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Coping with dialects from birth: Role of variability on infants' early language development. Insights from Norwegian dialects

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Abstract

Previous research suggests that exposure to accent variability can affect toddlers' familiar word recognition and word comprehension. The current preregistered study addressed the gap in knowledge on early language development in infants exposed to two dialects from birth and assessed the role of dialect similarity in infants' word recognition and comprehension. A 12-month-old Norwegian-learning infants, exposed to native Norwegian parents speaking the same or two Norwegian dialects, took part in two eye-tracking tasks, assessing familiar word form recognition and word comprehension. Their parents' speech was assessed for similarity by native Norwegian speakers. First, in contrast to previous research, our results revealed no listening preference for words over nonwords in both monodialectal and bidialectal infants, suggesting potential language-specific differences in the onset of word recognition. Second, the results showed evidence for word comprehension in monodialectal infants, but not in bidialectal infants, suggesting that exposure to dialectal variability impacts early word acquisition. Third, perceptual similarity between parental dialects tendentially facilitated bidialectal infants' word recognition and comprehension. Forth, the results revealed a strong correlation between the raters and parents' assessment of similarity between dialects, indicating that parental estimations can be reliably used to assess infants' speech variability at home. Finally, our results revealed a strong relationship between word recognition and comprehension in monodialectal infants and the absence of such a relationship in bidialectal infants, suggesting that either these two skills do not necessarily align in infants exposed to more variable input, or that the alignment might occur at a later stage.

KEYWORDS
dialect, infant, language development, speech variability, word comprehension, word recognition

1 | INTRODUCTION

1.1 | Word representations in monodialectal infants

Human speech is an acoustic signal composed of bursts, hisses, vocalizations and voice modulations, that a child will learn to perceive as a sequence of meaningful units, for example, words (Gervain & Werker, 2008). This is a challenging task. First, in fluent speech, there are no systematic pauses between words to segment them. Second, and most important, words are produced differently, that is, have physically different acoustic signals, across speakers (Jaeger & Weatherholtz, 2016; Peterson & Barney, 1952), and contexts (Steinlen, 2005), meaning that there is no robust mapping between an acoustic signal and a word. In order to learn and recognize words efficiently, the child has to discover which acoustic detail allows to distinguish meaning in her language, that is, *lexically relevant cues* (e.g., changes in voice onset time to distinguish the English "bed" and "pet"), and which are not (e.g., gender-related changes in pitch or affect-related changes in pitch amplitude).

Adapting to speech variability requires considerable experience and language exposure. While 6- to 8-month-old infants recognize words produced by familiar speakers (Bergelson & Swingley, 2012, 2013; Tincoff & Jusczyk, 2012), they fail to recognize a newly learnt word, if it is produced in a different affect (Singh et al., 2004) or voice (Houston & Jusczyk, 2000) from what was used during learning. These studies suggest that young infants stock in memory all acoustic details, between and within-talker, present in variable speech, even if they are *lexically irrelevant*. It is only by the end of the first year that infants start processing speech variability in adult-like way: they understand words across speakers (Houston & Jusczyk, 2000) and affects (Singh et al., 2004), and show reliable speaker-independent recognition of familiar words over nonsense words (Hallé & Boysson-Bardies, 1994).

Yet, effective language use entails the ability to understand speakers across accents (e.g., dialects and foreign accented speech), who might differ in phonetic detail from the familiar (native) accent, but preserve the phonological structure of a word. For instance, the word "bat" is produced /bæt/ in South England but /bɑt/ in England's East midlands regions. Adaptation to dialectal variation relies on phonological constancy, that is, the ability to disregard the phonetic (accented) variations and to capitalize on the phonological structure of the word in order to recognize it (Best et al., 2009). This ability has been shown to develop between 19 and 22 months of age (Best et al., 2009; van Heugten & Johnson, 2014), that is, almost 1 year after that infants start mastering word recognition in their native (familiar) accent, suggesting that adaptation to dialectal variability requires more robust and/or mature phonological representations of words.

