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The role of accentual pattern in early lexical representation

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Abstract

The interaction between prosodic and segmental aspects of infant representations for speech was explored using the head-turn paradigm, with untrained everyday familiar words and phrases as stimuli. At 11 months English-learning infants, like French infants (Hallé & Boysson-Bardies, 1994), attended significantly longer to a list of familiar lexical items than to a phonetically comparable rare list, but 9-month-olds did not. Reversing the stress pattern of the familiar items failed to block word-form recognition in 11-month-olds, although a time-course analysis showed that it delayed the infant response. Changing the initial consonant of English words did block word recognition while change to the second consonant did not. Time-course analyses of both the English and the original French data showed that altering the consonant of the unaccented syllable delays word-form recognition in both languages while change to the accented syllable has a stronger effect in English than in French.

Keywords: Accentual pattern; Infant speech perception; Lexical representation; Headturn paradigm; Phonological development; Primacy of word onset

In 1994 Hallé and Boysson-Bardies introduced a novel variant on the headturn paradigm previously used by Jusczyk (1992) and others to compare infants' responses to native language vs. non-native language word lists. In the new version, two word lists were drawn from the native language, one consisting of everyday (*familiar*) words likely to be used frequently in speech to the infant, the other consisting of (*rare*) words of closely similar phonotactic structure but low incidence in the language in general (and thus virtually certain to have been heard rarely, if ever, by infants). Hallé and Boysson-Bardies reported that without any explicit training 11-month-old French infants maintained longer head turns in response to the familiar words, suggesting that they had a lexical representation sufficient for word form recognition in the stripped-down situational setting of a darkened booth.

In a follow-up study Hallé and Boysson-Bardies (1996) took up the question of the specification of the infants' lexical representations by altering, in separate experiments, the initial and the medial consonant of disyllabic French words. In the former but not the latter case infants responded with significantly longer looks to the familiar word list, reflecting apparent word form recognition. The results were taken as a possible validation through direct experimental manipulation of earlier work in phonological development hypothesizing that infants' earliest lexical representations are holistic (Ferguson, 1978; Jusczyk, 1986; Macken, 1979; Menn, 1983; Vihman & Miller, 1988; see also Fowler, 1991; Walley, 1993). That is, the results suggested that in some cases infants will respond to a familiar word even when

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the form with which they are presented is not fully accurate, or does not fully correspond to the form normally heard. This can be taken to mean that infants' word representations are not fully specified, so that certain changes can go undetected, permitting a recognition response.

The experiments to be reported here return to these issues, extending the paradigm to test English infants, 9- as well as 11-month-olds, and to include alterations to stimuli affecting stress pattern ('misstressing') as well as consonants at syllable-onset ('mispronunciation'). We make use of time-course analyses to compare infants' responses to the normal and the deviant stimuli. This allows us to distinguish immediate from delayed recognition of altered and unaltered familiar words. Additionally, we reanalyse the original French data in order to make a direct comparison between the effect of initial vs. medial consonant change on the two populations of infants.

The broad goal of the study is to explore the relative weight of prosodic and segmental aspects of infant representations for speech at the end of the first year. Intensive experimental studies of infant speech perception over the past 10–15 years have provided a developmental picture in which advances are first seen mainly with respect to *prosodic* knowledge or familiarity with the native language, while increasing familiarity with *segmental* patterning emerges largely in the second half of the first year (Vihman, 2002). As is now widely appreciated, infants' capacity to discriminate contrasting speech patterns is acute from the first months of life (see Jusczyk, 1997; Vihman, 1996 for reviews). With respect to the recognition of familiar speech patterns, however, infants have been found to be responsive to native language prosodic patterns from soon after birth (Mehler et al., 1988), but to respond differentially to native vs. non-native segmental patterns only some months later (Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993b). From 9 months on we find evidence for increasing familiarity responses to native vs. non-native segmental patterns (Jusczyk et al., 1993b; Jusczyk, Luce, & Charles-Luce, 1994), and by 10–12 months we see a loss of capacity for discriminating non-native consonantal contrasts, from which an attentional shift shaped by familiarity with native segmental patterns has been inferred (Best, McRoberts, LaFleur, & Silver-Isenstadt, 1995; Lalonde & Werker, 1995; Werker & Tees, 1984).

More recent studies have provided a good deal of experimental evidence bearing on the period of transition in the middle of the first year, when segmental as well as prosodic patterns begin to be known. In several studies of infant capacities to segment words from the speech stream Jusczyk, Morgan and their colleagues investigated the changing developmental role of prosodic pattern and its relation to segmental cues. For example, Morgan (1996) reported that 6-month-olds responded only to changes affecting the prosodic patterns of trained syllable sequences, apparently failing to detect segmental changes (see also Morgan & Saffran, 1995). Mattys, Jusczyk, Luce, and Morgan (1999) provided strong evidence that infants have already developed familiarity with subtle distributional characteristics of segmental patterning by 9 months of age. However, the final experiment in this study demonstrated that where the prosodic and phonotactic cues were in conflict, the 9-month-olds disregarded the phonotactic cue (i.e., the cue based on segmental sequence). Thus, it appears that at 9 months prosodic patterns continue to be more salient to infants than segmental patterns (cf. also Jusczyk, Cutler, & Redanz, 1993a; Myers et al., 1996).

One study of infant capacities for word segmentation provided evidence that infants can recognize segmental sequences as early as 7 months. Jusczyk and Aslin (1995) trained or 'primed' infants with a set of monosyllabic words to which they were later exposed in a short narrative context. These English-learning infants showed evidence of recognizing the trained words (whereas 6-month-olds did not), but failed to show word recognition (or segmentation of the narrative passages) when the initial consonant of the words had been altered in training (e.g., *tup* and *bawg* instead of *cup* and *dog*). The authors saw these results as reflecting 'rather detailed [infant] representations of the sound patterns of the target words' (p. 14; see also Bailey & Plunkett, 2002; Swingley & Aslin, 2002, who found altered initial segments to impair word recognition (in English) in 14–15- and 18- and 24-month-olds, respectively, and who drew a similar conclusion).

An alternative view is that the initial consonant may provide a crucial 'anchor' for infant word form representations in English, while the remainder of the representation may or may not include full segmental detail. Indeed, Jusczyk, Goodman, and Baumann (1999) showed that commonalities characterizing either onset consonants or onset CV sequences in CVC monosyllables were sufficient to result in longer looking times in 9-month-old infants, although assonance (commonalities in the medial vowel only) and rhyme (VC portion of the CVC monosyllable) failed to do so. In a follow-up study with older infants Goodman and Juszcyk (2000) found that 14-month-old infants also responded to similarities in onset consonants (in monosyllables) but not to rhymes; 18-month-olds also failed to exhibit an attentional response to rhymes.

Recall that in Hallé and Boysson-Bardies' (1996) study, contrary to Jusczyk and Aslin (1995), infants responded to familiar words (e.g., *canard* 'duck') despite an initial consonant change (*ganard*, *shanard*). This study differed from that of Jusczyk and Aslin (1995) in four important respects: infant age (7 vs. 11 months), language (English vs. French), stimuli (words trained as part of the experiment vs. words familiar from everyday exposure), and task (response to individual words embedded in narrative passages vs. response to word lists). Hallé and Boysson-Bardies proposed that their results could be due to a shift in infant representation for speech—in the second half of the first year, just the period in which words begin to be understood—from an earlier relatively well specified 'phonetically analytic' representation to a later, more global or segmentally underspecified representation characteristic of a '"lexical" attention mode' (p. 477). This interpretation takes the age difference to be the crucial one (see also Werker & Stager, 2000). An alternative interpretation would emphasize instead the language difference between the two studies, supposing that it may have been differences in the interaction of the segmental and prosodic aspects of speech in English vs. French that were responsible for the different findings. Long term exposure to the consistent iambic patterning of French disyllabic words and phrases might draw infants' attention away from word-initial consonants (as Hallé & Boysson-Bardies, 1996, also suggest, p. 477), whereas the trochaic patterns most typical of English might lend special weight to the initial consonant.

