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Categorical perception of affective and linguistic facial expressions

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ABSTRACT

Two experiments investigated categorical perception (CP) effects for affective facial expressions and linguistic facial expressions from American Sign Language (ASL) for Deaf native signers and hearing non-signers. Facial expressions were presented in isolation (Experiment 1) or in an ASL verb context (Experiment 2). Participants performed ABX discrimination and identification tasks on morphed affective and linguistic facial expression continua. The continua were created by morphing end-point photo exemplars into 11 images, changing linearly from one expression to another in equal steps. For both affective and linguistic expressions, hearing non-signers exhibited better discrimination across category boundaries than within categories for both experiments, thus replicating previous results with affective expressions and demonstrating CP effects for non-canonical facial expressions. Deaf signers, however, showed significant CP effects *only* for linguistic facial expressions. Subsequent analyses indicated that order of presentation influenced signers' response time performance for affective facial expressions: viewing linguistic facial expressions first slowed response time for affective facial expressions. We conclude that CP effects for affective facial expressions can be influenced by language experience.

1. Introduction

In his book "The expression of the emotions in man and animals", Darwin (1872) noted that Laura Bridgman, a woman who was born deaf and blind, was able to spontaneously express a wide range of affective facial expressions that she was never able to observe in others. This case was one of the intriguing arguments Darwin put forth in support of the evolutionary underpinnings of facial expressions in humans. Since then, an extensive body of research, including seminal cross-cultural studies by Ekman and colleagues (Ekman, 1994; Ekman & Friesen, 1971; Ekman et al., 1987), has provided empirical support for the evolutionary basis of affective facial expression production. Yet, the developmental and neural mechanisms underlying the perception of facial expressions are still not fully understood. The ease and speed of facial expression perception and categorization suggest a highly specialized system or systems, which prompt several questions. Is the ability to recognize and categorize facial expressions innate? If so, is this ability limited to affective facial expressions? Can the perception of affective facial expressions be modified by the experience? If so, how and to what extent? This study attempts to elucidate some of these questions by investigating categorical perception for facial expressions in Deaf[1] users of American Sign Language – a population for whom the use of facial expression is required for language production and comprehension.

Categorical perception (CP) is a psychophysical phenomenon that manifests itself when a uniform and continuous change in a continuum of perceptual stimuli is perceived as discontinuous variations. More specifically, the perceptual stimuli are seen as qualitatively similar

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[1] By convention, uppercase Deaf is used when the use of sign language and/or membership in the Deaf community is at issue, and lower case deaf is used to refer to audiological status.

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within categories and different *across* categories. An example of categorical perception is the hue demarcations in the rainbow spectrum. Humans with normal vision perceive discrete color categories within a continuum of uniform linear changes of light wavelengths (Bornstein & Korda, 1984). The difference between green and yellow hues are more easily perceived than the different hues of yellow, even if the change distances in the wavelength frequencies are exactly the same. Livingston, Andrews, and Harnad (1998) argued that this phenomenon is a result of compression (differences among stimuli in the same category are *minimized*) and expansion (stimuli differences among categories are *exaggerated*) in the perceived stimuli relative to a perceptual baseline. The compression and expansion effects may reduce the continuous perceptual stimuli into simple, relevant, and manageable chunks for further cognitive processing and concept formation.

Recently, several studies have indicated that linguistic category labels play a role in categorical perception (Gilbert, Regier, Kay, & Ivry, 2006; Roberson, Damjanovic, & Pilling, 2007; Roberson, Pak, & Hanley, 2008). Roberson and Davidoff (2000) found that verbal interference eliminates CP effects for color, although this effect was not observed when participants were unable to anticipate the verbal interference task (Pilling, Wiggett, Özgen, & Davies, 2003). Roberson et al. (2008) found CP effects for Korean, but not for English speakers for color categories that correspond to standard color words in Korean, but not in English. Roberson et al. (2007) propose that linguistic labels may activate a category prototype, which biases perceptual judgments of similarity (see also Huttenlocher, Hedges, & Vevea, 2000).

