis 1) or confidence (analysis 2) also interacted with argument quality. We would expect a mediator to reduce the interaction term of curvilinear vocal speed X argument quality. Perceived ability to process had this influence, remaining a significant moderator, $B = 0.12$ [0.05, 0.19], $t(3615) = 3.53$, $p < 0.001$, and completely eliminating curvilinear vocal speed as a moderator, $B = -0.65$ [−3.10, 1.79], $t(3615) = -0.52$, $p = 0.600$. Perceived confidence was a significant moderator, $B = 0.07$ [0.01, 0.13], $t(3615) = 2.26$, $p = 0.024$, but did not reduce curvilinear vocal speed's moderation effect to non-significance, $B = -2.39$ [−4.72, −0.06], $t(3615) = -2.01$, $p = 0.044$. In sum, curvilinear vocal speed appears to undermine processing by impairing ability to process, rather than by undermining motivation or the source's perceived confidence.

Finally, we used moderated mediation (PROCESS Model 14; Hayes, 2022) to analyze these effects. Specifically, this model examined if vocal speed had negative curvilinear effects on perceived ability, motivation, and confidence; and then whether these variables interacted with argument quality to influence attitudes. In this instance, because vocal speed had negative curvilinear effects on all three process variables, $ps < 0.001$, we would expect significantly negative "moderated mediation index" values for variables that interacted with argument quality as expected (i.e., such that higher levels of the variable increased processing). The moderated mediation index was significantly negative for perceived ability, $MMI = -1.18$ [−1.81, −0.58], and for confidence, $MMI = -0.51$ [−1.03, −0.04], as expected. Surprisingly (but consistent with the prior paragraphs), the moderated mediation index was positive for motivation, $MMI = 0.81$ [0.17, 1.44], because higher motivation was related to less message processing.

## General Discussion

By investigating a broader spectrum of speech rate than has been explored in prior research, these data provide the first empirical evidence demonstrating a curvilinear relationship