Analyses of children's early words in relation to their adult targets provide indirect support for the idea that the stressed or accented syllable might be better represented by children than the unstressed syllable, since the stressed syllable tends to be more accurately reproduced while the unstressed syllable in disyllabic productions is often adapted for ease of production of the word pattern as a whole, with vowel or consonant assimilation or omission affecting the unstressed but generally not the stressed syllable in a number of languages. In particular, French initial consonants may be omitted or replaced by [h] or a consonant harmonising with the medial consonant (*voilà* 'there you are' > [lala] (Laurent)), while in English it is the onset consonant of the second (unstressed) syllable that is more likely to harmonize to the word-initial consonant (*water* > [wawa] (Deborah); examples from Vihman, 1996, Appendix C).

The contrast between the accentual systems of English and French makes the replication of a French study with English infant participants a useful starting point for the further exploration of the relative importance of prosodic vs. segmental patterns in early lexical representation or word-form recognition. The mixed-stress English accentual system makes it possible to test directly the effect of a stress shift on infant word form recognition. Furthermore, the fact that most of the disyllabic words used with infants are trochaic provides a good opportunity, in light of the French study, to test the hypothesis that the stressed syllable is better represented than the unstressed syllable. Finally, by directly analysing the time-course of both the English data and the original French data we should be able to identify both similarities and differences in infant responses, providing a more reliable basis for interpretation of the findings of the two sets of experiments taken together.

Studies investigating the responses of infants exposed to English in the prelinguistic period have not so far used as stimuli untrained real words or phrases that children may be expected to learn from everyday experience. The experiments we report here were designed to provide evidence from English that replicates the Hallé and Boysson-Bardies studies with regards to all but the language factor, making it possible to better establish the interrelation of prosodic and segmental aspects of early lexical representation. Specifically, we address the question of whether, and to what extent, the accented syllable may serve as an anchor for infants' first lexical representations. In addition we explore the balance, or trade-off, between prosodic and segmental pattern as a basis for infant responses to speech at 11 months.

In order to establish a baseline age for untrained lexical representation in the absence of any situational cue we began by replicating, with children exposed to British English, the basic finding of longer attending to familiar vs. rare lexical items at 11 months (Hallé & Boysson-Bardies, 1994), while testing to see whether 9-month-old infants exposed to English might already exhibit such a differential response (Experiment 1). We then used the 'modification of familiar words' paradigm (Hallé & Boysson-Bardies, 1996) in follow-up experiments to test the weight of prosodic factors and the degree of integration of segmental and prosodic aspects of lexical representations. We first tested the role of accentual contour per se in infant familiar word or phrase recognition by 'misstressing' the words used as stimuli (Experiment 2) and then altered first the initial, then the medial consonant in trochaic words to test whether 'mispronouncing' the words would block recognition (Experiment 3). Time-course analyses of both the present English data and Hallé and Boysson-Bardies' French data are used here in an attempt to gain insight into the infants' response to the deviant (misstressed or mispronounced) stimuli.

Experiment 1

To ascertain whether infants exposed to English would respond with greater attention to lexical items expected to be familiar from their everyday experience we conducted a replication of the study reported by Hallé and Boysson-Bardies (1994), using for the familiar list materials drawn primarily from a longitudinal study of infants acquiring American English. We included two samples of children, at ages 9 and 11 months, in an attempt to ascertain the approximate earliest age for a familiarity response to a list of everyday lexical items. Like Hallé and Boysson-Bardies (1994), but in contrast to Jusczyk and Aslin (1995), we used as stimuli words and phrases that we could expect the infants to have heard in their home environment; there was no specific lexical training within the context of the experiment.

Method

The general procedure used was the head turn preference method originally developed by Colombo and Bundy (1981, 1983) and Fernald (1985), later modified by Jusczyk and his colleagues (Jusczyk et al., 1993b), and subsequently adapted by Hallé and Boysson-Bardies (1996). The procedure is based on the observation that infants tend to orient their head towards an attended sound source, together with the assumption that infants will attend longer to (or show an apparent tendency to 'prefer') words (or other patterns) which they recognize ('familiar words and phrases').

Participants

Two groups of 12 infants were tested, one at 9 and the other at 11 months of age (Baseline9 [Experiment 1a] and Baseline11 [Experiment 1b], respectively). The infants in the younger group averaged 39 weeks, 3 days (range: 38 weeks, 1 day, to 42 weeks, 3 days). There were 7 males and 5 females in this group. Eight additional infants participated but could not be tested successfully due to crying (5) and equipment problems (3). The infants in the older group averaged 48 weeks, 1 day (range: 46 weeks, 5 days, to 49 weeks, 2 days). Eight male and 4 female infants were tested in this group. Two additional infants were tested but did not meet training criteria (they looked towards one side only during the training phase).

Stimuli

The lexical lists used as stimuli are presented in Table 1. Disyllables were used because they make up the single largest category of words produced by infants, cross-linguistically (Boysson-Bardies & Vihman, 1991), and also because they could serve to test the effect of misplaced stress on infants' recognition of familiar words or phrases in a planned follow-up experiment. Familiar words and disyllabic phrases were chosen from those found in studies of young infants' production (Hart, 1991; Vihman & McCune, 1994), since we may suppose that these would also be among the first word forms for which children form stable representations. Cultural and dialect differences between American and British English were taken into account (e.g., the British baby talk term *nappy* [US *diaper*] was used). Responses to the Oxford Communicative Development Inventory (Hamilton, Plunkett, & Schafer, 2000) by a separate sample of 18 English parents of 11-month-olds living in the North Wales area indicated that a mean of 6 infants understood each of the words used as stimuli (five of the words were reported to be understood by 9 or more infants). Note that this is a conservative estimate of the number of words likely to prove familiar, since 'understanding' (or appreciation of the form-meaning link) is not required of the infants in the experiment but only 'recognition' (of the word form alone). Furthermore, since the words were presented as lists rotating through different orders across trials (as described under Procedure, below), each infant had a reasonable chance of hearing one or two familiar words on any given trial.

Phrases consisting of a function word combined with a monosyllabic content word were included alongside single words for several reasons. First, they make up a substantial proportion of the disyllabic patterns of English, in infant-directed speech as well as elsewhere (Morgan, 1996; Vihman, DePaolis, & Davis, 1998). Secondly, studies of early production in English suggest that short phrases are often treated as if they were a single lexical unit by children (e.g., Dore, Franklin, Miller, & Ramer, 1976; Peters, 1983; Peters & Menn, 1993). Since we were interested not in how children are able to segment words but rather in the nature of infant lexical representations, recognition of short phrases that

Table 1
Stimuli used in Experiments 1 and 2

	Familiar word	Phonetic transcription	Rare word (unfamiliar to infants)	Phonetic transcription
Trochaic	apple	/æpəl/	bridle	/braɪdəl/
	baby	/beɪbi/	cycle	/saɪkəl/
	button	/bʌtən/	fog light	/fɔglaɪt/
	mummy	/mʌmi/	maiden	/meɪdən/
	nappy	/næpi/	manna	/mænə/
	sleepy	/slipi/	mortar	/mɔtə/
	thank you	/θæŋkju/	thorough	/θʌrə/
Iambic	a ball	/əbɔl/	a bine	/əbaɪn/
	away	/əwèɪ/	a noose	/ənus/
	balloon	/bəlun/	compare	/kəmpɛə/
	fall down	/fɔldaʊn/	disturb	/dɪstɜb/
	tonight	/tənaɪt/	taboo	/təbu/

are often heard as units seemed as relevant to us as the recognition of what counts as single word units for the adult system. Finally, we wanted to include lexical items reflecting the dual accentual system of English, but attempts at phrases account for by far the majority of iambic patterns found in children's early production lexicons (Vihman et al., 1998); iambic words are extremely uncommon. Out of the 60 distinct identifiable disyllabic word types attempted at age 16 months by 20 participants in Vihman and McCune (1994), only three (5%) were iambic (*balloon*, *goodbye*, *hello*). In short, inclusion of disyllabic iambic phrases as stimuli alongside conventional word forms seemed appropriate for testing 9- and 11-month-old infants acquiring English.

The 'rare' items were chosen from words that were relatively uncommon according to the frequency tables of Francis and Kucera (1982) (words with less than 114 occurrences in the one million word corpus). The phonotactic complexity of the rare items was matched to that of the familiar, although care was taken to avoid excessive similarity (e.g., *apple* and *opal*). To balance the vowel-initial iambs in the familiar list we included in the rare list two iambic phrases consisting of the indefinite article followed by a rare monosyllabic word (*a bine*, *a noose*). In addition, *fog light* was included as a quasi-phrasal trochaic pattern, to balance the familiar (trochaic) phrase *thank you*. Although neither *fog light* nor (*a*) *bine* occur in Francis and Kucera's tables, we considered them infrequent enough to be included as 'rare' (i.e., unlikely to have ever been heard by the infants).

