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Speech rate and intelligibility of Arab Airlines' safety instructions

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Abstract

We first analyzed and reported the speech rate (SR) of safety instructions (SIs) for nine Arab airlines, including Saudia, Flynas, EgyptAir, and Oman Air. EgyptAir had the slowest SR and Omani Air the fastest, a statistically significant difference (Kruskal-Wallis, $p < 0.001$). Then, we assessed the impact of normal and accelerated (by 5%, 10%, 15%, and 20%) SR in passenger-boarding noise (-6 dB) on speech intelligibility evaluation. Listeners' ratings demonstrated that intelligibility diminished to 48% at the original SR and to 7% at the 20% accelerated SR and that SR was a statistically significant factor (repeated-measures ANOVA, $p < 0.01$). Arab airlines are advised to consider this finding and consult the International Civil Aviation Organization on the recommended SR.

Keywords: speech rate, speech intelligibility, noise, safety instructions, Arab airlines

Introduction

Within the plentiful scholarship on talker-listener interaction and speech intelligibility, the concept of speech rate (SR) has been examined consistently in numerous studies, yet experiments on SR combined with and/or compared to noise have been conducted only in a few such studies (e.g., Adams & Moore, 2009; Rosenhouse & Kishon-Rabin, 2003; Rosenhouse et al., 2006). The aim of these studies was to probe and understand the impact both of production conditions (i.e., SR) and listening conditions (i.e., noise) separately and collectively on intelligibility. Among such diverse conditions are aircrafts and air traffic control (ATC) towers, which are two critical environments for intelligibility (and safety). Taylor and colleagues (1994) reported that SR exerts a negative impact on aircraft pilots' ability to execute simulated ATC instructions, while Nitta and colleagues (2018) observed that American ATC officers who were native speakers of English did not slow their SR when communicating with nonnative pilots. The current study adds to the existing literature, first, by establishing a baseline for the SR (syllables per second [sps]) of safety instructions (SIs) for nine Arab airlines (e.g., Saudia, Flynas), and, second, by assessing the impact of SR in noise on intelligibility evaluation. The findings should enhance our understanding of the interplay between SR and noise and its pertinence to intelligibility, especially in Arabic, a language that presently suffers a scarcity of studies on speech rate (e.g., Aldholmi et al., 2021a).

Part I: SR analysis of SIs

Methods

We obtained YouTube video clips containing Modern Standard Arabic (MSA) SIs for nine Arab airlines (Saudia [S], Flynas [N], Qatar Airways [Q], Oman Air [O], Etihad Airways [Et], Emirates Airlines [Em], EgyptAir [Eg], Royal Jordanian [J]) and Royal Air Maroc [M], representing four major Arabic varieties: Arabian Peninsula (Gulf), Egypto-Sudanic, Levantine, and Maghrebi Arabic. We made efforts to select only clips that appeared to be original, complete, and unnoisy. We then extracted .WAV audio from each clip, segmented and syllabified the sentences, and removed long pauses. The pause removal process was based on a criterion of 200 ms and guided by pause classification and methodological consideration in previous research (e.g., Sakamoto et al., 2018; Tanka et al., 2011). Finally, SR was calculated according to the equation below.

$$\text{Equation 1. } SR \text{ (sps)} = \frac{\# \text{ of syllables}}{\text{Utterance Duration (seconds)} + \text{Pauses (200 ms or less)}}$$

Results

The analysis of 485 sentences containing SIs yielded that EgyptAir had the slowest SR (*Median* = 5.8 sps, *Mean* = 5.8 sps) whereas Omani Air had the fastest (*Median* = 7.1 sps, *Mean* = 6.9 sps). The SR medians for the other airlines (Figure 1A) ranged between 6.0 sps (*Mean* = 5.9) and 6.7 sps (*Mean* = 6.9). A Kruskal-Wallis test showed a statistically significant difference between the medians for all airlines, $H(8) = 91.495$, $p < 0.001$. As shown in Figure 1B, the pairwise comparisons revealed (a) that all differences among Gulf airlines, with the exception of the difference between Oman Air and Qatar Airways, were not statistically significant, $p > 0.05$; and (b) that the statistically significant differences occurred between EgyptAir or Royal Air Maroc and most other airlines, $p < 0.05$, but not between EgyptAir and Royal Air Maroc, $p > 0.05$.

