The Effects of Familiarity with a Voice on Speech Perception.

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Introduction

In this report, we review progress in an on-going investigation into the relationship between mechanisms of voice identification, talker normalization, and word recognition.

The variability that exists between talkers presents a substantial problem to theories of speech perception, as well as speech recognition by machines. Because of physiological differences (e.g., vocal tract length, head size, age, sex), social differences (e.g., differences in accent), the way different talkers produce the same speech sound may differ acoustically, and the way they produce different speech sounds may be very similar acoustically. Despite this variability, people seem to effortlessly match the acoustic signals to the proper linguistic percepts.

However, careful experimental designs reveal that people are more efficient (faster and/or more accurate) at speech perception tasks when they listen to only one talker than when they listen to two or more talkers in random alternation. For example, Kato and Kakehi [1] have demonstrated that accuracy gradually increases in transcribing speech when the talker is kept constant, and drops off sharply when the talker changes. Nusbaum and Morin [2] have presented subjects with vowels, CV and CVC syllables, and words in a speeded-target monitoring task; in two talker-variability conditions: in the blocked-talker condition, all stimuli were produced by a single talker; in the mixed-talker condition, utterances from at least two talkers were presented in random order. Subjects were consistently slower (by approximately 25 ms) to respond in the mixed-talker condition than in the blocked-talker condition for each sort of stimulus. This “normalization effect” is thought to result from the time it takes to compute a representation of talker characteristics which enables appropriate mappings from acoustics to percepts. When the talker does not change, the representation is held in working memory and can be referenced more efficiently than talker characteristics could be recomputed for every sample of speech, which results in a performance advantage in the blocked-talker condition. In other words, given a constant context of talker characteristics, listeners can “tune” to a talker and constrain the amount of processing necessary for recognition.

If the representations of talkers stored in long-term memory for talker identification are compatible with the (hypothesized) process of contextual tuning, we might expect that those representations could be referenced in less time than it takes to compute a representation for talker normalization. A listener might be able to avoid recomputing talker characteristics when the talker changes from one highly familiar talker to another. This possibility motivated Experiment 1.

Experiment 1: Normalization

The stimuli for all three experiments were drawn from the same database. We recorded two parents and one or two children from seven Japanese families reading lists of Japanese moras (consonant-vowel sequences). Adults and older children read a list of 100 moras. Younger children read a 45 item subset of the full list.

Both adults from six of the seven families recorded participated in Experiment 1. All of the subjects were native speakers of Japanese with no history of hearing or speech disorders.

We used the monitoring paradigm described by Nusbaum and Morin (1992). A speeded-target monitoring task was used and hit rate, false alarm rate, and response times were calculated. Subjects were presented with an orthographic (hiragana) representation of a target mora on a computer display and were instructed to press a response button whenever they heard the mora they saw on the screen.

Each subject listened to four talkers in a blocked-talker condition, in which all targets and distractors in each trial were produced by a single talker. The four talkers were a familiar adult (the subject’s spouse), a familiar child (the subject’s child), and an unfamiliar adult and an unfamiliar child. Each subject also listened to every possible pairing of the four talkers in a mixed-talker condition, where half the targets and distractors were produced by each of two talkers and randomly ordered.

Results

Although there were no reliable differences in hit rates (above 94% in all conditions) or false-alarm rates (below
3 Experiment 2: Talker Identification

The lack of an advantage for familiar versus unfamiliar talkers, and the typical normalization effect for a monitoring task (slower RT in mixed than blocked condition) for unfamiliar and familiar talkers may be due to the fact that the stimuli were so short (on the order of a few hundred ms) that subjects would not have been able to identify the familiar talkers.

In Experiment 2, ten of the subjects who participated in Experiment 1 were first familiarized with the voices of two new unfamiliar adults and two new unfamiliar children. This familiarization was followed by training on the four unfamiliar talkers, practice at identifying all six talkers (familiar and unfamiliar), and a talker-identification test.

Subjects learned to identify the new unfamiliar talkers fairly well based on training with relatively few (30) mora tokens (M = 80%). Performance for familiar talkers was also high (M = 92%). This suggests that the use of relatively short stimuli should not have been the cause of the lack of familiarity effects in Experiment 1.

4 Experiment 3: Talker Identification and Mora Transcription

In Experiment 3, we tested the possibility that subjects could use knowledge about talkers in a higher-level task than the one we used for Experiment 1. Because several weeks elapsed between Experiments 2 and 3, subjects were refamiliarized with the unfamiliar talkers they had been trained to identify in Experiment 2. Subjects were then tested in their ability to identify the six talkers they had been tested on in Experiment 2.

Following the identification task, subjects were asked to transcribe moras produced by three different pairs of talkers: highly-familiar talkers (the familiar adult and child from Experiments 1 and 2); trained-on talkers (one pair of unfamiliar talkers they had been trained to identify in Experiment 2); and exposed-to talkers (the unfamiliar adult and child from Experiment 1, that subjects had never been asked to identify). In addition, stimuli were presented in two talker conditions, as in Experiment 1: blocked and mixed.

In order to avoid ceiling effects on accuracy, we made the stimuli for mora identification noisy by randomly selecting 10% of the samples of each stimulus and changing the signs of the values of these samples. This resulted in a sufficient level of degradation that the stimuli were moderately difficult to identify.

Following the transcription task, subjects’ ability to identify the six talkers used in Experiment 2 was tested again.

4.1 Results

In figure 2, accuracy in the three voice identification tests are compared. Accuracy on family talker pairs did not improve from test-to-test since it was initially very high. By the time of the posttest in Experiment 3, accuracy on the unfamiliar talker pairs was approaching that on the familiar talkers.

An ANOVA revealed that subjects were significantly
more accurate in the mora transcription task when stimuli were blocked by talker (M=66%) than when the talker changed randomly from trial to trial (M=55%; F(1,9)=5.42, p<.05; see Figure 3).

The effect of familiarity was also significant (F(2,18)=3.64; p<.05). Subjects were more accurate at identifying moras produced by their family members (M=68%) than unfamiliar adults they had been trained to identify (M=58%) and talkers they had heard before but had not been trained to identify (M=49%; see Figure 3).

5 Summary

The three experiments discussed here show that, although representations of highly-familiar talkers in long-term memory facilitate accuracy and speed of talker identification, as well as accuracy at identifying speech in noise, those representations cannot be referenced in order to circumvent the response-time effect resulting from talker variability examined in Experiment 1.

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REFERENCES