Basing our frequency values on Mines, Hanson, and Shoup (1978), we tested the comparability of the input frequency of the phonemes in the two lists (disregarding vowels, given the wide dialect differences between American English, reflected in Mines et al., and British English, used for our stimuli). A Mann–Whitney test showed no significant difference ($z = -.54$, $p = .59$).

All items (for this and all subsequent experiments reported below) were recorded using a Shure 5155D microphone and a Rane MS1 microphone preamp connected to a Tascam DA-P1 DAT recorder. The stimuli were spoken by a female speaker of Southern British English free of any strong regional accent. Fundamental frequency (mean, maximum, and minimum F0), duration and amplitude of each word stimulus were measured (see first table of the Appendix), and independent t tests were performed to ensure that there were no significant acoustic differences between the two lists. Outliers were removed, as far as possible.

Apparatus

All experiments were conducted in a quiet room with the infant seated on the caregiver's lap, facing the center panel of a three-sided test booth, where a camera and red light were mounted. A blue light and Pioneer speaker were mounted on each side panel. The lights, camera, and speaker were all approximately at the infant's eye level. A Tulip DT Intel 5 PC with an integrated experimenter response box and a 9 in. black and white monitor (connected to the center panel camera) were located behind one side panel to control stimulus presentation and record infant listening times, as judged on-line (by observing infants turning toward or away from the loudspeaker that served as the sound source). The response box was equipped with a series of buttons that controlled the onset of each trial and also allowed the experimenter to record whether the infant was turning toward or away from the stimuli. The computer initiated and terminated trials, in response to the experimenter's signals, by means of an OROS AU22 AD /DA programmable 16 bit sound card. The AU22 fed a Pioneer amplifier connected to the speakers.

Procedure

Throughout this study we followed the head turn preference paradigm as modified by Hallé and Boysson-Bardies (1996). In each experiment two types of word lists (12 lexical items each) were presented and the infant's total listening time to each list type was recorded. Both the experimenter and the caregiver wore headphones playing music chosen to effectively mask the speech stimuli (constant level with no quiet passages). For each participant, each of the two stimulus types was associated with one side throughout the experiment. The side assigned to stimulus type as well as the order of presentation was counterbalanced across subjects. The experimenter was unaware of which stimulus type was associated to which side. Each experiment with each infant consisted of three phases: familiarization, training, and test. In all three phases the center light flashed until the infant's attention was directed to midline, after which the trials began. The *familiarization phase* was designed simply to acquaint the infant with the speech stimuli and the speaker they came from. The two lists were each played in full once, sequentially, from opposite sides. No side light was turned on during this phase.

In the *training and test phases* that followed, once the experimenter judged the infant's gaze to be directed to the midline the center light was extinguished and one of the side lights (chosen by the computer) began flashing. The computer-chosen speech stimuli then began to play after a .5 s delay. The side light remained on for the duration of the training and test phases. When the infant oriented at least 30° toward the side light the experimenter held down a button to record the amount of time the infant oriented to the stimuli; the experimenter released this button whenever the infant turned away. Any interval of time turning away was thus omitted from the total listening time. The trial was terminated if the infant failed to orient after the initial stimuli (four stimuli in the training phase, three in the test phase) or turned away for more than 2 s.

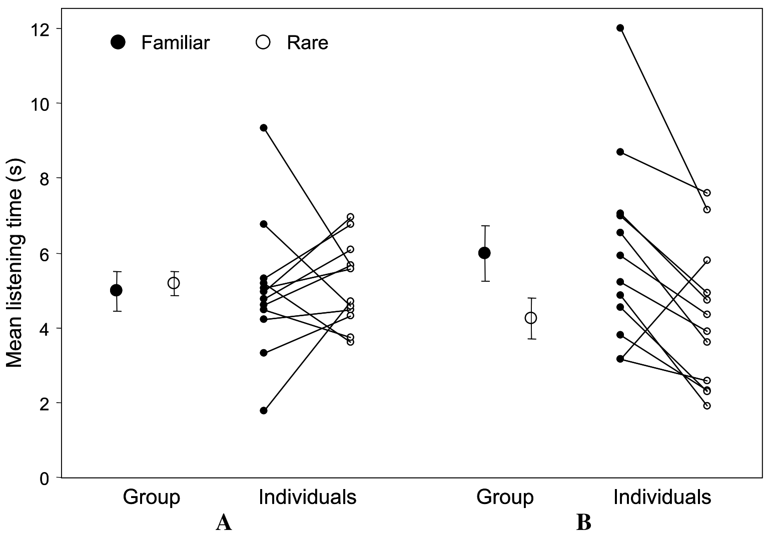

Fig. 1. (A) Word and phrase recognition at 9 months (Baseline 9, Experiment 1a); (B) Word and phrase recognition at 11 months (Baseline11, Experiment 1b). Individual children's mean listening times are plotted as well as group means and standard error bars.

Four trials were presented in the training phase (two familiar and two rare). Note that this second phase is called 'training' only because its purpose is to teach infants the contingency between their physical orientation and the availability of the stimuli. The two lists are therefore presented an equal number of times during this phase. There is no 'training' in the sense used in other paradigms, where a single set of stimuli are presented for familiarization.

For the test phase, the six list-orders of each stimulus type (familiar, rare) were pseudo-randomized with the precondition that each stimulus (word or phrase) must occur as one of the first two stimuli of one list-order to ensure that each infant heard each of the stimuli over the course of the test phase. In the test phase 12 different list-orders were thus presented (six pseudo-randomizations of each of the two 12-item list types), although no more than two lists in a row of the same type (familiar or rare) were allowed. The time needed to present a word or phrase was 570 ms, on average (see first table of the Appendix). Since the interstimulus interval was 500 ms, each stimulus, or lexical item, took up about 1 s, so that an infant head turn of 3 or 4 s reflects orientation to 3 or 4 stimuli of a given type.

Reliability was assessed by having an independent judge record listening times from videotapes (with the audio portion turned off). Two randomly chosen sessions were recoded from each experiment, yielding a correlation of $r = .85$ for the 192 trials. The coding was also checked for the number of early terminations (trials cut short) vs. extension errors (trials falsely extended), following Pinto, Fernald, McRoberts, and Cole (1999). No systematic bias in favour of one list over the other was found.

Results

The results of Baseline9 (Experiment 1a) and Baseline11 (Experiment 1b) are summarized in Fig. 1 (based on the test phase only[1]). As can be seen from the individual infants' listening times to each list type, 11 out of 12 of the 11-month-old infants listened longer to the familiar list, while at 9 months only 4 out of 12 infants did so. As a group, the 11-month-old infants showed longer mean listening times to the familiar stimuli ($M = 5.99$, $SD = 2.54$) than to the rare ($M = 4.26$, $SD = 1.89$) ($t(11) = 3.38$, $p = .006$), but the 9-month-olds did not ($M = 4.98$, $SD = 1.82$ for familiar vs. $M = 5.27$, $SD = 1.29$ for rare, $t(11) = .49$, ns). A mixed design ANOVA (age: between subjects factor, list: within subjects factor) revealed a significant interaction between age and stimulus sets, indicating that the 11-month-olds listened to the familiar list type significantly longer than did the 9-month-olds ($F(1, 22) = 12.19$, $p = .016$).

Discussion

In our first experiment we successfully replicated in infants exposed to English the French finding of familiar word form recognition by 11 months. The 9-month-old infants failed to show longer listening times to familiar lexical items. These results suggest that a lexical representation for the forms of frequently used words and

[1] Note that, following the convention, listening times from the test phase alone were analyzed in the first instance. However, in the time-course analyses we included listening times for the training phase as well.

phrases may not yet have stabilized for the majority of infants as early as 9 months. However, for most infants exposed to British English as well as for most infants exposed to French such a representation appears to be in place by 11 months of age.