However, infants might show phonological constancy even earlier, at the age of 15 months, if they had been familiarized with the accent/dialect prior to the test (van Heugten & Johnson, 2014). Fifteen-month old Canadian English-learning infants who heard a familiar story in unfamiliar Australian English accent showed listening preference for the known words as compared to the nonsense words, suggesting that they had recognized words produced in unfamiliar accent. Therefore, brief exposure to unfamiliar accented speech promotes the mappings between the sounds and the words in unfamiliar accent and in the native accent, and boosts infants' word recognition across accents (phonological constancy). Other studies have shown that speaker variability augments phonological processing in word learning in 14-month-old infants (Rost & McMurray, 2009). Given these results, one might expect that infants exposed to dialectal variability from birth should show reliable word recognition in familiar dialects. Yet, recent studies on multidialectal infants suggest that variability does not benefit phonological processing, but, on the other hand, hinders the establishment of stable word representations (Buckler et al., 2017; Durrant et al., 2015; Floccia et al., 2012; van Heugten & Johnson, 2017).

Research Highlights

- We examined the role of dialectal exposure from birth on early word comprehension and phonological word form recognition in 12-month-old Norwegian infants.
- Unlike English and French peers, neither mono- nor bidialectal 12-month-old Norwegian infants recognized familiar words, suggesting cross-linguistic differences in the onset of word recognition.
- Monodialectal, but not bidialectal infants showed evidence of word comprehension, suggesting that early exposure to dialects might affect word comprehension in bidialectal infants.
- Performance in the word recognition and word comprehension tasks were highly correlated in monodialectal infants, but not in bidialectal infants.

1.2 | Word representations in bidialectal infants

So far, by the time we submit the final paper, six studies[1] – performed by two research groups – have examined early word knowledge in infants and toddlers naturally exposed to one versus two dialects (Buckler et al., 2017; Durrant et al., 2015; Floccia et al., 2012; van der Feest & Johnson, 2016; van Heugten & Johnson, 2017). The youngest age group examined so far refers to infants of 12.5-months of age. Van Heugten and Johnson (2017) assessed mono-dialectal and multidialectal infants' preference for familiar over nonsense words, using the Headturn Preference paradigm. The results revealed that 12.5- to 14.5-month-old infants exposed to multiple dialects (~33% of exposure to Canadian English and ~65% to other variants of English, which included foreign-accented English[2]) failed to show preference for familiar over nonsense words produced in the dominant regional accent (Canadian English), whereas infants receiving uniform input succeed in this task. The authors concluded that exposure to multiple accents impacts the precision/quality of early word representations, which are less constrained in 12.5- to 14.5-month-old multidialectal infants, as compared to infants receiving uniformly accented speech.

Word comprehension studies in older bidialectal infants/toddlers, on the other hand, suggest that infants' word representations are dialect-sensitive and reflect the properties of the incoming speech (Durrant et al., 2015; van der Feest & Johnson, 2016). At 20 months of age, bidialectal infants detect only those mispronunciations that concern the specific details that vary across dialects, as, for example, vowel mispronunciations for infants exposed to South and East England dialects, yet they disregard consonant mispronunciation (Durrant et al., 2015). At 24 months of age, infants show dialect-sensitive accurate knowledge of the phonological categories in both Dutch dialects: multidialectal infants adapt their phonological expectations based on the phonetic contrastive cues relevant for a speaker's dialect (van der Feest & Johnson, 2016). So, the same type of mispronunciation, for example voicing of a devoiced fricative consonant, is detected as "error" in the dialect that maintains voicing contrasts, but is disregarded in the dialect that devoices fricatives (although see Floccia et al., 2012 for infants' preference for community dominant accent). These results concord with previous research in monodialectal and bilingual infants showing that infants are sensitive to fine-grained acoustic features of parental input (Cristia, 2011) and use them to build their phonemic representations (Bosch & Ramon-Casas, 2009, 2011).

In sum, the results of a handful of available studies in bidialectal (English or Dutch learning) infants suggest that exposure to two dialects hinders the establishment of stable word form representations in young 12.5- to 14.5-month-old infants (one study only), but benefits later word processing, as 24-month-old bidialectal toddlers demonstrate dialect-specific sensitivity to the incoming speech and efficient word recognition (van der Feest et al., 2022).[3] However, due to differences in task (word form recognition in 12.5- to 14.5-month-old infants and word comprehension and mispronunciation sensitivity in 20- to 24-month-old infants) and accent type (native vs. foreign) between studies, the developmental trajectory of word form recognition and word comprehension in bidialectal infants remains unclear.

