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Beyond stop consonants: Consonantal specificity in early lexical acquisition

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Abstract

Previous research has shown that 20-month-old infants can simultaneously learn two words that only differ by one of their consonants, but fail to do so when the words differ only by one of their vowels. This asymmetry was interpreted as developmental evidence for the proposal that consonants play a more important role than vowels in lexical specification. However, the consonant/vowel distinction was confounded with another distinction, that of the continuous status of the phonemes used (discontinuous stop consonants versus continuous vowels). The present study investigated 20-month-olds' use of phonetic specificity while simultaneously learning two words that differ by a continuous consonant. The results obtained parallel those previously found for stop consonants, confirming the original claim of an asymmetry between the roles of consonants and vowels at the lexical level.

Keywords: Language acquisition; Word learning; Object categorization; Phonetic specificity; Consonants/vowels

Many recent studies have focused on infants' ability to use specific phonetic information in the process of learning new words during the second year of life, and on their ability to include such specific phonetic information in their early lexical representations. Evidence suggests that although some children produce mispronunciations until quite late in development, early lexical representations are specified to a certain extent. However, the bulk of the research in this domain has concentrated on plosive consonant contrasts, and extensions to other kinds of phonemic contrasts are now required. Accordingly, the aim of the present study was to evaluate whether 20-month-old infants can simultaneously learn pairs of words that differ only by one non-plosive consonant, and compare their performance to previous results obtained with the same procedure for plosive consonants and for vowels (Nazzi, 2005).

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Research on early phonetic specificity has witnessed renewed interest due to the proposal that vowels and consonants (considered as mutually exclusive sets of phonemes) might play different roles in language processing and acquisition (Nespor, Peña, & Mehler, 2003). More specifically, the proposal is that all consonants would be more important at the lexical level while all vowels would be more important at the prosodic and syntactic levels (while both types of phonemes would contribute to the morphosyntactic level).

The claim that vowels are more informative at the prosodic and syntactic levels comes from different domains. In particular, Nespor et al. (2003) note that vowels are the main carriers of prosodic information, and therefore play a crucial role in defining some basic linguistic distinctions such as the type of rhythm of a particular language, to which even newborns are sensitive (Nazzi, Bertoncini, & Mehler, 1998). Moreover, vowel-based prosodic information has also been found to provide cues about syntactic information (e.g., parsing of syntactic constituents, disambiguation of lexically ambiguous sentences, specification of relative order of head/complement syntactic parameter), which could be used by adults to process continuous speech and by infants to bootstrap syntactic acquisition (e.g., Christophe, Guasti, Nespor, & van Ooijen, 2003).

Similarly, the claim regarding the privileged implication of consonants at the lexical level is based on linguistic evidence that not only do consonants outnumber vowels in most languages (Crystal, 1997; Ladefoged & Maddieson, 1996), but also distinctiveness between consonants within a word tends to be maximized while it tends to be reduced for vowels (see for example the discussion on vowel harmony in Nespor et al., 2003). Further evidence, from the psycholinguistic domain, comes from studies showing that English, Dutch or Spanish adults asked to transform auditorily presented nonwords (e.g., kebra) into words tend to keep their consonants and change one of their vowels (e.g., cobra) rather than the other way round (resulting in, e.g., zebra; c.f., van Ooijen, 1996; Cutler, Sebastian-Galles, Soler-Vilageliu, & van Ooijen, 2000, for behavioral data, and Sharp, Scott, Cutler, & Wise, 2005, for converging PET scan data). Moreover, an artificial language learning experiment looking at French adults' ability to segment fluent speech showed that lexical transitional probabilities can be tracked in a context of fixed consonants and variable vowels, but not the other way round (Bonatti, Peña, Nespor, & Mehler, 2005).