Investigation of the CP phenomenon in various perceptual and cognitive domains has provided insights into the development and the working of mechanisms underlying different cognitive processes. For example, our understanding of cognitive development in speech perception continues to evolve through a large body of CP studies involving voice-onset time (VOT). VOT studies have shown that English listeners have a sharp phoneme boundary between /ba/ and /pa/ sounds which differ primarily in the onset time of laryngeal vibration (Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Liberman, Harris, Hoffman, & Griffith, 1957). Other variants of speech CP studies have shown that 6-month-old infants can easily discern speech sound boundaries from other languages not spoken by their families. For example, infants from Japanese speaking families can distinguish /l/ and /r/ sounds, which are difficult for adult speakers of Japanese to distinguish; however, when they reach 1 year of age, this ability diminishes (Eimas, 1975). Bates, Thal, Finlay, and Clancy (2003) argue that the decline of ability to discern phonemic contrasts that are not in one's native language neatly coincides with the first signs of word comprehension, suggesting that language learning can result in low-level perceptual changes. In addition, Iverson et al. (2003) used multi-dimensional scaling to analyze the perception of phonemic contrasts by Japanese, German, and American native speakers and found that the perceptual sensitivities formed within the native language directly corresponded to group differences in perceptual saliency for within- and between category acoustic variation in English /r/ and /l/ segments.

Similar effects of linguistic experience on categorical perception have been found for phonological units in American Sign Language (ASL). Using computer generated continua of ASL hand configurations, Emmorey, McCullough, and Brentari (2003) found that Deaf ASL signers exhibited CP effects for visually presented phonologically contrastive handshapes, in contrast to hearing individuals with no knowledge of sign language who showed no evidence of CP effects (see Brentari (1998), for discussion of sign language phonology). Baker, Isardi, Golinkoff, and Petitto (2005) replicated these findings using naturally produced stimuli and an additional set of contrastive ASL handshapes. Since categorical perception occurred only for specific learned hand configurations, these studies show that CP effects can be induced by learning a language in a different modality and that these effects emerged independently of low-level perceptual contours or sensitivities.

1.1. Categorical perception for facial expression

Many studies have found that affective facial expressions are perceived categorically when presented in an upright, canonical orientation (Calder, Young, Perrett, Etcoff, & Rowland, 1996; Campanella, Quinet, Bruyer, Crommelinck, & Guerit, 2002; de Gelder, Teunisse, & Benson, 1997; Etcoff & Magee, 1992; Herpa et al., 2007; Kiffel, Campanella, & Bruyer, 2005; Roberson et al., 2007). Campbell, Woll, Benson, and Wallace (1999) undertook a study to investigate whether CP effects for facial expressions extend to learned facial actions. They examined whether Deaf signers, hearing signers, and hearing nonsigners exhibited CP effects for syntactic facial expressions marking yes–no and Wh-questions in British Sign Language (BSL) and for similar affective facial expressions: surprised and puzzled. Syntactic facial expressions are specific linguistic facial expressions that signal grammatical contrasts. Yes–no questions in BSL (and in ASL) are marked by raised brows, and Wh-questions are marked by furrowed brows. Campbell et al. (1999) found no statistically significant CP effects for these BSL facial expressions for any group. However, when participants from each group were analyzed individually, 20% of the non-signers, 50% of the Deaf signers, and 58% of the hearing signers demonstrated CP effects for BSL syntactic facial expressions. Campbell et al. (1999) suggested that CP effects for BSL expressions may be present but weak for both signers and non-signers. In contrast, all groups showed clear CP effects for the continuum of surprised-puzzled facial expressions.

Campbell et al. (1999) acknowledged several possible methodological problems with their study. First, the groups differed significantly in the age at which BSL was acquired. The mean age of BSL acquisition was 20 years for the hearing signers and 7 years for the Deaf signers. Several studies have shown that the age when sign language was acquired is critical and has a lifelong impact on language proficiency (e.g., Mayberry, 1993; Newport, 1990). Second, and perhaps more importantly, only six images were used to create the stimuli continua (two end-points and four intermediates). With such large steps