Experiment 2

Having established a baseline age for responding with longer listening to words and phrases familiar from everyday life in the absence of situational cues or specific training, we were interested in exploring in greater detail the quality of the lexical representations that underlie infant attention to familiar words and phrases at 11 months. Several studies have demonstrated the continuing importance of prosody in infants aged 8–9 months, at a time when attention to and memory for segmental patterning is emergent (Jusczyk et al., 1993a; Mattys et al., 1999; Morgan, 1996; Morgan & Saffran, 1995). Experiment 2 was thus designed to test the hypothesis that a change in accentual pattern would block infant recognition of familiar lexical items at 11 months. If infants' representations crucially depend on prosodic pattern at that age, then the infants should fail to recognize misstressed words. Thus, when presented with misstressing of words and phrases in contrasting familiar vs. rare list types, they should display no list type bias in listening time (Experiment 2a, Misstressing). At the same time, when presented with alternating misstressed and normally stressed familiar words and phrases, longer listening to the normally stressed familiar list type could be expected (Experiment 2b, Stress vs. misstress).

Participants

Two groups of 12 11-month-old infants each participated in Experiments 2a and 2b. The average age of infants tested in Experiment 2a was 47 weeks, 5 days (range: 46 weeks, 1 day to 49 weeks, 6 days). There were seven males and five females in this group. All the infants successfully completed the experiment. The infants tested in Experiment 2b averaged 48 weeks, 6 days (range: 47 weeks, 4 days, to 51 weeks, 2 days). This group consisted of six male and six female infants. One additional infant was tested but did not complete the experiment due to crying.

Stimuli

The same stimuli were used as in the Baseline experiment (Experiment 1), but with an accentual shift, such that *BAby* ['beɪbi] was now produced as *baBY* [beɪ'bi], for example. Both familiar and rare word and phrase lists were recorded as before, but with the accentual shift creating trochees out of the five iambic items and iambs out of the seven trochees on each list. Where the initial familiar stimulus included a maximally reduced vowel (schwa), the stress shift necessarily led to an 'upgrade' of the vowel (to [ʌ] in 5 of the 12 stimuli: See Table 1, to [u] in *tonight*); on the other hand, only those items with [ʌ] under stress in the initial stimulus suffered a reduction (to schwa) under stress shift (*button*, *mummy*). The same speaker produced the stimuli, following the same recording procedures. In order to create naturalistic stimuli the speaker followed a prepared script in which each word or phrase with altered stress was contrasted with the expected stress pattern, using the frame 'I didn't say BAby. I said *ba*BY'. Acoustic analyses of the stimuli were conducted in the same way as in Experiment 1 in order to ensure the comparability of the stimuli in the two list types for each experiment (see second and third tables of the Appendix).

Procedure

The procedure was identical to that used in Experiment 1.

Results

Misstressing (Experiment 2a) resulted in longer mean listening times to the familiar list type despite the altered prosody: $M = 5.33$s ($SD = 1.88$) for altered familiar vs. $M = 2.87$s ($SD = 1.67$) for altered rare ($t(11) = 5.84$, $p = .001$; Fig. 2). Eleven out of 12 infants attended longer in response to the misstressed familiar list type. Consistent with the results of Misstressing, Stress vs. misstress (Experiment 2b) produced the converse finding of no significant difference in listening times for the normally stressed familiar and the misstressed familiar list types: $M = 4.5$s ($SD = 2.18$) unaltered Familiar ('Stress') vs. $M = 4.35$s ($SD = 1.61$) altered Familiar ('Misstress'), ($t(11) = .22$, ns; Fig. 2). Five out of 12 infants attended longer in response to the normally stressed familiar list type. A mixed design ANOVA was performed with condition (contrasting list: unaltered familiar vs. altered rare) as between subjects factor and list type as within subjects factor. A significant interaction between list type and condition was found, indicating that infants listened to the misstressed familiar list type significantly longer when it was contrasted with the misstressed rare list type (Misstressing: $F(1, 22) = 10.44$, $p = .004$) than when it was contrasted with the normally stressed familiar list type (Stress vs. Misstress). Thus, contrary to our hypothesis, infants exposed to English showed no loss of familiar word and phrase recognition when the stress pattern was reversed (and no greater attention to normally stressed than to misstressed familiar list type when these were contrasted).

Discussion

The results of Experiments 2a and 2b, although contrary to our prediction, were coherent: Eleven-

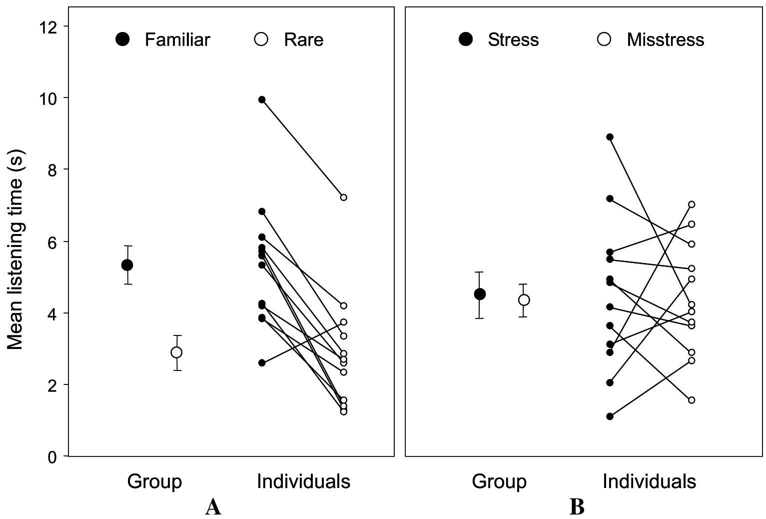

Fig. 2. (A) Altered stress familiar vs. altered stress rare (Misstressing, Experiment 2a); (B) Unaltered stress familiar vs. altered stress familiar (Stress vs. misstress, Experiment 2b). Individual children's mean listening times are plotted as well as group means and standard error bars.

month-olds seemed relatively insensitive to the stress change. Specifically, they recognized familiar words and phrases despite a stress shift, and they failed to show greater interest in familiar words and phrases with a normal stress pattern when they were heard in direct contrast with familiar words and phrases with inverted stress. These results suggest that the infants had a mental representation of the segmental pattern of the familiar items sufficient to detect the familiar forms even when they were misstressed, as if spoken in a foreign accent.

Because the results of Misstressing and Stress vs. misstress (Experiments 2a and 2b) were unexpected under the hypothesis that prosodic patterns would influence infant responses more than segmental patterns, we looked at the results in greater detail, examining the time-course of infant attention to familiar vs. rare word list types. Listening times were pooled separately for the first and the second half of each experiment, beginning with Baseline11 (Experiment 1b), which provides a baseline of infant responses to unaltered familiar stimuli. Since we wanted to trace the possible change in infants' relative attention to the two list types within the largest possible window in each case, and since the structure of the training and test trials is essentially the same, we included both training and test trials (four training and four test trials in the first half, eight test trials in the second half). Repeated measures ANOVAs were performed on the listening times obtained during the first and the second half of each experiment, with List and Time as within subject factors. Table 2 summarises the results.

For Baseline11 (Experiment 1b) the effect of List is significant, with greater attention to familiar than to rare words and phrases (see Table 2). The effect of Time is also significant, probably due to progressive fatigue in the infants as well as to habituation to the stimuli (see also Colombo & Bundy, 1983). However, in this experiment there is no List by Time interaction, which suggests that relative attention to the familiar list was consistent over the course of experiment (see Fig. 3).

A quite different time-course effect is seen in Misstressing (Experiment 2a). Here the List by Time interaction is significant; greater attention to the (misstressed) familiar words and phrases is evident only in the second half of the experiment (see Table 2 and Fig. 4). In Stress vs. misstress (Experiment 2b), on the other hand, we see a consistent decline in interest in both list types over the course of the experiment (Time effect, Table 2), as in Baseline11, with no List by Time interaction. The time-course pattern seen in Misstressing thus suggests an initial lack of greater attention to misstressed familiar words and phrases in comparison with the unknown lexical items. After a few trials the infants apparently adjust to (come to disregard) the misstressing and show longer listening to the familiar over the rare list type, presumably based on the segmental patterns alone. We return to this point in the General discussion.

Experiment 2 showed that, overall, misstressing without mispronunciation did not block word form recognition. This moves us to ask, would mispronunciation without misstressing have a stronger effect on word recognition? In order to further explore the interaction between segments and accentual pattern in infants' word form recognition we developed new stimuli, systematically modifying the initial and medial consonant of English trochaic words to test the flexibility of infant representations.