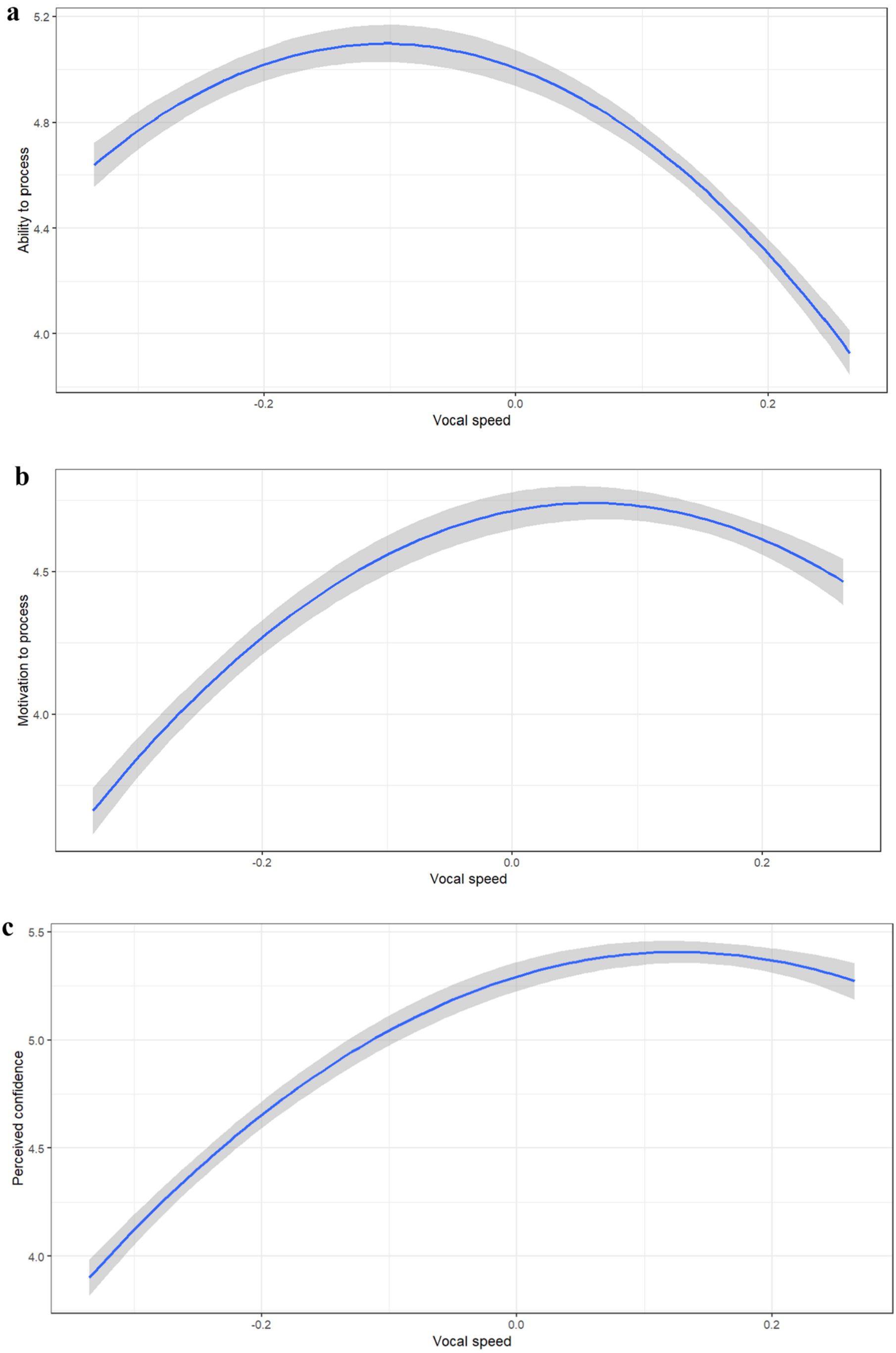



**Fig. 7** **a** Relation between manipulated vocal speed and perceived ability to process. **b** Relation between manipulated vocal speed and perceived motivation to process. **c** Relation between manipulated vocal speed and perceived speaker confidence. *Note* Shaded region represents 95% confidence interval

between rate of speech and perceptions of speaker confidence, as well as motivation and perceived ability to process. Moreover, our data suggests this general pattern may also extend to the relationship between rate of speech and processing (i.e., the relative difference by which argument quality affects persuasion, and the degree to which thoughts and attitudes align), with downstream consequences for persuasion. Importantly, our results support past research that showed an increase in processing (e.g., LaBerbera & MacLachlan, 1979) and a decrease in processing (e.g., Hausknecht & Moore, 1986; Moore et al., 1986), as a function of speech rate. That is, in line with the ELM, our data confirmed that under conditions of moderate elaboration, the process by which speech rate affects persuasion is driven by the amount of processing. Importantly, we show that the effects of speech rate on persuasion are non-linear across a wider spectrum of this variable. Indeed, at very fast rates of speech, processing declines and persuasion is reduced following exposure to strong arguments but increased following exposure to weak arguments.

## Theoretical Implications

Our research expands on a substantial literature that demonstrates how nonverbal features of a persuasive message source have implications for how messages are processed and accepted or rejected (Briñol & Petty, 2009; Guyer et al., 2021). Specifically, the present research addresses the inconsistent literature on vocal speed, which has suggested that faster speech is sometimes a benefit to persuasion (Apple et al., 1979; Hausknecht & Moore, 1986; Miller et al., 1976), sometimes a detriment to persuasion (Lautman & Dean, 1983; O'Connell et al., 1989), or has negligible effects (e.g., Gunderson & Hopper, 1976; Woodall & Burgoon, 1983). We suggested that vocal speed's relationship to persuasion may be complicated because it may be mediated by several underlying mechanisms, may depend on argument quality, and may also be curvilinear.