The two lines of research above suggest that consonants matter more than vowels for lexical processing in adults. However, if consonants also play a more fundamental role than vowels at the lexical level during development, as proposed by Nespor et al. (2003), than one would predict that early lexical representations would be better specified in terms of consonants than in terms of vowels. Similarly, infants should be better able to pay attention to fine consonantal information while learning new words than to fine vocalic information. In the following, we review the literature on early lexical specificity for evidence related to these two predictions.

Many studies have investigated whether or not the lexical representations of words known by infants between the ages of 11 and 24 months are phonetically specified (for French: Hallé & de Boysson-Bardies, 1996; for English: Bailey & Plunkett, 2002; Fennell & Werker, 2003; Swingley & Aslin, 2000, 2002; Vihman, Nakai, DePaolis, & Hallé, 2004; for Dutch: Swingley, 2003). These studies show that early lexical representations are phonetically specified at least to a certain degree, infants often reacting differently to the presentation of a correct known word versus a mispronunciation of the same word. These studies further show that infants accept a certain degree of phonetic variation when hearing mispronunciations, as suggested by the fact that mispronunciation affects but does not entirely block comprehension. However, the evidence

gathered in these studies is limited in at least one important way: the effects of alterations to different types of phonemes (plosive or non-plosive consonants, vowels) were never compared. Therefore, it is not possible to evaluate the prediction, based on Nespor et al. (2003), that consonant-based mispronunciations affect lexical recognition to a greater extent than vowel-based mispronunciations.

Complementing the above research, other studies have investigated whether infants are able to process specific phonetic information in the process of learning new words, a task potentially more demanding than that of recognizing familiar words. This issue was explored by evaluating whether infants are able to learn simultaneously two phonetically similar words. Using two different methods, Werker, Fennell, Corcoran, and Stager (2002) and Nazzi (2005) established that both English- and French-learning 20-month-olds can simultaneously learn two words differing only by their initial plosive consonants. Evidence from the French-learning infants shows that this is the case even when the words are contrasted on non-initial consonants. However, learning in similar conditions could not be obtained at 14 months of age (Pater, Stager, & Werker, 2004; Stager & Werker, 1997), suggesting that word learning might initially be too demanding for infants' limited computational resources, and that in this process, some phonetic information is disregarded or not accessed.

As a way of evaluating the Nespor et al. (2003) proposal, Nazzi (2005) directly compared 20-month-olds' ability to learn simultaneously two phonetically similar words when the words differed by either one of their plosive consonants or one of their vowels. The results showed that infants' performance was above chance level for the word pairs contrasted on a consonant, but that it was at chance level for the word pairs contrasted on a vowel, and significantly lower than the performance in the consonant conditions. These results are compatible with the Nespor et al. (2003) proposal that consonants play a more prominent role in lexical processing and acquisition than vowels. However, this conclusion would be stronger if the data obtained for consonants could be found to generalize beyond the case of plosive consonants, the only kind of consonants that have been explored so far in these word-learning tasks. In particular, the consonant–vowel difference in Nazzi (2005) is confounded by another distinction: plosive consonants are discontinuous phonemes while vowels are continuous phonemes (similarly, plosives are lowest on the sonority scale while vowels are highest).

In order to reinforce the original interpretation of Nazzi (2005), a new study was conducted investigating 20-month-olds' simultaneous learning of two similar words differing by one continuous non-plosive consonant. The procedure was identical to the one used by Nazzi (2005). The words contrasted were the following: [nuk]/[muk] (nasal contrast), [rize]/[lize] (liquid contrast), and [fepɔd]/[ʃepɔd] (fricative contrast). Given that the Nespor et al. (2003) proposal does not distinguish between subtypes of consonants and vowels, performance in this new experiment should be at the level of performance found for plosive consonants, and significantly above that found for vowels in Nazzi (2005).

1. Method

1.1. Participants

Sixteen 20-month-old infants ($M = 20$ months, 20 days; range = 20 months, 3 days–21 months, 4 days) from monolingual French-speaking families participated in this experiment. There was an equal number of boys and girls. Most infants came from white, middle-class backgrounds,

Fig. 1. One of the six sets of objects used in the present study. Which two objects were given the same name was counterbalanced across participants.

although infants from other ethnic backgrounds were also represented. Two additional infants were tested, but failed to complete the session.