1.3 | Factors boosting accent adaptation

Studies in monodialectal infants have shown that, under specific conditions, infants can show adaptation to an unfamiliar accent (including foreign) even before the critical 19 months of age (Best et al., 2009; Mulak et al. 2013; van Heugten et al., 2018). For example, 12- and 15-month-old infants can recognize familiar words in unfamiliar-accented speech, if they have been familiar with this unfamiliar accent prior to the test (van Heugten & Johnson, 2014) or when the unfamiliar accent variant was very close to their native accent (Schmale et al., 2010), respectively. Is it possible that dialectal similarity (accent distance between dialects) and dialect (accent) exposure, factors facilitating accent adaptation in monodialectal infants, influence early language development in bidialectal infants who are naturally exposed to two dialects?

Schmale et al. (2012) suggested that the amount of accent variability in language input can modulate infants' adaptation strategy when faced with unfamiliar dialects. The authors distinguished two adaptation strategies, lexical specific and general. Infants exposed to little inconsistency in dialectal input are likely to use lexical top-down strategy to accommodate accents (see also White & Aslin, 2011). Lexical strategy relies on clear evidence of differences in pronunciation between dialects (e.g., /bæt/ in South England but /bɑt/ in England's East midlands regions) and is facilitated by the presence of visual cues (e.g., pictures of objects as in the word comprehension task). In line with this hypothesis, 12-month-old monodialectal infants have been shown to recognize familiar words produced in an unfamiliar accent minimally different from the native one (Schmale et al., 2010). In contrast, infants exposed to highly inconsistent input, when dialects differ along a number of dimensions, including segmental and suprasegmental cues, are likely to use a general expansion strategy, which may require an expansion (or relaxation) of phonemic categories in order to accommodate deviating examples (Schmale et al., 2012). The general expansion strategy might have negative consequences, as infants can erroneously accept close speech sounds as being members of the same category, for example, /sek/ and /sæk/ can be perceived as good candidates of /sak/ "sock" (White & Aslin, 2011). In line with this hypothesis, 24-month-old Canadian-English infants, exposed to at least one foreign-accented caregiver, showed delayed and less efficient word comprehension, as compared to infants exposed to uniform input (Buckler et al., 2017). These results align with previous research showing that inconsistencies in parental speech are inversely related to the accuracy of early phonemic representations in infancy and childhood (Bosch & Ramon-Casas, 2009, 2011; Mayr & Montanari, 2015). Note that, while 18-month-old monodialectal infants tolerate some deviations in foreign-accented speech and use lexical strategy to recognize familiar word forms, they fail to recognize mispronounced versions of words produced in foreign-accented speech, suggesting that monodialectal infants do not accommodate (severe) phonological deviations (at least in the absence of a referent, as shown in van Heugten et al., 2018). In sum, although previous research suggests that the degree of dissimilarity in pronunciation between parental accents might modulate the quality of infants' early word representations, with highly dissimilar variants leading to coarser word representations, yet, to the best of our knowledge, no study, so far, has examined this question empirically.

Studies in young monodialectal infants have shown that accent exposure can boost infants' adaptation to (unfamiliar) regional and foreign accents. For instance, as little as 2 min of exposure can enable monodialectal infants to segment and recognize words produced in unfamiliar accents (Schmale et al., 2012; van der Feest & Johnson, 2016; van Heugten & Johnson, 2014). In general, research in monodialectal infants has shown a linear positive relationship between the quantity of language input/exposure and infant's vocabulary size (Legacy et al., 2018; Rowe, 2012). Similarly, research in bilingual toddlers revealed a strong relationship between a child's early language development (vocabulary size and grammatical complexity) and the amount of input she receives in that language (Hoff et al., 2012). Interestingly, there was no relationship between these skills across languages (Hoff et al., 2018), suggesting that input contribution is language-specific.[4] Yet, studies in bidialectal infants showed either no relationship between the amount of dialectal exposure and infants' ability to recognize (van Heugten & Johnson, 2017) and understand words in this dialect (Buckler et al., 2017; Durrant et al., 2015), or infants' indifference to the frequency of accent exposure, with better word recognition in a community dominant accent (Floccia et al., 2012). Therefore, more research is needed to understand the role of dialect exposure in bidialectal infants' word form recognition and word comprehension abilities.