Our six experiments collectively support all three contentions. First, the effects of vocal speed at initially moderate elaboration conditions cannot be understood without taking into account the cogency of one's argument, given that vocal speed's effects operate by shaping the extent of elaboration in listeners. Relative to a very slow reference point, faster vocal speed may initially increase perceived ability to process, motivation to process, and the apparent confidence of the speaker. However, these effects later attenuate or even reverse. We also found clear evidence that perceived ability to process was particularly key in explaining the processing effects, which we showed have clear consequences for persuasion. Thus, the largest contribution of the present work is to provide greater theoretical clarity to a construct (vocal speed) that has often resulted in confusion between scholars, alongside theoretical guidance for future research into vocal speed, which should consider mechanisms, context, and diverse functional forms by which vocal speed translates into persuasive benefits.

Advances in technology allowed us to create more precise manipulations of speech rate by employing a digital recording and editing process, thus definitively ruling out many of the issues with the vocal manipulations used in past research. As a result, our studies directly addressed problems surrounding the interpretation of past research that may—at least in part—have stemmed from methodological issues with their manipulations of speech rate. Taken together, these data offer the best evidence to date that illustrate not only how but also why (i.e., the underlying psychological processes) different properties of voice influence the success of a persuasive appeal at different points along the elaboration continuum. These findings are capable of reconciling apparent inconsistencies in past research that have fueled considerable debate regarding the processes responsible for the effects of speech rate on persuasion.

## Practical Implications

From a marketing perspective, including features in an advertisement that capture a listener's attention has important downstream consequences that can influence future purchasing decisions. This is particularly relevant from a pragmatic standpoint given that large sums of money are often invested into advertisements that expose a potential consumer to a product for as little as 15 s (Newstead & Romaniuk, 2009). While a variety of factors can contribute to the overall effectiveness of an advertisement (see, Muehling & Bozman, 1990; Petty et al., 1983; for reviews), the frequent reliance on actors to communicate the benefits of a product to an audience (Chattopadhyay et al., 2003), suggests that perhaps ad effectiveness can be influenced by certain features of the speaker. Indeed, research suggests one factor that likely plays an influential role is the variability in different qualities of a speaker's voice (Hausknecht & Moore, 1986; LaBarbera & MacLachlan, 1979; Moore et al., 1986). For example, increasing the speaker's rate of speech not only decreases the length of advertisements, which in turn reduces their cost (MacLachlan & Siegel, 1980).

## Limitations and Constraints on Generalizability

It is important to note that these studies do not make specific claims regarding the "perfect" vocal speed, nor did we attempt to identify the exact speed (in WPM) at which message processing and persuasion is most optimal. This relates to our limited sampling of seven different vocal speeds (between main and supplementary experiments), which allowed us to make many curvilinear functions but do not allow us to state precisely what speed would be optimal for maximizing processing and/or persuasion. However, the precise inflection point whereby both processing and persuasion are maximized likely depends on the interplay between a variety of factors, including the individual levels of various vocal properties (e.g., speech rate, pitch, loudness, intonation, etc.), characteristics of the source (e.g., authority, expertise, trustworthiness, etc.), characteristics of the message (e.g., complexity, argument quality and quantity, personal relevance, repetition, etc.), characteristics of the recipient (e.g., need for cognition, need for closure, etc.), and situational factors such as the presence of distraction. Rather, our claims regarding the effects of vocal speed on processing and persuasion are made at a more general level, and research should continue to investigate the various contributing factors that can influence these relationships. Moreover, given that the present research focused only on one vocal property (speech rate) of many, we cannot make claims regarding the generalizability of these data to other characteristics of voice. For instance, it would be useful to know whether curvilinear pattern observed in our studies on vocal speed may also apply in the context of changes to vocal pitch or loudness. Additionally, it may be the case that our specific measures of perceived motivation were too narrow and thus did not sufficiently capture how individuals evaluate when, how, and the extent to which stimuli are perceived as motivating. Therefore, broadening our coverage of how we measure this variable may allow us to account for processing effects.

