The SAGE Encyclopedia of Human Communication Sciences and Disorders

Categorical Perception

Contributors: Isabel Falé
Edited by: Jack S. Damico & Martin J. Ball
Book Title: The SAGE Encyclopedia of Human Communication Sciences and Disorders
Chapter Title: "Categorical Perception"
Pub. Date: 2019
Access Date: May 18, 2019
Publishing Company: SAGE Publications, Inc.
City: Thousand Oaks,
Print ISBN: 9781483380834
Online ISBN: 9781483380810
DOI: http://dx.doi.org/10.4135/9781483380810.n108
Print page: 321

Categorical perception (CP) is a cognitive phenomenon through which a person's perceptual system perceives sensory changes in a continuum of stimuli as discrete categories. Categorization by itself is a fundamental cognitive human activity that allows one to comprehend and predict events and objects in the world. This phenomenon points to the tendency humans have to understand the world through the categories they have shaped.

CP functions in the connection of human's higher level conceptual and lower level perceptual systems. It is widely accepted that perception precedes conceptualization. In fact, people need the data brought to them by their *perceptual* systems in order to encode them into categories within their *conceptual* systems. However, CP reveals the existence of a bidirectional interplay between those systems.

It is still unclear whether this cognitive phenomenon results from learning or whether it is innate, in terms of a neurological predisposition for such, or both. For instance, according to Patricia Kuhl's studies, exposure to a language alters adult and infant perception. Language environment provides information that formats perception areas of sound categories, dismissing those areas that are not used for categories that will progressively lose sensitivity to sound discrimination. In a certain way, the acquisition of sound categories also means a loss in the ability to discriminate sound. However, this apparent loss can be altered by experience—namely, by learning a new language.

Alvin Liberman and his colleagues were the first to report this cognitive ability in an experiment that turned out to be a classic in speech perception studies. According to this experiment, listeners were shown to be able to classify and discriminate (stop) consonant–vowel stimuli (CV) along a continuum of gradually increasing changes in the consonant's second-formant (F2) transition. This classic CP experiment was primarily developed to test segmental features perception.

It involved two tests: (a) an identification test, in which stimuli should be classified into categories and (b) a discrimination test, in which a sequence of three stimuli (ABX) were presented, the first two stimuli (AB) being different from one another and the third stimuli (X) being different from or equal to A or B. If the perception was categorical, the peak of discrimination coincided with the category boundary revealed by the identification test. This means that humans are more accurate and faster at discriminating a pair of stimuli that cross a category boundary than a pair of stimuli that belongs to the same category.

The CP experiment paradigm was initially used to distinguish gradual changes along a continuum in very short data (little sound fragments, segments, syllables). However, researchers have tested this research paradigm with longer structures such as words or sentences or longer sound structures. Through the years, researchers have designed and used different versions of the classical paradigm, especially concerning the discrimination tasks and the number of stimuli repetitions that are needed for confident data.

In fact, one of the major problems CP poses refers to the need of testing the same stimulus several times, which can interfere in the experiment participants' attention caused by stimulus repetition. For this reason, CP experiments can test only a small set of stimuli each time. Otherwise, the quantity of stimuli can turn out to be so huge that experiment participants cannot respond to the experiment with attention and accuracy.

CP was primarily reported in color perception and in speech sound perception, but it has also been found in several other domains, such as visual categories—for example, facial expressions. CP effects found in speech stimuli and color were taken as evidence of a special human cognitive ability, which meant that there was, for example, a level of processing that was specific to speech sounds in humans.

Surprisingly, Kuhl found that chinchillas and monkeys also revealed CP, with discrimination and identification boundaries occurring in the same places of human CP boundaries. However, Kuhl did not find particular evidence for prototypes of speech categories in monkeys. Another consideration is the fact that speech sound categorical perception is a natural process that does not imply effort for humans, whereas for animals, it results from a heavy training process.

There are several models of CP. Two of the main approaches adopt opposing perspectives when defining a category: One considers a category to be represented by its prototype; the other argues that a category is defined by its boundaries. In both cases, a CP effect is found. Both of these opposite principles have been developed in computational models.

Prototype models assume that category prototype generation is the result of finding common characteristics shared by category members. So categories are represented considering the most typical element of the category. The categorization process proceeds by matching stimulus to prototypes stored in memory and finding the best match. Boundary models, on the other hand, represent categories by their periphery, not by their center. This approach relies on the fact that sometimes the most effective member of a category is not the prototype but rather a distortion of the prototype that is closer to the category boundary.

These two approaches have been researched in several experimental studies, but empirical results vary. Some studies reported good discrimination near a prototype, supporting the prototype model. Other studies observed that sensitivity peaks related with CP depend on the presence of salient cues at boundary, supporting boundary models. In fact, empirical results point to evidences that argue in favor of the idea that rather than being opposite, these models may be complementary: One of the models considers the center of a category and the other its periphery.

See also Auditory Phonetics; Cognitive Processes and Operations; Language Acquisition; Phonetics; Speech Perception, Theories of

Isabel Falé
http://dx.doi.org/10.4135/9781483380810.n108
10.4135/9781483380810.n108

Further Readings

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