1.4 | The current study

The current study fills a gap in bidialectal developmental literature and examines word recognition and word comprehension in 12-month-old Norwegian-learning infants exposed to two Norwegian dialects spoken by native speakers of Norwegian. To the best of our knowledge, this is the first study that examines language development in Norwegian infants exposed to dialects, which is very common in Norway. The first aim of our study is to replicate, conceptually, in Norwegian infants exposed to bidialectal Norwegian speech, the results of van Heugten and Johnson (2017) study with multidialectal Canadian–English infants (one third of them were exposed to foreign-accented English). The second aim of our study is to extend our knowledge on early language development in multidialectal infants by directly examining their comprehension of familiar words (including the temporal dynamics analysis), using an eye-tracker and an intermodal preferential looking (IPL) task, and comparing it to their word recognition skills. Although both tasks share a recognition component, they do not tap into the same processes. While word recognition informs about infants' ability to recognize familiar word forms over similar-sounding unfamiliar ones (infants' development of sensitivity to phonological distinctiveness, Best et al., 2009), word comprehension task provides insights into infants' development of word-object mappings (lexico-semantical knowledge). Therefore, successful word recognition (preference for familiar words) might operate in an absence of an established mapping between this word and its referent; likewise, successful word comprehension might operate in an absence of accurate word phonological representation, as infants can use semantical/contextual (Bergelson & Aslin, 2017a, 2017b), perceptual (Arias-Trejo & Plunkett, 2010), and frequency (Kartushina & Mayor, 2019) cues to disambiguate between objects and show word comprehension even when items are mispronounced (Mani & Plunkett, 2010). To the best of our knowledge, the current study would be the first to examine the relationship between word recognition and word comprehension abilities in 12-month-old infants. Importantly, the third aim of the study is to assess, for the first time, the role of dialectal similarity and dialectal exposure on infants' ability to recognize and understand words.

In Oslo and its surroundings, it is not uncommon that Norwegian parents speak different dialects to their infants (around 50% of families who took part in previous research), providing thus rich but often inconsistent linguistic input as compared to infants growing up in monodialectal families. For instance, a child growing up in a bidialectal family has to learn, similarly to monodialectal Norwegian infants, that some differences in sound production between parents are language-specific and lexically relevant (e.g., changes in vowel height /y/-/ø/, as in *lys* "light" vs. *løs* "loose" and changes in vowel length /ɑ/-/ɑː/, as in *takk* "thanks" vs. *tak* "roof"). However, in addition, they are to discover that some of these differences are dialect-specific and lexically irrelevant (e.g., trill or tap /ɾ/ in Eastern dialect (Oslo region) vs. uvular /ʁ/ in Western dialect [e.g., Bergen], so /ɡoːɾ/ vs /ɡoːʁ/ refer to the same word *gård* "farm"). Bearing in mind that there are also differences in the use of lexical and phrasal tones between some Norwegian dialects, retrieving lexically relevant cues and building representations for words might become a very challenging task for a bidialectal Norwegian child.

In the current study, we examined word recognition and word comprehension in two groups of Norwegian infants: monodialectal infants receiving similar input from both parents speaking the Oslo (Eastern) dialect, and bidialectal infants exposed to the Oslo dialect and to a different type of Norwegian dialect (that can belong to one of the remaining three group-types of dialects: Western, Central, and Northern). All four types of dialects are mutually intelligible, but clearly recognizable even by an untrained ear for their differences at segmental and suprasegmental levels, that is, the phonetic realization of a number of sounds (or their omission) and the use of lexical pitch accents[5] (Johnsen, 2012; Kerswill, 2016; Mæhlum & Røyneland, 2012; Røyneland, 2009), but also for their differences at morpho-syntactic (in particular related to differences in gender attribution for words) and lexical levels. Word recognition was tested using the Visual Fixation paradigm (as in Frank et al., 2020), where infants heard, in a random order, eight lists of familiar and nonsense words. Longer listening times to word lists were interpreted as evidence for listening preference driven by the recognition of familiar word forms. Word comprehension was tested using the IPL task (as in Bergelson & Aslin, 2017b; Bergelson & Swingley, 2012), that has recently been adapted for Norwegian and tested with 6- to 9-month-old infants (Kartushina & Mayor, 2019). On each trial, infants saw two pictures of familiar objects on the screen and heard a sentence "Look at the 'target'!," where the target was the label of one of the objects. Longer looking times at the target as compared to the distractor were interpreted as evidence for word comprehension.