## Future Directions

Professional speech coaches and public speaking programs often advocate in favor of employing a dynamic vocal style (e.g., speaking slower on key points and faster on information of lesser importance) to increase listener engagement when communicating. Given the moderating role of vocal speed on processing, with different consequences for persuasion depending on argument quality, this provides an interesting avenue for future research. Our experiments showcased conditions in which the persuasive message was either composed entirely of weak or strong arguments. However, often communicators must present strong arguments from two parties who are in opposition to one another (e.g., two-sided messages used in political campaign speeches). The present research suggests that in such a case, an optimal strategy may be to communicate at a moderate pace when presenting strong arguments that support one's own position yet use a very rapid pace to undermine processing when delivering arguments that oppose one's position. Conversely, one might reverse this strategy to maximize the persuasive benefits when presenting weak arguments supporting one's own and the opposition's position on an issue. Future research should test, under controlled laboratory conditions and naturalistic settings, whether this communication strategy might yield the predicted outcomes under diverse conditions (e.g., political speeches, public debates, university presentations) and for a broad range of variables (e.g., attitudes, behavioral intentions, word-of-mouth, voting behavior, etc.).

Moving beyond research focused specifically on vocal speed, consider that the interpersonal communication process often involves other non-verbal aspects of communication such as facial expressions and body language. Similar to voice, both facial expressions and body language also provide a rich variety of information that likely interacts in important ways with speech rate to influence attitudes. Thus, investigating how varying combinations of facial features, body language, speech rate, and message content might interact the persuasion process is an important next step in disentangling how a multitude of factors work in combination with one another to influence the efficacy of persuasive appeals.

The effects of the current research are likely to be moderated by the meanings associated with vocal speed. By default, people are likely to associate speed with high validity meanings (e.g., confidence, credibility). However, if the meaning of vocal speed changes, then the effects observed in these studies are likely to vary. For example, if vocal speed was associated with low validity meanings (e.g., vocal speed indicating anxiety, an attempt to conceal information, or the side effect of medication, etc.), then the effects might reverse (e.g., Briñol et al., 2006).

Beyond testing the role of meaning, future work can also benefit by examining the extent to which other variables relevant to speed can also operate via curvilinear effects, ranging from rapid thinking (Pronin, 2013; Pronin & Jacobs, 2008) to speed of locomotion (e.g., Reinhard et al., 2020; van den Berg et al., 2016). Broadening the levels of speed tested in those domains might also reveal curvilinear effects as was the case in the current studies for vocal speed.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s10919-024-00477-6.

**Acknowledgements** The manuscript was supported by the third author's SSHRC Insight grants (435-2015-0114; 435-2022-0034) and SSHRC Development grant (430-2019-00099).

**Author Contributions** J.G., T.V., M.S., and L.F. collected the data. T.V. analyzed the data and prepared figures. J.G. and T.V. wrote the manuscript. All authors reviewed the manuscript and facilitated its revisions.

**Funding** Social Sciences and Humanities Research Council, 435-2015-0114.

**Data Availability** Data and code are available on OSF at https://osf.io/5gwcb/. Data is provided within the manuscript or supplementary information files.

## Declarations

**Conflict of interest** The authors declare that they do not have a conflict of interest.

**Ethical Approval** The manuscript is not under consideration by any other journal. All data were collected in a manner consistent with the APA's Ethical Principles in the Conduct of Research with Human Participants, and participants completed informed consent prior to participating. The data are open, are described in the manuscript. We have no conflict of interest with these data. Experiment 1 was previously released as Experiment 3 of the first author's PhD dissertation.



## References

Apple, W., Streeter, L. A., & Krauss, R. M. (1979). Effects of pitch and speech rate on personal attributions. *Journal of Personality and Social Psychology, 37*(5), 715–727.

Baker, S. M., & Petty, R. E. (1994). Majority and minority influence: Source-position imbalance as a determinant of message scrutiny. *Journal of Personality and Social Psychology, 67*(1), 5–19.

Bem, D. J. (1972). Self-perception theory. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 6, pp. 1–62). Academic Press.

Boersma, P., & Weenink, D. (1992–2022). Praat; doing phonetics by computer [Computer program]. Version 6.2.06, retrieved 23 January 2022 from https://www.praat.org

Briñol, P., & Petty, R. E. (2009). Source factors in persuasion: A self-validation approach. *European Review of Social Psychology, 20*, 49–96. https://doi.org/10.1080/10463280802643640

Briñol, P., Petty, R. E., & Tormala, Z. L. (2006). The meaning of ease and its malleability. *Psychological Science, 17*, 200–206.