Table 2
Overview of time-course analyses of English and French experiments

Experiment No.	Name	Language group	Accent pattern	List effect	Time-course effect	List by time interaction
1b	Baseline11	English	Mixed	$F[1, 11] = 8.2, p < .02$	$F[1, 11] = 81.8, p < .001$	ns
2a	Mistressing	English	Mixed	$F[1, 11] = 13.0, p < .005$	$F[1, 11] = 14.9, p < .005$	$F[1, 11] = 7.2, p < .05$ (2nd)
2b	Stress vs. misstress	English	Mixed	ns	$F[1, 11] = 76.6, p < .001$	ns
3a	C1 change	English	**C̲V**CV	ns	$F[1, 11] = 15.2, p < .005$	ns
3b	C2 change	English	**CV**C̲V	$F[1, 11] = 7.6, p < .05$	$F[1, 11] = 10.3, p < .01$	($F[1, 11] = 4.1, p = .07$) (2nd)
2	Baseline11	French	CV**CV**	$F[1, 15] = 14.8, p < .005$	ns	ns
5	C1 change	French	C̲V**CV**	$F[1, 7] = 5.7, p < .05$	ns	($F[1, 7] = 4.6, p < .07$) (2nd)
6	C2 change	French	CV**C̲V**	($F[1, 11] = 3.4, p = .09$)	$F[1, 11] = 11.9, p = .005$	($F[1, 11] = 4.6, p = .05$) (1st)

Bold face indicates accented syllable; underlining indicates modified consonant. Where there is a significant List-by-time interaction, (1st) or (2d) refers to the half of the experiment in which a stronger P-ratio was found. (Marginally significant effects are in parentheses; ns, nonsignificant.)

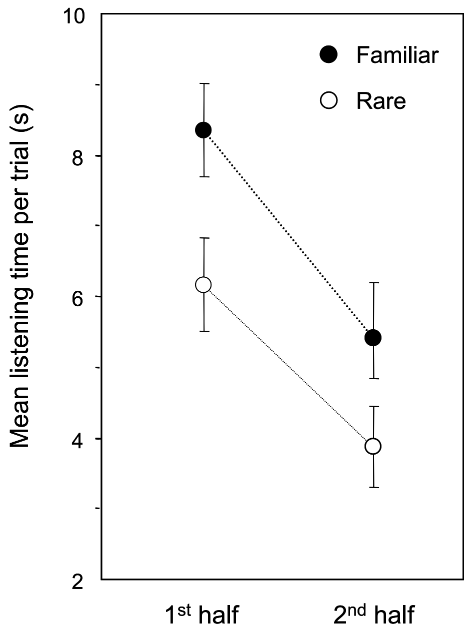

Fig. 3. List by Time interaction, Baseline11 (Experiment 1b). Mean group listening time in first vs. second half of experiment, including four training trials and 12 test trials.

Experiment 3

Since French words are primarily iambic while English words are primarily trochaic, we tested the hypothesis tentatively put forward by Hallé and Boysson-Bardies (1996) that it is the onset consonant of the accented syllable (the second for French iambs, the first syllable for English trochees) that critically anchors infant lexical representations. In order to do this we presented two pairs of contrasting stimuli to infants exposed to British English: Familiar trochaic words whose initial consonant was changed in manner of articulation, presented in contrast with a phonotactically and phonetically comparable set of rare trochaic words (ENG:C_1 change [Experiment 3a]), and the same trochaic words with the medial consonant changed in manner of articulation, presented in contrast with the same set of rare words (ENG:C_2 change [Experiment 3b]).

Participants

Two groups of 12 11-month-old infants each participated in Experiments 3a and 3b. The average ages of infants tested in these experiments were 48 weeks, 6 days for Experiment 3a (range: 47 weeks, 1 day to 50 weeks, 3 days) and 48 weeks, 3 days for Experiment 3b (range: 45 weeks, 5 days to 50 weeks, 6 days). There were 6 males and 6 females in the first group and 7 males and 5 females in the second group. An additional infant was

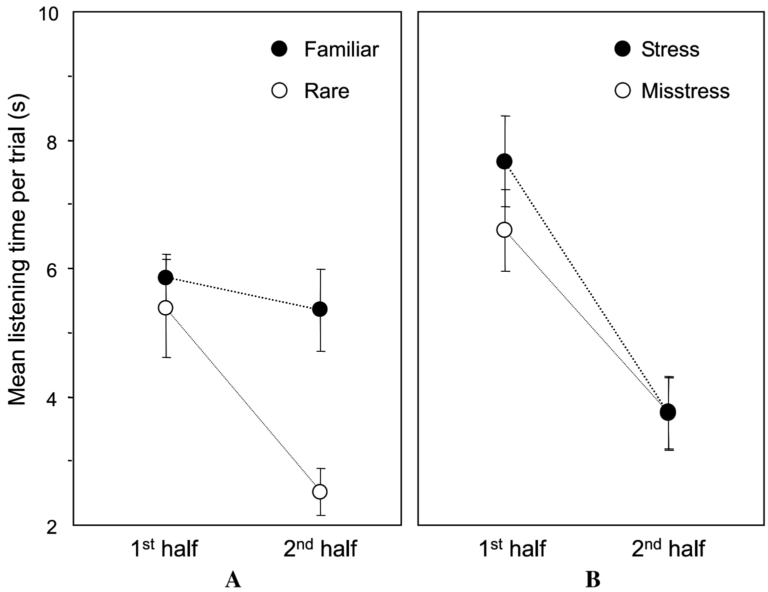

Fig. 4. List by Time interaction, Changes to stress pattern. (A) Misstressing (Experiment 2a) and (B) Sress vs. misstress (Experiment 2b). Mean group listening time in first vs. second half of experiment, including four training trials and 12 test trials.

tested in Experiment 3b but failed to complete the experiment due to crying.

Stimuli

A new set of familiar words were selected for this experiment, designed to begin with a singleton consonant which could be altered in manner of articulation to yield a possible English nonword in a straightforward manner (see Table 3). All but one of the words (*thank you*) also had a singleton medial consonant, to allow easy substitution by a consonant differing in manner of articulation. The mean number of infants reported to understand each word on the CDI ($N = 18$) was seven. Note that most of the altered forms are nonwords, although at least one is a real word which may be presumed to be unfamiliar to infants (*sickle*). The rare word list was designed to be comparable to the two altered familiar lists in terms of phonological complexity and types of phonemes. Again, Mann–Whitney tests were performed on the input frequencies of the consonants in each of the two altered familiar list types and the rare list type with reference to Mines et al. (1978). The results showed no significant difference between the two sets of list types ($z = -.88$, $p = .38$ for Familiar list type with altered initial consonant vs. rare list type; $z = -.54$, $p = .59$ for Familiar list type with altered medial consonant vs. rare list type). These stimuli were recorded by

Table 3
Stimuli used in Experiment 3 (all are trochaic)

Familiar word	Change C1	Phonetic transcrip.	Change C2	Phonetic transcrip.	Rare word	Phonetic transcrip.
bubbles	mubbles	/mʌbəlz/	bummles	/bʌməlz/	budget	/bʌdʒɪt/
buggy	muggy	/mʌgi/	bungy	/bʌŋi/	dinghy	/dɪŋi/
bunny	vunny	/vʌni/	buthey	/bʌði/	fitter	/fɪtə/
button	vutton	/vʌtən/	busson	/bʌsən/	gassy	/gæsi/
dinner	ninner	/nɪnə/	didder	/dɪdə/	meter	/mitə/
dirty	nirty	/nɜti/	dirny	/dɜni/	monger	/mɔŋgə/
doggy	noggy	/nɔgi/	dongy	/dɔŋi/	nubbins	/nʌbɪnz/
nappy	dappy	/dæpi/	nammy	/næmi/	piffle	/pɪfəl/
piggy	figgy	/fɪgi/	pingy	/pɪŋi/	saga	/sɑgə/
tickle	sickle	/sɪkəl/	tingel	/tɪŋəl/	tangy	/tæŋi/
tummy	summy	/sʌmi/	tuvvy	/tʌvi/	tenor	/tɛnə/
thank you	tank you	/tæŋkju/	thadge 'ou	/ɵædʒu/	zeboo	/zibu/

the same speaker as in the previous experiments, following the same general procedures. Also, the stimuli were measured acoustically to ensure that the two pairs of list types were equivalent (see fourth and fifth tables of the Appendix).