The following hypotheses were considered for monodialectal infants. Although, to date and to the best of our knowledge, no study has examined word recognition and word comprehension in Norwegian 12-month-old infants, data from parental reports suggest that having more lexically relevant cues (as compared to English, Norwegian has additional vowel lengthening and pitch modulation) does not delay word acquisition in Norwegian infants. A comparison of the median number of words understood by 12-month old Norwegian- and American–English-speaking infants, as reported by their parents using Communicative Development Inventories (CDIs; retrieved from wordbank.stanford.edu, see Frank et al., 2017; Kristoffersen & Simonsen, 2012; Simonsen et al., 2014), reveals comparable scores: 64 words for Norwegian and 77 words for English. Therefore, we expected that monodialectal Norwegian infants, similarly to British English (Vihman et al., 2004) and French (Hallé & Boysson-Bardies, 1994) infants, would show reliable listening preference for words over nonsense words and would show word comprehension for familiar words used in the IPL task, similarly to English-learning 12-month-old infants (Bergelson & Swingley, 2015; van Heugten & Johnson, 2017).

The following hypotheses were considered for bidialectal infants' performance in word recognition and word comprehension tasks. First, if exposure to accent variability hinders the establishment of accurate (phonological) word representations, as reported in van Heugten and Johnson (2017) study with multiaccented infants, then bidialectal Norwegian infants, exposed to two dialects spoken by native Norwegian speakers, would show no preference for words over nonsense words (H0).[6] However, if we do observe word recognition in our bidialectal infants (H1), then we would conclude that exposure to accent variability, present in families speaking two Norwegian dialects natively, does not delay infants' early word representations (development of phonological constancy). In addition, following Schmale et al. (2012) hypothesis on the role of accent similarity in monodialectal infants' accent adaptation, we predicted that bidialectal infants exposed to similar dialects would show better word recognition as compared to bidialectal infants exposed to dissimilar dialects. This result would suggest that large inconsistencies between parental dialects lead to broader or coarser phonological representations for words. Finally, we also predicted that the amount of exposure to the target (Oslo) dialect would modulate infants' word recognition accuracy, with more exposure leading to better word recognition.

Second, we hypothesized that, in the word comprehension task, bidialectal infants would orient their gaze to the target object (H1) after hearing its name, demonstrating that bidialectal infants' word representations were precise enough to disambiguate between two familiar, phonologically dissimilar words (e.g., "foot" and "banana"), when visual cues are present (top-down lexical facilitation). However, if bidialectal 12-month-old infants fail to display word comprehension (H0), we would conclude that regular exposure to accent variation in parental speech (i.e., inconsistent word pronunciations between speakers' dialects) weakens/delays the establishment of word – object associations required for successful word comprehension in naturalistic listening conditions. In addition, we expected that the degree of perceptual similarity between parental dialects would not affect infants' word comprehension, given that visual cues facilitate object disambiguation (even when the accented pronunciation of a word deviates from the target, van Heugten et al., 2018), yet, we predicted that infants exposed to the target dialect more frequently would show better word comprehension.

Finally, given the lack of studies on the relationship between word recognition and comprehension in 12-month-old infants, two possible outcomes were considered in the current study. First, word comprehension and word recognition might follow distinct developmental patterns. This possibility stems from research showing that infants can map a word to its referent from as early as 6 months of age (at least for some familiar items as, e.g., bottle, banana, hand, see Bergelson & Aslin, 2017b; Bergelson & Swingley, 2012; Tincoff & Jusczyk, 1999), whereas they fail to recognize familiar word forms before the age of 11 months (Carbajal & Peperkamp, 2017; Hallé & Boysson-Bardies, 1994; Vihman et al., 2004, 2007). These studies suggest that infants can disambiguate between two familiar items (likely by relying on other available cues, as, e.g., semantic, conceptual, perceptual, and frequency cues, see Kartushina & Mayor, 2019) despite the lack of a phonologically detailed word form representation (required to succeed in the recognition task). Yet, an alternative outcome can also be expected. A recent study suggests that infants' word knowledge contributes to their development of the phonetic categories (Swingley & Alarcon, 2018), implying a tight relationship between lexico-semantical and phonological abilities in infants (see also Swingley, 2009). Similarly, Van Heugten and Johnson (2017) revealed a positive relationship between early lexico-semantical and phonological abilities in 18-month-old bidialectal infants by showing that the vocabulary size (as revealed by parental reports in the CDI) predicted their performance in the recognition task. In line with these studies, we expected a positive correlation between word comprehension and word recognition abilities, with word comprehension performance being superior or equal to word recognition.

