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Vowels, then consonants: Early bias switch in recognizing segmented word forms

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ABSTRACT

The *division of labor* hypothesis proposed by Nespor, Peña, and Mehler (2003) postulates that consonants are more important than vowels in lexical processing (when learning and recognizing words). This consonant bias (C-bias) is supported by many adult and toddler studies. However, some cross-linguistic variation has been found in toddlerhood, and various hypotheses have been proposed to account for the origin of the consonant bias, which make distinct predictions regarding its developmental trajectory during the first year of life. The present study evaluated these hypotheses by investigating the consonant bias in young French-learning infants, a language in which a consistent consonant bias is reported from 11 months of age onward. Accordingly, in a series of word form segmentation experiments building on the fact that both 6- and 8-month-old French-learning infants can segment monosyllabic words, we investigated the relative impact of consonant and vowel mispronunciations on the recognition of segmented word forms at these two ages. Infants were familiarized with passages containing monosyllabic target words and then tested in different conditions all including consonant and/or vowel mispronunciations of the target words. Overall, our findings reveal a consonant bias at 8 months, but an opposite vowel bias at 6 months. These findings first establish that the consonant bias emerges between 6 and 8 months of age in French-learning infants. Second, we discuss the factors that might explain such a developmental trajectory, highlighting the possible roles of pre-lexical and phonological acquisition.

1. Introduction

Consonants and vowels are two basic phonological categories found in all languages (Ladefoged, 2001) and these two categories can be distinguished at many levels. First, consonants are cross-linguistically more numerous than vowels: the majority of languages have more than 20 consonants while five vowel systems are the most common. Systems having more vowels than consonants, such as Swedish or Danish are very rare (Ladefoged & Maddieson, 1996; Maddieson, 1984). Second, these two categories differ at the acoustic level: vowels tend to be longer, more stable (corresponding to steady state portions of the speech signal) and have more energy than consonants (Ladefoged, 2001; Repp, 1984). This makes them more easily perceivable *in utero* (Granier-Deferre, Ribeiro, Jacquet, & Bassereau, 2011), leading to greater experience with vowels compared to consonants even by birth. However, consonant contrasts appear to be overall more discriminable than vowel contrasts when normalized for duration and intensity (Bouchon, Floccia, Fux, Adda-Decker, & Nazzi, 2015). Third, adult research shows that at the perceptual level, consonants are processed more categorically (Fry, Abramson, Eimas, & Liberman, 1962) and faster than vowels (Vergara-Martínez, Perea, Marín, & Carreiras, 2011) and seem to activate different brain areas (Caramazza, Chialant, Capasso, & Miceli, 2000; Carreiras & Price, 2008). Fourth, while infants initially discriminate native and non-native phoneme contrasts (for a review, see Kuhl, 2004), they start acquiring their native vowel inventory around 6 months of age (Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992; Polka & Werker, 1994), but it is generally considered that infants start acquiring their native consonant inventory (Werker & Lalonde, 1988; Werker & Tees, 1984) around 10–12 months of age (though see Hoonhorst et al., 2009, for evidence of acquisition of a consonant contrast by 8 months in French-learning infants).

1.1. The functional division of labor hypothesis

Since the earliest evidence of word comprehension is found around 6 months (Bergelson & Swingley, 2012; Tincoff & Jusczyk,

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1999, 2012), many studies have investigated the link between early phonological and lexical acquisition by exploring the way infants recruit their early perceptual capacities, especially their ability to perceive and process consonant and vowel contrasts, in lexical processing. The differences between consonants and vowels outlined above have led Nespor, Peña, and Mehler (2003) to propose a functional 'division of labor' that could facilitate infants' acquisition of their native language. Of importance for the present study, this hypothesis proposed a consonant bias (C-bias) at the lexical level: consonants would be more involved in learning and recognizing words than vowels (which are proposed to be more involved at the prosodic and syntactic levels). The present study will investigate the role of the C-bias in recognizing segmented word forms in order to specify its developmental origin.