Procedure

The procedure was identical to that used in Experiment 1.

Results

In order to test the hypothesis that consonants would be better represented in stressed than in unstressed syllables, in experiment 3 we altered the manner of articulation of: (a) the initial and (b) the medial consonant in a list of trochaic English words. The infants failed to show a group difference in listening times between familiar and rare words when the initial consonant was changed: $M = 4.38$s ($SD = 1.51$) for initial consonant change familiar vs. $M = 4.05$s ($SD = 1.8$) for unchanged rare ($t(11) = .46$, ns; Fig. 5). Seven out of 12 infants listened longer to the altered familiar word list.

A separate group of 12 infants did listen significantly longer to the familiar words when the medial consonant was changed: $M = 5.33$s ($SD = 1.54$) medial consonant change familiar vs. $M = 3.29$s ($SD = 1.49$) unchanged rare ($t(11) = 3.05, p = .011$; Fig. 5). In this case, 11 out of 12 infants looked longer toward the altered familiar list. A mixed design ANOVA revealed that the interaction between list type (familiar vs. rare) and condition (initial vs. medial consonant change) is significant ($F(1,22) = 4.68$, $p = .042$), indicating that the infants listened significantly longer to the familiar list with altered medial consonants (Eng:C_2 change) than they did to the familiar list with altered initial consonants (Eng:C_1 change).

Discussion

Experiment 3 showed that the relation of the altered consonant to the accentual pattern affects the English infants' response: The infants fail to recognize familiar words when the accented syllable onset is changed but do recognize them when the unaccented syllable onset is changed. However, regardless of the accentual pattern there are good reasons to see the first consonant (or the first syllable as a whole) as 'special' for purely temporal processing reasons, based on various types of adult data. The initial consonant is heard and processed first, and thus provides the most efficient cue for lexical access, as emphasized by the cohort model (e.g., Marslen-Wilson, 1987; Marslen-Wilson & Tyler, 1978; see also Allopena, Magnuson, & Tanenhaus, 1998; Mattys & Samuel, 2000). This could be expected to apply to infants as well as adults. Consistent with this idea, an Event Related Potentials study of English 11-month-olds has shown that familiar monosyllabic and disyllabic words are distinguished by an involuntary brain response as early as 250 ms after stimulus onset—time for the infants to have heard only two or at most three phonemes of the familiar word (Thierry, Vihman, & Roberts, 2003). These findings support the importance of the initial consonant in infant processing of lexical form, at least for those exposed to English (see also Bailey & Plunkett, 2002; Jusczyk & Aslin, 1995; Swingley & Aslin, 2002).

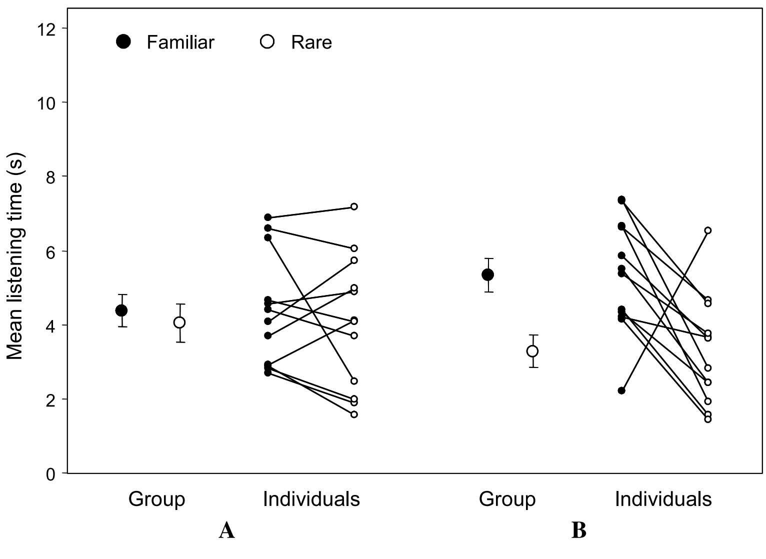

Fig. 5. (A) Familiar (with C1 change) vs. rare (Eng:C_1change, Experiment 3a); (B) Familiar (with C2 change) vs. rare (Eng:C_2change, Experiment 3b). Individual children's mean listening times are plotted as well as group means and standard error bars.

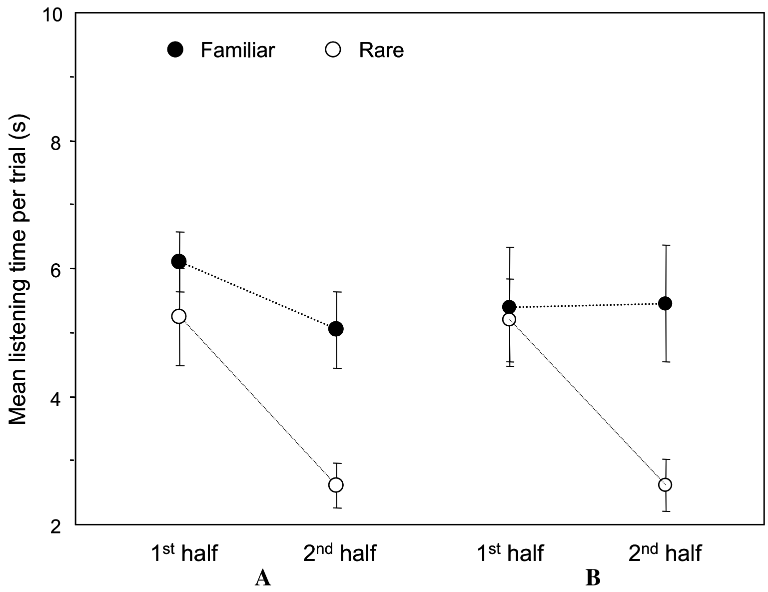

Fig. 6. List by time interaction, Changes to unaccented syllable. (A) ENG:C_2change (Experiment 3b), and (B) FRENCH:C_1change (Experiment 5, Hallé & Boysson-Bardies, 1996). Mean group listening time in first vs. second half of experiment, including 4 training trials and 12 test trials (English) or six training trials and 10 test trials (French).

Adult speech errors, which disproportionately affect word onsets, also suggest a special status for the initial consonant—in speech planning, in this case (Frisch, 2000; Shattuck-Huffnagle, 1987), while adult tip-of-the-tongue phenomena, or errors of lexical access based on phonological associations (malapropisms), in which the wrong word is recalled, testify to the special status of the initial consonant in adult memory for words (Fay & Cutler, 1977). Indirect evidence from Arabic (Frisch, 2000) suggests that the primacy of the initial consonant may not be specific to English or to the accentual characteristics of English. Rather, Frisch argues that this is 'a general cognitive phenomenon affecting the perceived similarity of initial consonants that is caused by the process of lexical access and phonological encoding' (p. 294).

In order to test the relative importance for infant word form recognition of accentual pattern in comparison with the possibly universal primacy of word onsets in auditory processing we undertook time-course analyses of both the data resulting from our own English C_1 and C_2 change experiments and the original data testing the effect on French infants of C_1 and C_2 change (Hallé & Boysson-Bardies, 1996).[2] Consider first the effect of onset-consonant change in the *unaccented syllable* in both languages (ENG:C_2 change [Experiment 3b], FRENCH:C_1 change [Experiment 5, Hallé & Boysson-Bardies, 1996). List is significant in both languages (Table 2), while Time shows a significant decline in English but not in French. However, the time-course analysis reveals the same (marginally significant) List by Time interaction in both language groups: Familiar words with altered onset consonant in unaccented syllable tend to elicit increased attention in the second half of the experiment (Table 2 and Fig. 6). Thus the significantly longer overall attention to familiar words observed in both ENG:C_2 change (Experiment 3b) and FRENCH:C_1 change (Experiment 5, Hallé & Boysson-Bardies, 1996) are largely due to the second half of the experiment, or later trials. This is the same List by Time interaction that we saw in the case of Misstressing, suggesting a tendency for infants to recognize deviant familiar word forms only in the later trials, with little difference between the two list types in the first few trials. The effect is very similar in the two language groups.

