



*Finding Phonological Features in Perception*

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## SUMMARY

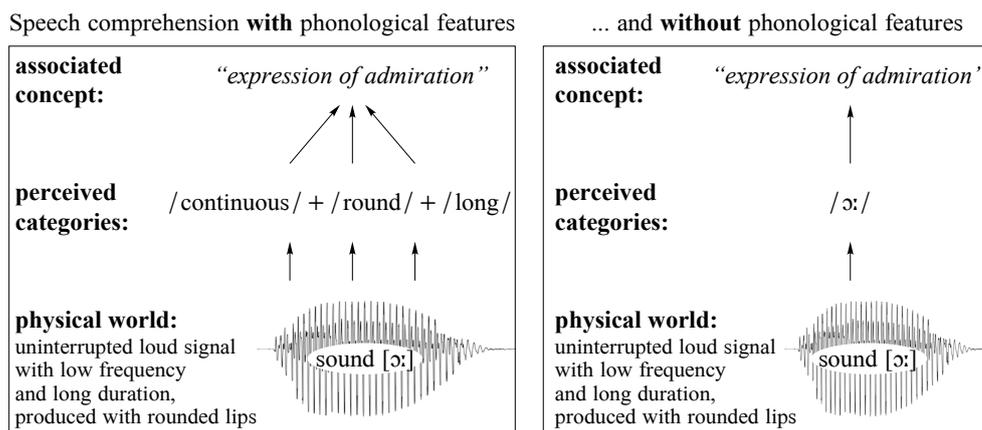
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Most objects in the world around us are associated with abstract concepts. A real-world object is thus a physical realization of an abstract category. For instance, the object pictured on the back cover of this book is associated with the concept “Rubik’s cube”. Also, every physical object has a number of individual properties some of which are contrastive, which means that they differentiate the given object from other objects associated with other concepts. For instance, some of the properties of the object  are: shape of a cube, six different colours, rotating parts.

Speech sounds are like objects. Firstly, speech sounds, or strings of speech sounds, are associated with abstract concepts. A speech sound is thus a physical realization of an abstract category. For instance, the speech sound that is produced by the speaker pictured on the back cover of this book is a single vowel ‘o’ (which phoneticians transcribe as [ɔ:]), and in some languages, it is associated with the concept of “expression of admiration”. Similarly, the vowel [ɔ:] is also found in the string of sounds [dɔ:g], which is, in American English, associated with the concept “a companion animal that barks”. Secondly, every speech sound has a number of individual properties some of which are contrastive, which means that they differentiate the given sound from other sounds associated with other concepts. For instance, the sound [ɔ:] consists of an uninterrupted loud acoustic signal, it is relatively long, it is produced with rounded lips, and it has a considerable amount of energy in low frequencies. The properties of speech sounds that are contrastive are called *phonological features*.

Linguists know what properties are contained in every speech sound because people can be recorded as they speak and their speech sounds can be acoustically analyzed with a computer. However, linguists do not entirely know yet how people actually *listen* to speech sounds. Specifically, it has not yet been shown whether during speech comprehension, listeners recognize each of the contrastive properties of the sound (i.e. the phonological features) individually, or whether listeners immediately recognize the whole sound segment without the need to recognize each of its contrastive features on its own. In this thesis, we aimed to resolve that puzzle and reveal whether phonological features are found in perception. The Figure on the following page illustrates what speech comprehension may look like with and without phonological feature categories.

In order to investigate whether listeners perceive speech sounds through phonological feature categories, and whether they also learn speech sounds



as sets of phonological features, we carried out a number of experiments with human and virtual listeners. Importantly, note that when you play the sound [ɔ:] and ask a listener to tell you what she hears, she will most certainly report hearing an /ɔ:/, that is, she will name the whole speech segment. This is because speech segments have explicit labels, or names, which are known to all speakers of a given language (think of the alphabet, which contains names for most sounds of a given language). On the other hand, phonological features do not have any labels or names that would be known to an ordinary language user. For that reason, it is impossible to ask a listener whether she perceives [ɔ:] in terms of its individual features (i.e. as a category /continuous/ plus a category /round/ plus a category /long/) or whether she perceives it as an unanalyzed segment (i.e. as a category /ɔ:/).

Therefore, in our experiments, instead of straightforwardly asking participants whether they hear phonological features, we used a variety of behavioral, electrophysiological and computational methods that allowed us to uncover how humans process speech. For instance, we tested the perception of sound segments that have no abstract associations and no labels in a given language, but that contain some of the features that are present in the listeners’ native-language sounds. We reasoned that if humans are able to perceptually categorize the unknown sounds in the same way as they categorize their native-language sounds, we have evidence for feature categories in perception.

The results of our experiments indicate that adult listeners indeed perceive speech sounds in terms of phonological feature categories. For instance, a sound like [ɔ:] is perceived in terms of individual feature categories /continuous/ + /round/ + /long/ (as shown in the left panel of the Figure above). An illustration of this result is also provided on the cover of this thesis, where the physical object  is perceived as a set of contrastive features /cube/ + /colours/ + /rotation/.