1.2. Stimuli

Six triads of small objects were used during the testing session (an additional triad being used during a pretest). All objects were selected so that the infants would be unfamiliar with them and would not already have a name for them. All sets were made up of three very distinct objects, that all differed in shape, color, and texture in an effort to equalize their perceptual distance (see example in Fig. 1). The rationale for using triads of very different objects, rather than very similar objects, was to help infants learn and remember the different object-label pairings (see also Nazzi, 2005; Nazzi & Gopnik, 2001).

One pair of nonwords was used for the training trial ([vim]/[jim]). Three other pairs of nonwords were used for the six test trials, [nuk]/[muk], [rize]/[lize], and [fepɔd]/[ʃepɔd]. All three pairs of nonwords were used once, in counterbalanced order, for the first three test trials, and then reused in the same order for the last three test trials (the word of the pair being used as target was switched between its two occurrences).

1.3. Procedure

The procedure was identical to that used in Nazzi (2005). Infants were tested individually for about 10 min in a quiet room, in the presence of a caregiver.

After an informal warm-up period (playing with spinning plastic rings), the infant was seated on a chair across a table from the experimenter, and the testing session started. It comprised a training trial and six test trials. All trials were "naming" trials that tested for categorization based on naming.

The training trial was identical to the test trials (see below) except that the presentation of the objects and the categorization question were repeated if the infant's initial response was incorrect (although the infant was not told the answer was incorrect). The testing phase started independently of the response provided the second time.

Each of the six test trials was composed of a presentation phase, followed by a categorization question. Each trial started with the presentation of the three objects, one at a time. The infant was encouraged to manipulate each object for a few seconds, before placing it on the table. Within each trial, the objects were arranged on the table in a left-to-right sequence (child's perspective) in order to minimize memory load. The experimenter spoke while presenting each object, saying (for example): "Look! A [nuk]. This is a [nuk]. Do you want to play with the [nuk]? Yes, play with

the [nuk]. See this [nuk]? All right, let's put the [nuk] on the table. Here." Each object was named exactly six times. Within each trial, two of the objects were labeled with the same nonword (e.g., [nuk]), while the last object was labeled with the phonologically contrasted nonword (e.g., [muk]).

After the presentation phase, the experimenter tested categorization by putting one object of the named pair in his own hand, placed at equal distance from the remaining two objects, and asking the infant to give him "celui qui va avec" ("the one that goes with this one"). While waiting for the response, the experimenter looked at either the infant's face or the object in his hand in order to avoid influencing the infant's response. After the infant's response, positive feedback was provided regardless of the choice made. Successful performance corresponded to the selection of the similarly labeled object. The order of presentation of the trials (for the first three trials, that order being then repeated for the last three trials) and the pairs defined by the names were counterbalanced between participants. Moreover, the position of the paired objects on the table and the side of the object picked up by the experimenter within a pair was counterbalanced within participants.

Before the testing session, the parent filled out the vocabulary part of the French equivalent (Kern, 2003) of the MacArthur Communicative Development Inventory: Toddlers (CDI; Fenson et al., 1993) in order to determine the size of the infants' productive vocabulary. The questionnaires for two infants were not collected.

2. Results

For each trial, infants were given a score of 1 when the chosen object was the second of the named pair, and a score of 0 otherwise. Total scores could range from 0 to 6. Chance in this experiment is 50%, given that infants have to choose between two objects (whose pairing is counterbalanced; see Nazzi, 2005). The infants chose the second object with the same name 63.5% of the time, which is significantly more than chance ($t(15) = 2.92$, $p = .011$, two-tailed). As can be seen from Table 1, a majority of infants chose the correct object on more than half of the test trials. Moreover, performance was stable across the three pairs of pseudowords, the percentage of same name choices being of 62.5% for the pair [nuk]/[muk], 65.6% for the pair [rize]/[lize], and 62.5% for the pair [fepɔd]/[ʃepɔd] (all $t(15) < 1$).