Brown, B. L., Giles, H., & Thakerar, J. N. (1985). Speaker evaluations as a function of speech rate, accent, and context. *Language & Communication, 5*(3), 207–220.

Buller, D. B., & Aune, R. K. (1988). The effects of vocalics and nonverbal sensitivity on compliance: A speech accommodation theory explanation. *Human Communication Research, 14*, 301–332.

Cacioppo, J. T., & Petty, R. E. (1981). Social psychological procedures for cognitive response assessment: The thought listing technique. In T. Merluzzi, C. Glass, & M. Genest (Eds.), *Cognitive assessment.* Guilford.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology*, *42*(1), 116.

Chaiken, S. (1980). Heuristics versus systematic information processing in the use of source versus message cues in persuasion. *Journal of Personality and Social Psychology, 39*, 752–766.

Chaiken, S. (1987). The heuristic model of persuasion. In M. P. Zanna, J. M. Olson, & C. P. Herman (Eds.), *Social influence: The ontario symposium* (Vol. 5, pp. 3–39). Erlbaum.

Chattopadhyay, A., Dahl, D. W., Ritchie, R. J. B., & Sahin, K. N. (2003). Hearing voices: The Impact of announcer speech characteristics on consumer responses to broadcast advertising. *Journal of Consumer Psychology, 13*, 198–204.

Chebat, J.-C., Hedhli, K. E., Gélinas-Chebat, C., & Boivin, R. (2007). Voice and persuasion in a banking telemarketing context. *Perceptual and Motor Skills, 104*(2), 419–437.