In contrast, a different time-course effect is seen in the case of change to the onset consonant of *accented syllables* in English vs. French. The time-course analysis for ENG:C_1 change (Experiment 3a) most resembles the stress vs. misstress case (Experiment 2b): The two list types are not distinguished by listening time (List: ns), there is a decrease in interest over the course of the experiment (Time effect: Table 2), and there is no significant List by Time interaction (Table 2). In the case of FRENCH:C_2 change (Experiment 6, Hallé &

[2] The French experiments included 6 training and 12 test trials; in order to keep the total number of trials comparable across studies the last two test trials for French were not included in the analyses. For comparison we also included in our time-course analyses the French Experiment 2, which we term FRENCH:Baseline11. Here, as in ENG:Baseline11, there is no List by Time interaction: See Table 2.

Boysson-Bardies, 1996), on the other hand, there is a marginal List effect, a highly significant Time effect, and a marginal List by Time interaction which is the opposite of that seen in the case of unstressed onset consonant change (Table 2): The familiar but mispronounced words tend to elicit more attention than the rare words only in the *first* half of the experiment.

Fig. 7 shows the time-course effect for accented syllable change in the two languages. We see here that, for English, change to the consonantal onset in accented syllable effectively disguises the familiar words, while for French the effect is less dramatic. In early trials the French infants appear to be 'fooled' by the familiar initial (unaccented) syllables, but by the later trials the mispronounced familiar words no longer hold their attention to a greater extent than the unknown words. We take up the interpretation of these findings in relation to the issue of accentual pattern vs. primacy of word onset in the General discussion.

General discussion

We began by replicating with infants exposed to British English the finding reported by Hallé and Boysson-Bardies (1994), that 11-month-olds will respond with longer listening times to an untrained list of lexical items likely to be familiar from the home (Experiment 1). We also found that as a group 9-month-olds failed to respond differentially to familiar vs. rare lists, suggesting that they had not yet developed stable representations of enough of the lexical items to recognize them outside of an appropriate situational context. We followed up these findings with experiments designed to explore two aspects of early representations for familiar lexical items: (1) the relative importance or salience of prosodic vs. segmental patterning and (2) the interaction between accent and level of segmental detail in infants' representations of familiar words.

With respect to the relation of prosodic and segmental patterning, Experiment 2 produced results that went counter to our initial hypothesis. Based on the importance of prosodic patterns in holding infant attention over the first several months of life, we predicted that at 11 months prosodic pattern would constitute the most essential aspect of familiar words or phrases. Instead, we found that misstressed lexical units held infant attention when pitted against a contrasting list of mistressed rare items, while normally stressed familiar words and phrases held infant attention no longer than the contrasting misstressed familiar list type. The status of prosody in untrained word form recognition has not been directly tested before, but our results fit smoothly into the developmental picture outlined in the introduction. As noted earlier, in the past few years several studies taken together have suggested that infants make a gradual shift in the middle of the first year from familiarity primarily with native language prosodic patterns to recognition of a range of segmental patterns as well. Our findings provide evidence that by 11 months

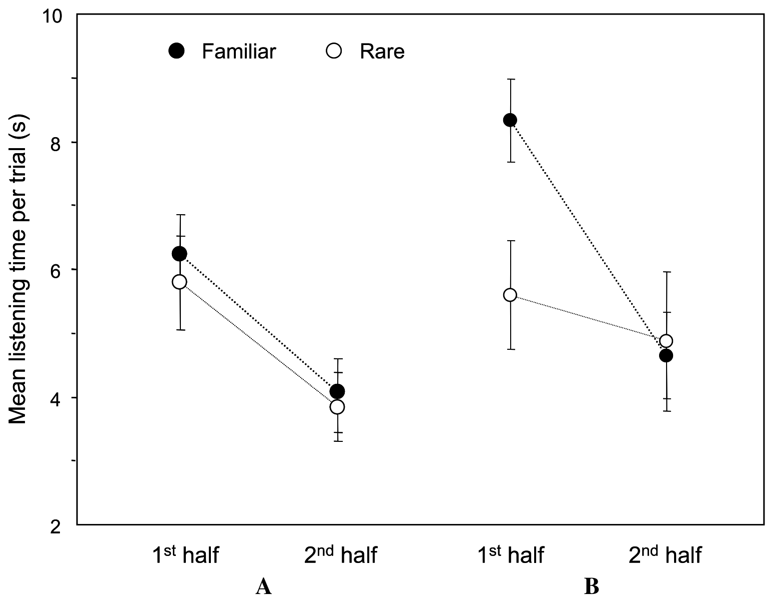

Fig. 7. List by time interaction, Changes to accented syllable. (A) ENG:C_1change (Experiment 3a), and (B) FRENCH:C_2change (Experiment 6, Hallé & Boysson-Bardies, 1996). Mean group listening time in first vs. second half of experiment, including 4 training trials and 12 test trials (English) or six training trials and 10 test trials (French).

infants have developed a representation of familiar lexical items that is sufficiently well specified for segmental sequence to permit the infants to disregard an unexpected accentual contour after only a small delay, 'listening through' misstressing to recognize the familiar words and phrases after a few trials.

Experiment 3 was designed to test the role of accentual contour in a different way, by manipulating the onset consonant of the stressed vs. the unstressed syllable. The study was meant to complement the results with French infants reported by Hallé and Boysson-Bardies (1996), who demonstrated that modification of the initial consonant of French familiar words in either voice or manner of articulation failed to block infant recognition, although omission of the initial consonant did have that effect. Hallé and Boysson-Bardies concluded from this that word representation at this age and level of lexical development is underspecified, or 'global rather than analytic' (p. 471). However, the study reported mixed findings with respect to modification of the manner of articulation of C_2. On the one hand, infants failed to listen longer to unaltered familiar words when these were contrasted with the same words with a changed second consonant (see note 1, p. 475: This experiment is comparable to our Experiment 2b, Stress vs. misstress, in that changed vs. unchanged versions of a single familiar list type are presented to the infants instead of a set of familiar words in contrast with a set of rare words, as in the other experiments.) On the other hand, another group of French infants failed to listen significantly longer to changed-C_2 familiar words than to a set of rare words, suggesting that the familiar words could *not* be recognized when C_2 was altered (Experiment 6, whose time-course is analysed here).

The English results are more clear-cut with respect to consonant changes: They validate our initial hypothesis, that changes to the onset consonant of the accented syllable will block word recognition while changes to the onset consonant of the unaccented syllable will not. This supports the idea of the stressed syllable as the anchor for infant word representations, an idea long suggested by the literature in word production studies (see Vihman, 1996, Chap. 9). More recent indirect evidence of the role of prosodic pattern in child word representations can be drawn from cross-linguistic differences in the incidence of word-initial consonant omission in early child productions. Whereas such omission is rare in English, it is common in Finnish (Savinainen-Makkonen, 2000; Vihman & Velleman, 2000), where medial geminate consonants appear to draw child attention away from word-initial position, and also to some extent in French and Welsh (Vihman, 2000). In French, it is the final vowel lengthening and iambic patterning that can plausibly be taken to reduce attention to the initial consonant; in Welsh both final vowel lengthening and long medial consonants characterize most accented disyllables (Vihman, Nakai, & DePaolis, in press; Williams, 1986).

However, notice that our findings present an apparent paradox in relation to the results of Experiment 2. If stress is not an essential part of the infants' representation of lexical units at this age, then why should changes to the onset consonant of stressed syllables affect them differently than changes to the onset consonant of unstressed syllables? One way to resolve this paradox is to note that whereas evidence of infant word form recognition in the absence of relevant situational cues suggests representation in memory, infant *failure* to react to a change in linguistic form need not be interpreted as the result of underrepresentation. It is also plausible that it is the weaker acoustic signal for the unstressed syllable in the experimental stimuli that leads infants to miss a change in onset consonant in unstressed but not in stressed syllable.

Let us consider further the relation of stress or accent to infant word form recognition, taking the time-course analyses of English and French together. The results with regard to alteration of the onset consonant in the unaccented syllable are essentially the same in the two language groups: Infants show recognition of the familiar words despite the mispronunciation, but there is a tendency for this recognition to emerge in the latter half of the experiment, suggesting an initial difficulty adapting to the oddly pronounced words (Fig. 6). In the case of alteration of the onset consonant in the accented syllable, the infants' response differs by language group: Such a change blocks recognition in English but does not block it as completely in French. In the case of C_2 (accented syllable) change in French, there is a marginal tendency for infants to attend longer to the changed familiar than to the rare words in the early trials, with a subsequent fading of this difference in allocation of attention (List by Time interaction, Table 2). This suggests that the infants may initially be misled by the intact first syllable into responding to the familiar words, with a loss of interest in the later trials as the words fail to sound familiar after all.