1.2. Evidence of a C-bias in lexical processing in adulthood

Many studies on adults have explored the consonant/vowel functional asymmetry, and found evidence of a greater reliance on consonants over vowels at the lexical level, hence a lexically-related C-bias, in tasks tapping written and oral lexical access (Acha & Perea, 2010; Cutler, Sebastián-Gallés, Soler-Vilageliu, & van Ooijen, 2000; Delle Luche et al., 2014; New, Araújo, & Nazzi, 2008; New & Nazzi, 2014; Van Ooijen, 1996), word segmentation (Bonatti, Peña, Nespor, & Mehler, 2005; Toro, Nespor, Mehler, & Bonatti, 2008) and word learning (Creel, Aslin, & Tanenhaus, 2006; Havy, Serres, & Nazzi, 2014). Some of these studies, carried out by Van Ooijen (1996) and Cutler et al. (2000) with English, Spanish and Dutch adults, showed a C-bias in lexical tasks: subjects were presented with non-words and each could be changed into a real word by substitution of a single consonantal or vocalic phoneme. The subjects were asked to press a response key as soon as they had thought of a real word substitution. Results showed that listeners in all 3 languages found it easier to create a real word by altering a vowel than by altering a consonant. Moreover, they were faster and more accurate when they were constrained to do a vowel substitution as opposed to a consonant substitution. These results established that adults prefer to change a vowel rather than a consonant to find a word; hence preserved consonant information was more important than preserved vowel information. More recently, Delle Luche et al. (2014) tested French and English adults using an oral lexical decision task providing more direct, online evidence. Different priming conditions were used: consonant-related, vowel-related and unrelated conditions. In the consonant-related condition, the prime and the target words shared the consonants while the vowels were minimally changed (e.g., /k**e**ʁø/ - /k**a**ʁ**o**/). In the vowel-related condition, the prime and the target shared the vowels while the consonants were minimally changed (e.g., /**g**a**ʒ**o/ - /**k**aʁo/). In the unrelated condition, the prime and the target words shared no phoneme (e.g., /geʒø/ - /kaʁo/). English and French subjects were evaluated on their priming effect (facilitation effect showed by faster reaction times) in the different conditions. Results showed that, overall, both English- and French-listeners had a larger priming effect in the consonant-related condition than in the vowel-related condition. These findings demonstrate that consonants are given more weight than vowels in accessing lexical representations, resulting in a C-bias in processing words. Taken together, and since this consonant advantage was found in various languages (French, English, Italian, Spanish…), the above studies suggest that the C-bias might be present cross-linguistically (although more languages should be tested).

1.3. Initial evidence of a C-bias in early lexical processing in French

In this context, many studies have explored the C-bias in toddlers during the second year of life, in order to determine its origin and specify potential changes in how consonants and vowels are processed during development. One of the first studies was conducted in French by Nazzi (2005) and used an interactive word learning task, namely the name based categorization (NBC) task. In this study, French-learning 20-month-olds were presented with triads of new objects, two of the objects receiving the same name and the third receiving a name differing by a one-feature phonetic change (e.g., /**p**ize/ vs. /**t**ize/ in the consonant condition, and /p**i**ze/ vs. /p**y**ze/ in the vowel condition). Infants' ability to learn the labels was evaluated by their recognition of the object-label links. Infants were considered to have learned a new word when succeeding in pairing the two novel objects labeled with the same name. Performance was better with consonant- than vowel-contrasted pairs, establishing a C-bias in word learning at 20 months. Similar results were found in different word learning tasks in French-learning 16-, 20- and 30-month-olds (Havy & Nazzi, 2009; Nazzi & Bertoncini, 2009; Nazzi & New, 2007), 3-, 4- and 5-year-old children and adults (Havy et al., 2014; though see Havy, Bertoncini, & Nazzi, 2011, for more mixed results, probably due to methodological limitations). In addition, a C-bias was also observed in familiar word recognition by French-learning 14-month-olds (Zesiger & Jöhr, 2011), infants reacting differently when hearing correct pronunciation vs. consonant mispronunciation but not when hearing correct versus vowel mispronunciations. These findings thus establish a relatively early C-bias in lexical processing in French, which is found across experiments over a range of phonetic features, including when comparing one-feature consonant and vowel changes. This calls for further studies to explore whether this bias is universal or language-specific, and to specify its origin.

1.4. Hypotheses regarding the developmental and crosslinguistic trajectory of the C-bias

Three hypotheses regarding the origin of the C-bias have recently been discussed in Floccia, Nazzi, Delle Luche, Poltrock, and Goslin (2014). According to the "initial bias" hypothesis, the C-bias would be present from birth, infants processing consonants and vowels as distinct phonetic categories from the very beginning. This hypothesis predicts neither developmental nor cross-linguistic differences in the expression of the C-bias. In contrast, the other two hypotheses propose that the C-bias is learned. According to the "lexical" hypothesis (based on Keidel, Jenison, Kluender, & Seidenberg, 2007), the C-bias would reflect experience with distributional information at the level of the lexicon. Indeed, Keidel et al. (2007) hypothesized that the C-bias found in Bonatti et al. (2005) might have resulted from adults' learning that consonants are more informative than vowels in distinguishing words in the lexicon of their native language, French. This proposal was based on their analysis of the 4943 CVCVCV words in the French corpus Lexique 3 (New, Pallier, Ferrand, & Matos, 2001) conducted to determine the mutual informativeness of consonants and vowels, which revealed that consonants are more informative than vowels in this language. Given the findings of a C-bias in French-learning 14-to-16-month-olds (Havy & Nazzi, 2009; Zesiger & Jöhr, 2011), this acquisition would have happened in early stages of lexical acquisition. Note that the lexical hypothesis predicts that the C-bias might change in development for a given language (with lexical acquisition) and might be modulated cross-linguistically depending on the relative mutual informativeness of consonants and vowels at the lexical level in each given language.

Lastly, according to the "acoustic/phonetic" hypothesis (partly based on Benavides-Varela, Hochmann, Macagno, Nespor, & Mehler, 2012; Bouchon et al., 2015; Floccia et al., 2014; Hochmann, Benavides-Varela, Nespor, & Mehler, 2011), the C-bias would also emerge during development but in relation to infants' early experience with the acoustic-phonetic properties of