The infants had a mean of 98 words (S.D. = 139; range 5–437); the median was of 31 words. There was no correlation between vocabulary size and categorization performance ($r = -.27$, $p = .36$).

Performance in the present experiment was compared to data from Nazzi (2005). An ANOVA on categorization scores with the main between-subject factor of contrast type (phonetically

Table 1
Distribution of infants according to their performance (chance level = 3)

Performance level	Number of infants
0	0
1	0
2	2
3	4
4	6
5	3
6	1

Table 2
Comparison of infants' performance across the different experimental conditions (mean percent correct answers) of Nazzi (2005) and the present study (p values, LSD tests)

	Different (73.6%)	Plosive consonants (64.2%)	Non-plosive consonants (63.5%)	Vowels (54.4%)
Different (Nazzi, 2005, Exp. 1) (73.6%)		.018	.048	<.001
Plosive consonants (Nazzi, 2005, Exp. 2) (64.2%)			.878	.001
Non-plosive consonants (present study) (63.5%)				.037
Vowels (Nazzi, 2005, Exp. 3) (54.4%)				

different, plosive consonant, vowel and non-plosive consonant[1]) revealed a main effect of contrast type, $F(3, 156) = 10.23$, $p < .001$. Performance was highest for phonetically different contrasts (73.6%), lowest for vocalic contrasts (54.4%), while performance for consonants, which was similar for plosive (64.2%) and non-plosive (63.5%) consonants, fell between these two end points, as shown by post hoc tests (see Table 2).

3. Discussion

The present results show that 20-month-old infants are able to learn simultaneously two phonetically similar words that contrast only by the place of articulation of one of their consonants, even when these consonants are continuous phonemes. Performance was similar for all three pairs tested, which involved, respectively, nasal, liquid, and fricative consonants. These results thus extend previous findings regarding 20-month-olds' use of consonantal specificity (Nazzi, 2005; Werker et al., 2002) to consonants other than discontinuous plosives. Overall performance in the present experiment (63.5%) is virtually identical to overall performance involving stop consonants in either initial (63.2%) or non-initial (65.3%) positions (Nazzi, 2005).

Moreover, performance in the present experiment with non-plosive continuous consonants is higher than what had previously been found for vocalic contrasts (Nazzi, 2005), therefore ruling out an interpretation of the difference in performance previously found between stop consonants and vowels in terms of phoneme continuity or sonority level. The present study brings further evidence in favor of the Nespor et al. (2003) proposal for a distinct role of consonants and vowels in language acquisition (for a discussion of the more crucial role of vowels at the prosodic and syntactic levels, see Nespor et al., 2003). Note that an extension of the present study to semi-vowels would help specify whether the consonant–vowel distinction is better characterized in terms of the "syllabic" or the "consonantal" feature (the former, contrary to the latter, grouping the semi-vowels with the consonants).

At this point, we consider two possible phonological implications of the proposal that consonants are more important than vowels at the lexical level (Nespor et al., 2003) in respect to French lexical roots. On the one hand, lexical roots might be made up of more consonants than vowels. On the other hand, consonants might be "used" more often than vowels to distinguish between

[1] Details on Nazzi (2005). Data for the different conditions correspond to the presentation of the following contrasts: phonetically different ([duk]/[zap], [pize]/[moRa], [kepɔd]/[nylis]), plosive consonant ([duk]/[guk], [pize]/[tize], [kepɔd]/[tepɔd]; [duk]/[dut], [pide]/[pige], [kepɔd]/[ketɔd]), vowel ([duk]/[dɔk], [pize]/[pyze], [kepɔd]/[køpɔd]; [duk]/[dœk], [pize]/[paze], [kepɔd]/[kupɔd]; [da]/[di], [pize]/[pizu], [kepRo]/[kepRi]) and non-plosive consonant ([nuk]/[muk], [rize]/[lize], [fepɔd]/[ʃepɔd]).