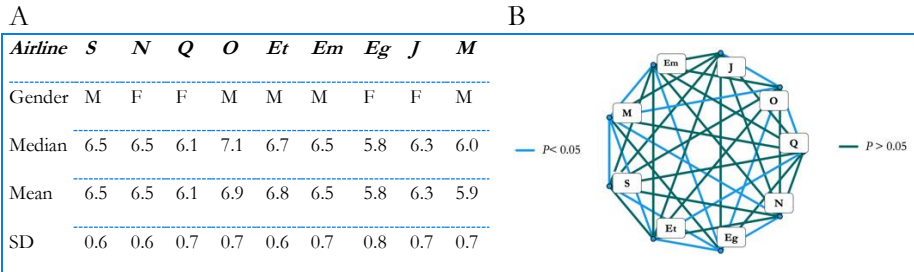


Figure 1. (A): Gender of talker and median, mean, and SD of SR for all airlines (B): Pairwise comparisons (B) between airlines (*note: each node shows a SR median*).

Part II: SR and intelligibility of SIs in Noise

Methods

Twenty imperative SIs were randomly selected from the Saudi Airlines (Saudia's in a male voice and Flynas's in a female voice) and aurally presented in a random order to 54 Saudi participants at the original SR (6.5 sps) and at an accelerated rate of the just-noticeable-difference (JND) level 5% (see Quené, 2007) as well as accelerations by 10%, 15%, and 20%. As in similar previous studies (e.g., Aldholmi, 2021b), the PSOLA (Pitch-Synchronous Overlap-and-Add) feature in Praat (Boersma & Weenink, 2022) was used for the acceleration process. All sentences were first normalized at 60 dB and then mixed with a passenger-boarding noise at -6 dB and resampled at 44100 hz. Fifty-four (22 male and 32 female) Saudi native speakers of Arabic (age, $Mean = 30.6$ $SD = 6.8$) used the online platform *Phonic* (Phonic, 2022) to rate the intelligibility of each sentence on a scale from zero to 100 (zero = completely unintelligible, 100 = completely intelligible). The participants were allowed to listen to each stimulus as many times as they wished, but no sentence appeared in more than one condition to each participant.

Results

The results showed that, in the simulated aircraft boarding noise, (a) the intelligibility diminished to 48% at the original SR and to 7% at the 20% accelerated SR (Figure 2B) and (b) that SR was a statistically significant factor (repeated-measures ANOVA, $F[2.9] = 52.6$, $p < 0.01$) in intelligibility rating. Pairwise multiple comparisons revealed that the differences between every two pairs of SR conditions were statistically significant, $p < 0.05$, with the exception of the comparison between 15% Acc and 20% Acc, $p = 0.847$ (Figure 2A).

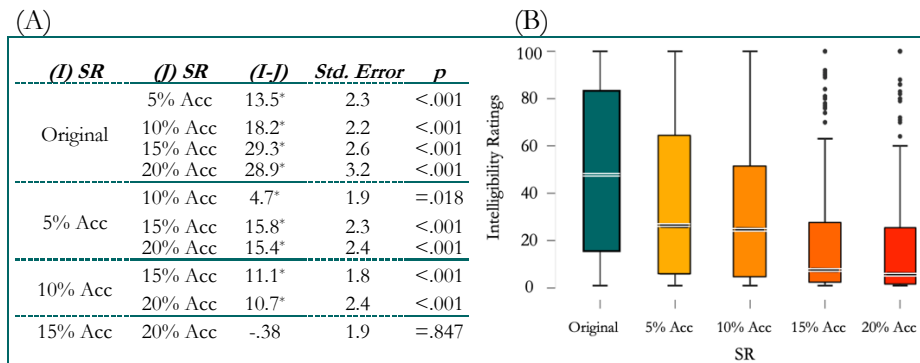


Figure 2. (A): Pairwise comparisons for all SR conditions (normal, 5%, 10%, 15%, and 20%), (B): Intelligibility ratings for all SR conditions.

Conclusion

Most Arab airlines seem to have a fast SR, especially considering that SIs are meant for both native and nonnative passengers. Most SR medians exceeded the average reported for Saudi, Egyptian, and Moroccan dialects (e.g., Aldholmi et al., 2021b; Vaane, 1982). A median SR of 6.1 sps for English ATC officers has been described as a worrying and unsafe SR (Nitta et al., 2018). The results also showed that a slight increment in SR coupled with noise can lead to a large decrement in intelligibility rating. Should Arab airlines be apprised of this finding, they should consult the International Civil Aviation Organization on the recommended SR and collaborate on further research in this regard.

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