Clark, J. K., Wegener, D. T., & Fabrigar, L. R. (2008). Attitude accessibility and message processing: The moderating role of message position. *Journal of Experimental Social Psychology, 44*(2), 354–361.
Crites, S. L., Fabrigar, L. R., & Petty, R. E. (1994). Measuring the affective and cognitive properties of attitudes: Conceptual and methodological issues. *Personality & Social Psychology Bulletin, 20*, 619–634.
Curran, P. J., & Hussong, A. M. (2009). Integrative data analysis: The simultaneous analysis of multiple data sets. *Psychological Methods, 14*(2), 81.
Fagan, A. (2019). How is your voice perceived? *Psychology Today*. https://www.psychologytoday.com/us/articles/201905/how-is-your-voice-perceived
Giles, H., & Street, R. L., Jr. (1985). Communicator characteristics and behavior. In M. L. Knapp & G. R. Miller (Eds.), *Handbook of interpersonal communication* (pp. 205–261). Sage.
Gunderson, D. F., & Hopper, R. (1976). Relationship between speech delivery and speech effectiveness. *Communication Monographs, 43*, 158–165.
Guyer, J. J., Briñol, P., Vaughan-Johnston, T. I., Fabrigar, L., Moreno, L., & Petty, R. E. (2021). Paralinguistic features communicated through voice can affect appraisals of confidence and evaluative judgments. *Journal of Nonverbal Behavior*. https://doi.org/10.1007/s10919-021-00374-2
Guyer, J. J., Fabrigar, L. R., & Vaughan-Johnston, T. I. (2018). Speech rate, intonation, and pitch: Investigating the bias and cue effects of vocal confidence on persuasion. *Personality and Social Psychology Bulletin, 45*(3), 389–405.
Hausknecht, D. R., & Moore, D. L. (1986). The effects of time compressed advertising on brand attitude judgments. *Advances in Consumer Research, 13*(1), 105–110.
Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (3rd edition)*. The Guilford Press.
Jiang, X., & Pell, M. D. (2014). Encoding and decoding confidence information in speech. In *Proceedings of the 7th International Conference in Speech Prosody, Social and Linguistic Speech Prosody,* 576–579.
Kim, S. Y., Allen, M., & Preiss, R. (2019). Meta-analysis of the curvilinear relationship between rate of delivery and message persuasiveness. *Communication, Society, and Media, 2*(1), 1–14.
LaBarbera, P., & MacLachlan, J. (1979). Time-compressed speech in radio advertising. *Journal of Marketing, 43*, 30–33.
Lautman, M. R., & Dean, J. K. (1983). The compression of television advertising. In P. Larry & A. G. Woodside (Eds.), *Advertising and consumer psychology* (pp. 171–196). Lexington Books.
London, H. (1973). *Psychology of the persuader*. General Learning Press.
MacLachlan, J. (1979). What people really think of fast talkers. *Psychology Today*, 113–117.
MacLachlan, J., & Siegel, M. H. (1980). Reducing the costs of TV commercials by use of time compressions. *Journal of Marketing Research, 17*(1), 52–57.
Mehrabian, A., & Williams, M. (1969). Nonverbal concomitants of perceived and intended persuasiveness. *Journal of Personality and Social Psychology, 13*, 37–58.
Miller, N., Maruyama, G., Beaber, R. J., & Valone, K. (1976). Speed of speech andpersuasion. *Journal of Personality and Social Psychology, 34*(4), 615–624.
Moore, D. L., Hausknecht, D., & Thamodaran, K. (1986). Time compression, response opportunity, and persuasion. *Journal of Consumer Research, 13*, 85–99.
Muehling, D. D., & Bozman, C. S. (1990). An examination of factors influencing effectiveness of 15-second advertisements. *International Journal of Advertising, 9*(4), 331–334.
Neill, C. (2016). 12 tips for public speaking. *Forbes*. https://www.forbes.com/sites/iese/2016/04/18/12-tips-for-public-speaking/?sh=4f5ec0de3a18
Newstead, K., & Romaniuk, J. (2009). Cost per second: The relative effectiveness of 15- and 30- second television advertisements. *Journal of Advertising Research, 50*(1), 68–76.
Ni, P. (2019). Do you talk too fast? How to slow down. *Psychology Today*. https://www.psychologytoday.com/intl/blog/communication-success/201911/do-you-talk-too-fast-how-to-slow-down
Nickell, G. S., & Pinto, J. N. (1984). The effects of compressed speech on listener attitudes. *Psychology and Marketing, 1*(1), 49–58.
O'Connell, D. C., Kowal, A., Bartels, U., Mundt, H., & van de Water, D. (1989). Allocation of time in reading aloud: Being fluent is not the same as being rhetorical. *Bulletin of the Psychonomic Society, 27*, 223–226.
Petty, R. E., & Briñol, P. (2012). The elaboration likelihood model. In P. A. M. Van Lange, A. Kruglanski, & E. T. Higgins (Eds.), *Handbook of theories of social psychology* (Vol. 1, pp. 224–245). Sage.
Petty, R. E., & Cacioppo, J. T. (1979). Issue-involvement can increase or decrease persuasion by enhancing message-relevant cognitive responses. *Journal of Personality and Social Psychology, 37*(10), 1915–1926.
Petty, R. E., & Cacioppo, J. T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. Springer-Verlag.

Petty, R. E., & Cacioppo, J. T. (1999). The elaboration likelihood model. In S. Chaiken & Y. Trope (Eds.), *Dual-process theories in social psychology* (pp. 41–72). Guilford Press.

Petty, R. E., & Cacioppo, J. T. (2016). Methodological choices have predictable consequences in replicating studies on motivation to think: Commentary on Ebersole et al. (2016). *Journal of Experimental Social Psychology, 67*, 86–87.

Petty, R. E., Cacioppo, J. T., & Schumann, D. (1983). Central and peripheral routes to advertising effectiveness: The moderating role of involvement. *Journal of Consumer Research, 10*, 135–146.

Petty, R. E., & Wegener, D. T. (1998). Attitude change: Multiple roles for persuasion variables. In D. Gilbert, S. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology (4th ed.)* (Vol. 1, pp. 323–390). McGraw-Hill.

Potter, R. F. (2000). The effects of voice changes on orienting and immediate cognitive overload in radio listeners. *Media Psychology, 2*(2), 147–177.

Potter, R. F., Jamison-Koenig, E. J., Lynch, T., & Sites, J. (2019). Effect of vocal-pitch difference on automatic attention to voice changes in audio messages. *Communication Research, 46*(7), 1008–1025.