2 | METHODS

2.1 | Participants

Word recognition at 11–12 months of age tested with eye-tracking paradigms has an effect size of Cohen's d ranging between 0.59 and 0.77[7] (Bergmann et al., 2018); word comprehension at 12 months of age assessed with IPL paradigms has an effect size of Cohen's $d = 0.64$ (Bergelson & Aslin, 2017a). To detect the smallest effect size (0.59) with a power of 0.80, we needed twenty-five participants in each group (Faul et al., 2009). However, in order to make sure that the design was powerful enough to detect a potential interaction between the trial type and infant group, we recalculated the sample size based on the interaction effect size $\eta_p{}^2 = 0.106$ reported in van Heugten and Johnson's (2017) study. To reach 80% power, we needed seventy participants ($n = 35$ in each group).

Infants were recruited from the National Registry (Folkeregister). The following criteria were used to include infants: (1) the child was born full term (gestational weeks > 37); (2) the child is exposed to 90% Norwegian or more at home; (3) both parents speak Norwegian to the child; and (4) the child has no developmental delays and no history of chronic ear infections. Total 111 parents expressed their interest in taking part in the study and filled in the consent form. All children were born full term, with no history of hearing and/or language disorders. Among those, 23 participants were excluded from the study: 16 parents canceled their appointment, due to a child's sickness or a Covid19-related quarantine; one parent did not fill in participant background questionnaire; four babies cried during the experiment and were not able to provide data for both tasks, so the experiment was stopped, and two babies had less than 90% of exposure to Norwegian.

Among the remaining 88 participants who completed both tasks, 16 were excluded in the word recognition task and 12 were excluded in the word comprehension task, as they did not validate at least half

TABLE 1 Participants who have successfully completed both tasks, final sample

Group	Number	Boys/girls	Age in days mean (sd)	Receptive vocabulary mean (sd)
Monodialectal	35	18/17	367 (7.0)	72 (67)
Bidialectal	35	13/22	368 (6.5)	73 (55)

of the trials in each task, after that we applied by-trial exclusion criteria (cf. Section 2). Among the remaining 72 participants in the word recognition task and 76 participants in the word comprehension task, 70 participants, which was our required sample size, successfully completed both tasks (see Table 1 for details). There were no differences in receptive vocabulary size ($p = 0.9$), as measured by the Norwegian version of the CDI for 8- to 16-month-old infants (Simonsen et al., 2014), or age ($p = 0.6$) between the two groups. Half of them ($n = 35$) were selected from monodialectal families where both parents speak Oslo (Eastern) dialect, whereas the other half from bidialectal Norwegian families, where parents speak two different dialects among four large groups of Norwegian dialects: Eastern, Western, Central, or Northern Norwegian.

The inclusion criteria in the bidialectal group was a minimum 30% of exposure to each dialect[8]; that was assessed by the language background questionnaire filled in by parents before their visit to the lab (see Section 2.3 for details). The study has been approved by the Norwegian Centre for Research Data (NSD).

2.2 | Stimuli

2.2.1 | Word recognition task

The stimuli were prepared closely following the methods used in van Heugten and Johnson studies (2014, 2017). We have selected 12 familiar words (*ball*, *bade*, *bil*, *drikke*, *pappa*, *bleie*, *hund*, *klemme*, *katt*, *takk*, *mamma*, *vann;* ball, bath, car, drink, father, diaper, dog, hug, cat, thanks, mother, water) and have created twelve nonsense words strictly matched in phonemes, onset, rhyme, and the number of phonemes (*brall*, *made*, *dil*, *klakke*, *tippa*, *keie*, *ban*, *blamme*, *patt*, *hokk*, *vumma*, *benn*). On average, 70% of 12-month-old Norwegian infants know the 12 selected familiar words (Simonsen et al., 2014). Note that all familiar words used in the study have a very similar segmental pronunciation across the four Norwegian dialects, with the exception of *drikke* that has a guttural "r" in the Western dialect.