There are at least two alternative ways to account for a difference in the effect of changing the onset consonant of the accented syllable in French vs. English. On the one hand, French is known to have relatively weak word-stress (or phrase-stress—since words are typically accented only in phrase-final position: Cruttenden, 1986); in fact, for French the term 'accent' is generally preferred over the term 'stress,' since there is no increase in amplitude on the accented syllable but instead a lengthening and in some cases a pitch change (Delattre, 1965). English, on the other hand, is known for its strong stress, with vowel reduction a common concomitant of the unstressed syllable (Cruttenden, 1986; Cutler & Carter, 1987). English and French, respectively, are considered models of the two contrasting types, 'stress-timed' and 'syllable-timed' languages, a long-standing intuitive classification for which investigators are still seeking the relevant acoustic correlates (see Grabe & Low, 2002; Ramus, Nespor, & Mehler, 1999). It is possible, then, that the effect of changing the onset consonant of the accented syllable is experienced differently by infants acquiring a language in which the accented syllable is prominent (as in English) vs. a language in which the accented syllable is less acoustically salient (as in French). Experimental work with a language with an acoustically prominent iambic stress pattern would be needed here.[3]

On the other hand, the various kinds of evidence for the primacy of word onset in auditory processing and representation that we reviewed above suggest that an interaction of accentual pattern with temporal processing factors may provide the most satisfactory interpretation of our findings. The 'special status' of the initial consonant should in principle be relevant for perceptual processing regardless of accentual pattern, since: (a) an initial consonant is preceded by no distracting segments (when the word is heard in isolation), while a medial consonant, even in syllable onset, lacks this advantage, and (b) the initial consonant 'meets the ear' first and thus has the potential to be processed first in lexical access. Recall, however, that changes to the first consonant (onset of the unaccented syllable) were disregarded by the French infants just as were changes to the second consonant in English (onset of the unaccented syllable). In English, initial consonants may be salient *both* because of the typically trochaic word pattern and because the first consonant has a natural temporal processing advantage. In French, on the other hand, the second syllable has the benefit of accent-based lengthening (in the experimental situation as well as in the child's representation in memory) but the first (unaccented) syllable has the advantage in terms of temporal processing. Our findings suggest that *both* the privileged status of the first consonant in processing *and* the salience afforded by accentual pattern are likely to be relevant to the infants' responses: Where the two factors operate together, as in English, to support the salience and/or memorability of the initial syllable, change to C_1 has a definitive effect in blocking infant word form recognition. However, where, as in French, the two factors work in opposite ways, the effects are different. Here change to (accented) C_2 failed to block recognition completely, while change to (unaccented) C_1 merely delayed word form recognition, as did misstressing in English.

A few conclusions are warranted by our findings. First, we see that misstressing does not block word recognition by 11-month-olds. At the same time, the List by Time interaction in the infants' recognition of misstressed words indicates that misstressing does slow down or delay infant word form recognition, even though it does not block it. Thus, accentual pattern does form a part of infants' lexical representations at 11 months. Infant response to the 'deviant' stimuli depends on the contrast presented in a given experiment, however: When misstressing combined with correct segmental pattern in familiar words is contrasted with unknown words, segmental pattern is well enough established in infants' representations of familiar lexical items to permit (delayed) recognition. However, when misstressed familiar words and phrases are pitted against normally stressed familiar words and phrases, infants give no more attention to the one than to the other.

Mispronunciation of the onset consonant in an unaccented syllable had only a minor effect on infant recognition of familiar words in either English or French (familiar words were recognized; there was a marginal tendency for later trials to show an increase in the difference in time listening to familiar words as compared to rare words). Change to the accented syllable had a stronger effect in both languages, blocking recognition in both English and French, although the effect was more immediate in English. Thus, accentual pattern does have an effect on word recognition here, whether this effect is due to the greater salience of the accented syllable in the signal to which the infant is exposed in the course of the experiment or to the long-term experience of hearing familiar words accented in a particular way. We conclude that both segmental and prosodic information play a role in the recognition of lexical forms at 11 months, as they do for adults (Cutler & Clifton, 1984).

Acknowledgments

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[3] Although in principle a complementary experiment with infants exposed to English would be helpful, in practice it is difficult to compile a sufficiently varied list of iambic words or phrases which we can expect infants to have heard frequently by 11 months. As noted earlier, there are few early learned iambic words, and iambic phrases involve a limited range of function words in the unstressed position, many of them vowel-initial.

Appendix

Comparison of F0, amplitude and duration between familiar and rare words and phrases (Experiment 1)

	Word tpe		t Value, level of significance (two-tailed)
	Familiar	Rare	
F0 average (Hz)	169 (7)	165 (5)	$t(22) = 1.12$, $p = .27$
F0 min (Hz)	140 (5)	144 (7)	$t(22) = -1.85$, $p = .08$
F0 max (Hz)	186 (7)	197 (19)	$t(22) = -1.84$, $p = .08$
Amplitude (rms V)	0.61 (.18)	0.61 (.17)	$t(22) = 0.07$, $p = .95$
Duration (ms)	562 (116)	578 (72)	$t(22) = -0.43$, $p = .67$

Values in parentheses are *SD*.

Comparison of F0, amplitude and duration between altered familiar and altered rare words and phrases (Experiment 2)

	Word type		t Value, level of significance (two-tailed)
	Altered familiar	Altered rare	
F0 average (Hz)	163 (8)	165 (5)	$t(22) = -.69$, $p = .50$
F0 min (Hz)	138 (8)	139 (4)	$t(22) = -.35$, $p = .73$
F0 max (Hz)	201 (15)	202 (12)	$t(22) = -.06$, $p = .95$
Amplitude (rms V)	.60 (.01)	.61 (.02)	$t(22) = -.96$, $p = .35$
Duration (ms)	631 (108)	603 (81)	$t(22) = .73$, $p = .47$

Values in parentheses are *SD*.

Comparison of F0, amplitude and duration between unaltered familiar and altered familiar words and phrases (Experiment 2)

	Word type		t Value, level of significance (two-tailed)
	Unaltered familiar	Altered familiar	
F0 average (Hz)	166 (6)	163 (6)	$t(22) = 1.10$, $p = .29$
F0 min (Hz)	137 (4)	137 (9)	$t(22) = -.18$, $p = .86$
F0 max (Hz)	201 (11)	203 (11)	$t(22) = -.63$, $p = .54$
Amplitude (rms V)	.66 (.18)	.68 (.11)	$t(22) = -.29$, $p = .77$
Duration (ms)	587 (128)	640 (106)	$t(22) = -1.10$, $p = .28$

Values in parentheses are *SD*.

Comparison of F0, amplitude and duration between altered familiar and rare words (C1 change, Experiment 3)

	Word type		t Value, level of significance (two-tailed)
	Familiar (C1 change)	Rare	
F0 average (Hz)	178 (5)	178 (7)	$t(22) = .04$, $p = .97$
F0 min (Hz)	151 (5)	151 (5)	$t(22) = .07$, $p = .94$
F0 max (Hz)	208 (11)	212 (12)	$t(22) = .85$, $p = .41$
Amplitude (rms V)	.70 (.03)	.71 (.03)	$t(22) = -.17$, $p = .87$
Duration (ms)	579 (83)	572 (81)	$t(22) = -.20$, $p = .84$

Values in parentheses are *SD*.

Comparison of F0, amplitude and duration between altered familiar and rare words (C2 change, Experiment 3)

	Word type		t Value, level of significance (two-tailed)
	Familiar (C2 change)	Rare	
F0 average (Hz)	178 (5)	178 (7)	$t(22) = .07$, $p = .94$
F0 min (Hz)	152 (6)	151 (5)	$t(22) = -.15$, $p = .88$
F0 max (Hz)	214 (10)	212 (12)	$t(22) = .42$, $p = .68$
Amplitude (rms V)	.71 (.01)	.71 (.03)	$t(22) = -.66$, $p = .52$
Duration (ms)	532 (78)	572 (81)	$t(22) = 1.21$, $p = .24$

Values in parentheses are *SD*.

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