lexical roots, a corollary of this being that lexical roots might have more neighbors resulting from a consonantal change (C-neighbors) than from a vocalic change (V-neighbors). Given the possible involvement of both consonants and vowels at the morphosyntatic level (Nespor et al., 2003), the above predictions, made for lexical roots, might not hold when considering all lexical entries (i.e., lexical roots + derived forms), an issue that we explored by performing parallel analyses of the French lexicon for the sole lexical roots and all lexical entries.

These analyses were conducted using the French lexical database "Lexique 2," which describes 71,000 different phonological lexical entries and 36,000 lexical roots and is based on a written corpus of 31 million words (New, Pallier, Ferrand, & Matos, 2001; New, Pallier, Brysbaert, & Ferrand, 2004). We restricted our analysis to content words having more than one phoneme (though similar results were obtained including function words). Semi-vowels were counted as consonants. Two analyses were computed, one on types and one on tokens: (a) the proportion of phonemes that are consonants, and (b) the proportion of lexical neighbors that are obtained by substituting one consonant (as opposed to one vowel).

The results of these analyses are presented in Table 3. Independently of the way it was calculated, the proportion of consonants appeared to account for about 57% of all phonemes making up words in French. This suggests that French words are made up of slightly more consonants than vowels, and that the same proportion of consonants and vowels are used to form lexical roots and to derive words from these roots.

However, the variations in the proportion of C-neighbors suggest different constraints on the use of consonants and vowels at the lexical and morphosyntactic levels. On the one hand, the results for the lexical roots (type and token analyses) show that C-neighbors account for about 2/3 of all neighbors, more therefore than the proportion of consonants within words. This higher proportion of minimal word pairs differing by a consonant than by a vowel is compatible with the prediction derived from the Nespor et al. (2003) proposal of a more crucial role of consonants at the lexical level.

On the other hand, the fact that there are only 49% of C-neighbors (type count) when all lexical entries (roots and derived forms) are taken into account suggests that in French, the constraints on consonants and vowels are different at the morphosyntactic and lexical levels. Given that we defined neighbors in terms of phoneme substitution, this drop in C-neighbors probably reflects the fact that derived forms can only be obtained by substitution of a vowel (e.g., in verb conjugation, [parle]/[parlõ]/[parla]), but not by substitution of a consonant.

In conclusion, the results from the corpus analysis bring further support to the proposal by Nespor et al. (2003) regarding the different roles of consonants and vowels in speech processing and language acquisition, in showing that consonants are more important than vowels at the

Table 3
Comparison of the proportion of phonemes that are consonants, and the proportion of lexical neighbors that are obtained by substituting one consonant (as opposed to one vowel) for lexical roots and all lexical entries

	Type frequency	Token frequency
Lexical roots		
Percentage of consonants	57.3	57.3
Percentage of C-neighbors	67.5	65.4
All lexical entries		
Percentage of consonants	57.0	57.3
Percentage of C-neighbors	48.7	60.7

lexical level (see Nespor et al., 2003, for evidence regarding the role of vowels at the prosodic and syntactic levels). They thus complement the evidence coming from infants' lexical acquisition (present study; Nazzi, 2005), and show that French-learning infants' performance is well adapted to the structure of the language they are acquiring. This raises the developmental question of whether this bias is language-general, or whether it develops under the influence of the native language and signals the acquisition of the native language phonological properties. Experimental evidence from languages, like Danish, in which there are more vowels than consonants would be crucial to answer this question. Finally, we found initial evidence that vowels and consonants are used differently at the morphosyntactic level in French. As pointed out by Nespor et al. (2003), the implication of consonants and vowels in morphosyntax is likely to vary crosslinguistically, which calls for the present research to be extended both developmentally and crosslinguistically.

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