Pronin, E. (2013). When the mind races: Effects of thought speed on feeling and action. *Current Directions in Psychological Science, 22*, 283–288.

Pronin, E., & Jacobs, E. (2008). Thought speed, mood, and the experience of mental motion. *Perspectives on Psychological Science, 3*, 461–485.

Reinhard, R., Shah, K. G., Faust-Christmann, C. A., & Lachmann, T. L. (2020). Acting your avatar's age: Effects of virtual reality avatar embodiment on real life walking speed. *Media Psychology, 23*(2), 293–315.

Rodero, E. (2020). Do your ads talk too fast to your audio audience?: How speech rates of audio commercials influence cognitive and physiological outcomes. *Journal of Advertising Research, 60*(3), 337–349.

Rodero, E., Potter, R. F., & Prieto, P. (2017). Pitch range variations improve cognitive processing of audio messages: Pitch variations improve cognitive processing. *Human Communication Research, 43*(3), 397–413.

Rucker, D. D., Briñol, P., & Petty, R. E. (2011). Metacognition: Methods to assess primary and secondary cognition. In K. C. Klauer, C. Stahl, & A. Voss (Eds.), *Handbook of cognitive methods in social psychology* (pp. 236–264). Guildford Press.

Scherer, K. R., London, H., & Wolf, J. J. (1973). The voice of confidence: Paralinguistic cuesand audience evaluation. *Journal of Research in Personality, 7*(1), 31–44.

Schlinger, M. R., Alwitt, L. F., McCarthy, K. E., & Green, L. (1983). Effects of time compression on attitudes and information processing. *Journal of Marketing, 47*, 79–85.

Simonsohn, U. (2018). Two lines: A valid alternative to the invalid testing of U-shaped relationships with quadratic regressions. *Advances in Methods and Practices in Psychological Science, 1*(4) 538–555. https://doi.org/10.1177/2515245918805755

Smith, B. L., Brown, L., Strong, W. J., & Rencher, A. C. (1975). Effects of speech rate on personality perception. *Language and Speech, 18*, 145–152.

Smith, S. M., & Shaffer, D. R. (1991). Celerity and cajolery: Rapid speech may promote or inhibit persuasion through its impact on message elaboration. *Personality and Social Psychology Bulletin, 17*, 663–669.

Smith, S. M., & Shaffer, D. R. (1995). Speed of speech and persuasion: Evidence for multiple effects. *Personality and Social Psychology Bulletin, 21*(10), 1051–1060.

Smith, V. L., & Clark, H. H. (1993). On the course of answering questions. *Journal of Memory and Language, 32*(1), 25–38.

Staats, A. W., & Staats, C. K. (1958). Attitudes established by classical conditioning. *Journal of Abnormal and Social Psychology, 57*, 37–40.

Street, R. L., Jr., & Brady, R. M. (1982). Speech rate acceptance ranges as a function of evaluative domain, listener speech rate, and communication context. *Communication Monographs, 49*, 290–308.

Street, R. L., Jr., Brady, R. M., & Putman, W. B. (1983). The influence of speech rate stereotypes and rate similarity of listeners' evaluations of speakers. *Journal of Language and Social Psychology, 2*, 37–56.

Van den Bergh, B., Euvinck, N., Schellekens, A. C., & Vermeir, I. (2016). Altering speed of locomotion. *Journal of Consumer Research, 43*, 407–428.

Vaughan-Johnston, T. I., Guyer, J. J., Fabrigar, L. R., Lamprinakos, G., & Briñol, P. (in press). Falling vocal intonation signals speaker confidence and conditionally boosts persuasion. *Personality and Social Psychology Bulletin*.

Wegener, D. T., Petty, R. E., & Smith, S. M. (1995). Positive mood can increase or decrease message scrutiny: the hedonic contingency view of mood and message processing. *Journal of Personality and Social Psychology*, *69*(1), 5.

Wheeless, L. R. (1971). Some effects of time-compressed speech on persuasion. *Journal of Broadcasting, 15*, 415–420.
Woodall, W., & Burgoon, J. K. (1983). Talking fast and changing attitudes: A critique and clarification. *Journal of Nonverbal Behavior, 8*(2), 126–142.