Patterns of Misperception of Arabic Consonants

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7 February 2015

1 Introduction

1.1 Misperception Experiments

- Previous work has shown a range of influences on consonant misperception, such as listeners' native language (e.g. Cutler et al. 2004), consonants' position in the syllable (e.g. Wang and Bilger 1973), and types of masking noise (e.g. van Phatak, Lovitt, and Allen 2008).
- Can patterns of misperception among oral consonants be extrapolated to guttural consonants (uvulars, pharyngeals, and glottals)? Data on consonant discrimination in Arabic (e.g. Kishon-Rabin and Rosenhouse 2000) and the phonological characteristics of gutturals (cf. McCarthy 1994) suggest that they will pattern differently.
- While there have been studies on misperception of illicit structures (e.g. Dupoux et al. 1999), there have not, to my knowledge, been studies on the patterns of misperception that occur in identification of licit structures; this study investigates such patterns.

1.2 Implications of Misperception Patterns

- The patterns of which sounds are confused most frequently and how noise type influences identification provide evidence for the cues which listeners are using to identify sounds.
- There are parallels between misperception of sounds and sequences in laboratory experiments and attested historical changes (Blevins and Garrett 2004); patterns of synchronic misperception can provide evidence for possible pathways of listener-driven change (Cf. Ohala 2003).

2 Experiment Design

2.1 Participants

There were two groups of participants: (1) Native speakers of Levantine Arabic who spent the majority of their childhood in a country where Arabic was the primary language, and (2) Native speakers of English who have been studying Arabic for at least 4 months.

2.2 Stimuli

Stimuli were nonce words produced in Modern Standard Arabic (MSA) by native speakers of Arabic. Syllable shapes were CV, ʔVC, ʔVRC, ʔVRV, and ʔVRVC, where R is each of the liquids (l, r); the initial vowel and word final vowel was a long vowel of each of the contrastive Arabic vowel qualities [i:], [a:], [u:], and the vowel between consonants was [ə].

2.3 Task

- In the main task, listeners saw an array of buttons with nonce words written in the Arabic script and listened to the stimuli (their order randomized within blocks of the same vowel), then clicked the button corresponding to the word which they thought they heard.
- Masking noise of perceptual loudness equal to the stimulus was played simultaneously with the stimuli, in order to increase the difficulty of the task and elicit a higher number of errors. The two noise types were: noise with intensity weighted towards lower frequencies (pink noise) or towards higher frequencies (blue noise).

3 Data and Discussion

In addition to differences in the average accuracy in each group, there were differences in the sounds which were most frequently confused and in the directions of confusion in each group, as well as effects of phonological environment, the consonant's place of articulation, and the type of masking noise; some of these influences interacted with each other.

3.1 Structure Confusions

Table 1: Native Listeners' Structure Identifications (as percents)

stimulus \ item selected	ʔVC	ʔVRC	ʔVRV	ʔVRVC
ʔVC	**96**	3	1	-
ʔVRC	6	**82**	2	10
ʔVRV	4	3	**75**	18
ʔVRVC	-	9	8	**83**

Table 2: Non-native Listeners' Structure Identifications (as percents)

	ʔVC	ʔVRC	ʔVRV	ʔVRVC
ʔVC	**93**	5	1	2
ʔVRC	22	**62**	3	14
ʔVRV	5	12	**64**	19
ʔVRVC	2	24	12	**61**

- Although the rate of misperceptions of structure was lower in the native listener group, the patterns of misperception were similar in both groups. In all instances of a consonant identified as a vowel or a vowel as a consonant, the consonant was a glide or a guttural.
- There was a difference between structural accuracy for words with guttural consonants or without them, which interacted with language background.
  - Native Arabic listeners identified structure with 89% accuracy for words without gutturals and 87% for words with gutturals
  - Non-native listeners identified them with 81% and 70% accuracy, respectively.

3.2 Segment Confusions

Following is a sample of the patterns of consonant identification for both listener groups.

Table 3: Native Listeners' Consonant Confusions as percents)

	r	s	sˤ	t	tˤ	d	k	q	x	ʁ	ħ	ʕ	h	ʔ	∅	other
r	**89**	-	-	-	-	-	-	2	-	3	-	2	-	3	-	1
s	-	**83**	3	4	-	-	1	1	4	1	-	1	2	-	1	-
sˤ	-	10	**90**	-	-	-	-	-	-	-	-	-	-	-	-	-
t	-	-	-	**68**	1	1	14	3	1	2	-	1	3	3	4	-
tˤ	-	-	-	2	**66**	-	-	23	2	-	-	-	-	2	-	5
d	-	-	-	2	-	**86**	1	-	-	3	-	-	-	1	6	1
k	-	-	-	5	4	1	**68**	8	4	2	-	-	2	4	2	-
q	-	-	-	-	3	-	2	**88**	3	-	-	-	-	3	1	-
x	-	-	-	1	1	-	-	1	**87**	1	2	-	5	-	2	-
ʁ	3	-	-	-	-	-	-	4	-	**79**	-	1	2	-	5	6
ħ	-	-	-	-	-	-	-	2	-	-	**84**	3	5	1	4	1
ʕ	-	-	-	-	-	-	1	2	2	2	3	**70**	3	13	4	-
h	-	-	-	1	-	2	-	2	2	1	14	-	**65**	8	3	2
ʔ	-	-	-	1	-	2	-	1	-	1	1	4	4	**78**	3	5
∅	-	-	-	-	-	-	1	1	1	1	-	-	6	5	**85**	-

