

Categorical perception of voicing, colors and facial expressions: A developmental study

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Abstract

The aim of the present paper was to compare the development of perceptual categorization of voicing, colors and facial expressions in French-speaking children (from 6 to 8 years) and adults. Differences in both categorical perception, i.e. the correspondence between identification and discrimination performances, and in boundary precision, indexed by the steepness of the identification slope, were investigated. Whereas there was no significant effect of age on categorical perception, boundary precision increased with age, both for voicing and facial expressions though not for colors. These results suggest that the development of boundary precision arises from a general cognitive maturation across different perceptual domains. However, this is not without domain specific effects since we found (1) a correlation between the development of voicing perception and some reading performances and (2) an earlier maturation of boundary precision for colors compared to voicing and facial expressions. These comparative data indicate that whereas general cognitive maturation has some influence on the development of perceptual categorization, this is not without domain-specific effects, the structural complexity of the categories being one of them.

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1. Introduction

Since its first theorization by Liberman et al. (1957) categorical perception has been a central notion in psychophysics and cognitive psychology. Psychophysicists have begun to study the relation between the physical parameters of the stimulus and its concomitant sensation and

psychologists have emphasized the fact that by transforming physical sensations into discrete representations, categorical perception constitutes an economical way to process the flow of information present in the environment (Snowdon, 1987).

According to the original definition, there is categorical perception (CP) when discrimination between stimuli depends on their identification into different categories (Liberman et al., 1957). Another categorical property resides in the occurrence of a response non-linearity around a category boundary. The degree of nonlinearity, or boundary precision (BP), can be evaluated either by measuring the steepness of the identification function around the perceptual boundary (the steeper the identification

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function, the greater the precision, Simon and Fourcin, 1978) or by measuring the size of the discrimination peak around the phoneme boundary (the larger the peak, the greater the precision, Wood, 1976). Although some minimal amount of response non-linearity is a prerequisite for CP (Schouten et al., 2003), these two properties are fairly independent (for a review see: Damber and Harnad, 2000). Fig. 1 schematically illustrates how the independent variation of CP and BP can lead to various levels of categorical performance.¹ In addition to CP and BP measures, the *location* of the boundary is also of interest in a developmental context. When only discrimination responses are collected, which is often the case in pre-linguistic children, the location of the discrimination peak indicates whether their categorical responses are organized around the adult boundaries in the environmental language.

1.1. Categorical perception development

Different studies have claimed an effect of age on the categorical perception of speech sounds. However, a closer look at the available evidence makes it clear that it does not concern CP but rather the location and the precision of the perceptual boundaries (see Table 1 for a summary). It is now accepted that during the first year of life, infants move from a language-general to a language-specific mode of perception and that the location of the perceptual boundaries changes accordingly (for a review see: Hoonhorst et al., 2009a). Whereas during the first months of life babies discriminate voicing contrasts according to the -30 and $+30$ ms language-general VOT boundaries (Aslin et al., 1981), they soon become specialists in their native language(s) by adopting the phonological boundary/ies relevant to the language(s) spoken in their environment (e.g. 0 ms VOT in French: Serniclaes, 1987). It is also fairly clear from different studies that there is an increase in BP which extends well after one year of age and is still not complete at the end of childhood. Contrary to the location and the precision of perceptual boundaries, CP does not progress during this period (Medina and Serniclaes, 2009) and there even seems to be a *decrease* in CP between childhood and adulthood (Elliott, Longinotti, Meyer, Raz & Zucker, 1981; see Table 1).

To summarize, whereas it has been demonstrated that both the location and precision of the boundaries change with age, little is known about the development of CP because most of the previous studies did not compare discrimination and identification. The first purpose of the present study was to collect further evidence on the possible effect of age on CP.

¹ Notice that not only the location of the discrimination peak but also its magnitude might depend on the task. Therefore, the most general BP criterion is the slope of the identification function or the expected discrimination peak which is related to the slope. It is only when there is no significant difference between the observed and expected discrimination scores that both scores can be jointly used for assessing BP.

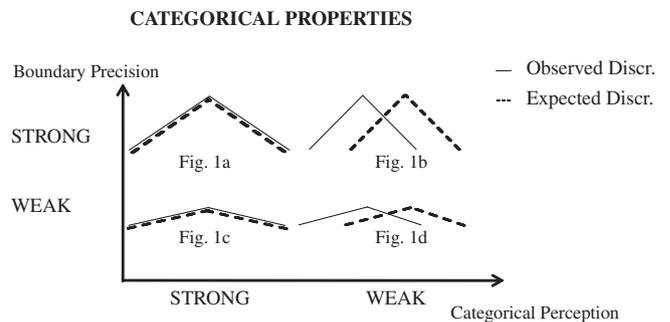


Fig. 1. Categorical perception properties. Boundary precision (BP) is larger when the discrimination peaks are larger (compare a with c and b with d). Categorical perception (CP) is larger when the match between observed and expected discrimination curves is better (compare a with b and c with d).

1.2. Influence of reading on categorical development

The second question raised in this paper concerned the influence of reading on the late development of speech perception. According to the *reading hypothesis* (Burnham, Earnshaw & Clark, 1991, Burnham, 2003), “the intensification of language speech perception between two and 6 years is related to the onset of reading instruction” (Burnham, 2003, p. 573). This hypothesis is supported by data on the identification of the -30 ms prevoiced/voiced contrast, which is phonemic in Thai but not in English. English-speaking children who started learning to read at 6 years are more sensitive to this foreign contrast than those starting to read earlier, at the age of 5 years (Burnham, 2003). These results suggest that reading experience sharpens the identification of native contrasts at the expense of the non-native ones, i.e., that reading experience improves BP. However, as sensitivity was only assessed with identification data, it cannot be inferred from these results that reading experience affects CP because the latter depends on the relationship between identification and discrimination.

Another hypothesis has been proposed to account for perceptual development; *the general cognitive hypothesis* defended by Lalonde and Werker (1995). In their study (Lalonde and Werker, 1995), 8–10-month-old babies showed a synchronous change in a native vs. non native linguistic discrimination task, a visual categorization task and an object search task, a result which led Lalonde and Werker to conclude that speech perception development is underlined by a maturation of general cognitive competences. This hypothesis led us to explore the perception of different perceptual continua, namely those of voicing, color and facial expression continua.

Data on *color perception* mimic those found with VOT. Non-linearity in color perception has been demonstrated in adults whatever their spoken language (Franklin et al., 2005), in 4-month-old infants (Bornstein et al., 1976) and animals (bees: Von Frisch, 1964; pigeons: Wright and Cumming, 1971; monkeys: Sandell et al., 1979). However, these results have to be interpreted with caution because other data show that color categories are not genetically

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