A native Norwegian female speaker, who was born and grew up in Oslo (Eastern dialect), was recorded while reading the stimuli in a child-directed speech style using the following recording parameters: 44 kHz, 16 bits, two channels. Known and nonsense words were read by pairs in order to match the intonation pattern between them. The recordings were checked for auditory quality and saved to individual wav files. Some residual noise in the recordings was removed in Praat (Boersma & Weenink, 2020) using the *remove noise* function (window length 0.025 s, filter 80–10 kHz, smoothing bandwidth 40 Hz, and spectral subtraction noise reduction method). Known and nonsense words were closely matched for average length (723 and 748 ms, $p = 0.39$), average pitch of the first vowel (208 and 206 Hz, $p = 0.76$) and average pitch of the second vowel (253 Hz and 247 Hz, $p = 0.41$). All twenty-four word types were equated for amplitude: the mean amplitude was set to 70 dB. We created eight word lists, four for each word type. Within each list, each word was repeated twice, resulting in 24 words; their order differed between lists. Within each list, words were interspersed with 740–750 ms silences; all lists last 35.09 s. The word lists (four known and four nonsense word lists) were combined pseudorandomly to create four presentation orders, with the restriction that lists of the same word type could not occur more than twice in a row (see https://osf.io/6btq2/).

2.2.2 | Word comprehension task

The stimuli for the word comprehension task were similar to those used in a recent study (Kartushina & Mayor, 2019). Sixteen pictures, depicting familiar objects were used in this task (for detailed description refer to Kartushina & Mayor, 2019), see https://osf.io/6btq2/. Pictures were assembled in eight picture pairs (see Figure 1). The objects within each pair were edited so that their relative brightness and size were approximately the same. The eight picture-pairs were laid out on a light-gray background with the size matching the experimental screen (as shown in Figure 1). An additional set of eight picture-pairs was created by switching the sides of the objects within each pair to counterbalance the side of object presentation, resulting in 16 picture pairs, in total.

Sixteen audio files (described in Kartushina & Mayor, 2019) were used to prompt infants' looks at the target. A native female speaker of Eastern Norwegian dialect (different from the one used in the word recognition task) was recorded while reading at a slow speed and in a child-directed fashion four types of sentences: "Can you find the < target > ?," "Where is the < target > ?," "Do you see the < target > ?" and "Look at the < target > !." The target words were the 16 labels of the items depicted on the pictures. The same sentence-frame was used for the two words within a pair (e.g., "Look at the apple!" and "Look at the foot!"). Therefore, each type of sentence was paired with two picture pairs. The following parameters were used for recordings: 16 bits, 2 channels, 44 kHz. Similar to word recognition task, the stimuli average amplitude was equalized and was set to 70 dB. In line with previous research (as in Bergelson & Swingley, 2012), a 1.5 s silence was added before the sentence onset. Trials ended 3.5 s after the target word onset. The length of the sentences varied from 5.4 to 6.2 s ($m = 5.7$ s).

In order to fully counterbalance the side of picture presentation, audio files ($n = 16$) and picture pairs ($n = 16$) were combined to create 32 video files (to run in Tobii TX300 eye-tracker). That is, infants heard each target word twice: once when the target picture is on the left side and once when the target picture is on the right side of the screen. Four presentation order lists were created, with the restriction that there are at least two different picture pairs between two similar picture

FIGURE 1 Picture-pairs used in the word comprehension task

pairs (e.g., "apple-foot," "hair-banana," "bread-leg," "foot-apple"). Note that the target words used in the study have a very similar segmental pronunciation across the four Norwegian dialects, with the exception of *brillener* glasses, *brød* bread *and hår* hear that have a guttural "r" in the Western dialect (trill in other dialects) and *bein* leg that is produced with an [e] in Western dialect ([a] in other dialects).

2.2.3 | Language background questionnaire

Infants' exposure to each dialect was collected from the Language Background questionnaire that parents filled in prior to their lab visit (see https://osf.io/6btq2/). To measure dialectal exposure, we asked parents to indicate, how much time (in %) the child heard her mother's and her father's speech. The sum should equal 100%. In addition, parents were asked to fill in a word knowledge questionnaire. This questionnaire asked, for each of the twenty words used in the word comprehension and in the word recognition tasks (three of them are shared between the two tasks), how frequently parents would have used it (on a scale from 0-never to 5-very frequently) while interacting with the child or in her presence, since their baby was born.