- In the native listener group, most of the common misperceptions were not strongly paralleled by misperceptions in the opposite direction, e.g. there were 3 times as many cases of [t] identified as [k] than [k] identified as [t].
- The most common misperception error in the native listener group was hearing the voiceless uvularized alveolar stop [tˤ] as the voiceless uvular stop [q].

Table 4: Non-native Listeners' Segment Confusions (as percents)

	r	s	sˤ	t	tˤ	d	k	q	x	ʁ	ħ	ʕ	h	ʔ	∅	other
r	**74**	-	-	-	-	-	1	2	1	15	-	-	1	2	-	4
s	-	**72**	19	5	-	-	-	-	1	-	-	-	-	-	-	3
sˤ	-	41	**55**	2	1	-	-	-	-	-	-	-	-	-	-	1
t	-	1	-	**58**	9	1	7	4	2	-	4	-	1	4	5	4
tˤ	2	-	-	12	**29**	4	1	17	1	4	5	3	3	4	-	15
d	1	-	-	5	2	**62**	1	-	1	3	-	-	1	2	9	13
k	-	-	1	10	1	1	**43**	20	5	1	4	1	1	4	4	4
q	-	-	-	3	2	1	11	**54**	6	7	3	2	-	5	3	3
x	-	1	-	2	1	-	3	3	**60**	4	11	1	3	3	5	3
ʁ	7	-	1	-	1	2	-	2	3	**59**	1	4	5	4	4	7
ħ	1	-	-	3	1	1	1	5	4	1	**38**	4	18	6	11	6
ʕ	2	-	-	-	-	1	2	5	3	2	5	**35**	5	28	11	1
h	1	-	-	2	1	-	1	2	4	4	29	4	**25**	11	12	4
ʔ	-	-	-	2	-	-	3	2	1	2	5	10	3	**56**	14	2
∅	-	-	-	1	-	-	1	-	-	-	1	1	7	6	**83**	-

- Among non-native listeners, there was a stronger correlation between identification of one sound as another and the converse, which may suggest that some errors reflect incomplete learning of phonological boundaries.
- The most common confusions in the non-native group of listeners were between uvularized consonants and their non-uvularized counterparts (e.g. [s] and [sˤ]), and between pharyngeals and glottals (e.g. [h] and [ħ]).

Influences on segment accuracy

- The accuracy of consonant identification was influenced by the phonological environment in both groups of listeners:
  - In both groups of listeners, consonants were more accurately identified in codas (mean accuracy 69%) than in onsets (mean accuracy 66%), and least accurately when following liquids (mean accuracy 60% following /l/; 56% following /r/).
- The accuracy of segment identification differed by the region of the consonantal constriction.
  - Non-native listeners had significantly lower accuracy in identifying guttural consonants (47% correct) than consonants with other places of articulation (68% correct).
  - For native listeners, this difference was not present: guttural consonants were identified with 79% accuracy, while other consonants were identified with 80% accuracy.

- There was an effect of noise type on accuracy of identification; sounds were identified more accurately in higher frequency noise than in lower frequency noise.
  - Native listeners identified consonants with 83% accuracy in high frequency noise and 68% accuracy in low frequency noise.
  - Non-native listeners identified consonants with 64% accuracy in high frequency noise and 52% accuracy in low frequency noise.
  - This effect interacted with place of articulation; guttural consonants seemed to suffer more interference from low frequency (pink) noise than non-guttural consonants did.

Table 5: Accuracy with Noise Type and Consonant Region for Native Listeners (as percents)

	blue	pink
guttural	83	66
non-guttural	84	73

Table 6: Accuracy with Noise Type and Consonant Region for Non-native Listeners (as percents)

	blue	pink
guttural	55	42
non-guttural	73	66

4 Conclusions

- There are differences in the behavior of guttural and non-guttural consonants, so one should be cautious about extrapolating from oral consonant data to guttural consonants.
- The primary cues for consonant identification are more concentrated at lower frequencies, particularly for guttural consonants. Native and non-native listeners may be attending to different cues.
- The patterns of misperception of guttural consonants provide a potential source of information on paths of sound change for some of these rare sounds; the observed directions of misperception do not consistently match up with posited directionality for sound changes.

References

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