2.2.4 | Perceived similarity between parental dialects

As far as the dialectal similarity is concerned, to the best of our knowledge, there is no objective (global) measure allowing to quantify relative perceptual difference/distance between two (Norwegian) dialects. However, Norwegian speakers are quite aware of the differences between dialects: after a brief exposure to an unfamiliar speaker, they can easily name her/his accent and indicate the region of Norway where the speaker grew up.

Dialectal similarity in parental speech was assessed by an independent group of 40 raters (all native Norwegian speakers). To record natural (spontaneous) parental speech, at the end of the language background web-questionnaire, parents were prompted to click on a link that redirected them to an experimental platform e-Babylab (Lo et al., submitted)—a web application developed based on the framework provided in Frank and colleagues study (Frank et al., 2016)—where each parent was shown five simple pictures (selected from the CELF battery used to assess language production and comprehension, Wiig et al., 2013) and was asked to describe[9] each of them by answering one question (Hva gjør jenta/gutten? – "What is the girl/boy doing?"). The parents were instructed to give a subject-verb-object type answers (e.g., "the girl opens the door," "the boy reads a book," etc. see "Pictures to record parental speech" on https://osf.io/6btq2/). Audio recordings from both parents were combined into pairs, such that each family contributed to five recording pairs. Native Norwegian speakers were instructed to rate the overall/holistic similarity between the two dialects in a pair on a scale from 1-very similar to 10-very distinct (similar to the scale that parents used to rate dialect similarity in the family) by pressing a corresponding key touch on a key board. On each trial, raters were asked to listen to five audio recordings, each of them containing the same sentence produced by both of the child's parents (e.g., *Gutten leser en bok* – "The boy is reading a book"). Participants could listen to the recordings as many times as they wanted, yet they were asked to make an assessment of dialectal similarity based on their first holistic impression. The experiment was run on a university platform via e-Babylab (Lo et al., 2021), raters' recruitment was implemented on https://www.prolific.co/. Raters were paid around 18 euros for that task. To facilitate the assessment, we provided an example of two very distinct dialects (Stavanger and Tromsø, who are dissimilar in a number of phonological, i.e., segmental, prosodic and suprasegmental, and lexical cues) and two very similar dialects (Oslo and Hamar).

2.3 | Procedure

Data collection were performed in one session at the BabyLing laboratory, at the University of Oslo, equipped with an Eye-link 1000 eyetracker.[10] Prior to the lab visit, parents received an information letter, briefly presenting the aims of the study, and filled in three questionnaires (see https://osf.io/6btq2/), that is, a language background and parenting attitudes questionnaire, and the Norwegian version of the McArthur Communicative Development Inventory (Simonsen et al., 2014), using online forms provided for the academic use by the University of Oslo, https://nettskjema.uio.no/ (similar to Qualtrics). A female native speaker of Norwegian received parent(s) with their child in the reception room of the lab and briefly explained the tasks that the child would perform. Then, the parent signed the consent form and the experimenter accompanied her to the eye-tracking room with her child.

Both tasks were performed on an Eye-link 1000 eye-tracker, 500 Hz sampling rate (monocular), infant mode calibration and a 1280 × 1024 pixels screen resolution. The child was sitting on her parents' lap facing the experimental computer screen fitted with an eye-tracker base. Parents wore sound-attenuating headphones through which they heard masking music (a custom blend of instrumental music and a pastiche of randomly timed and random amplitude stimulus materials from Frank et al., 2020). The parents were asked not to talk to the child, point to the screen or shift their bodies. The experimenter was sitting in the same room, behind the parent, so neither the child nor the parents saw her. The experimenter was wearing noise-attenuating headphones presenting the same masking music, as for the parents. The stimuli were presented at the average amplitude of 65 dB through two speakers, positioned at the left and right sides of the screen. The experimenter was able to monitor infants' looking behavior via the control screen, situated in front of the experimenter. The test started with an automated 5-point calibration procedure (slow version), which was followed by the tasks. The order of the tasks was counterbalanced across participants. All infants were tested in both word comprehension and word recognition tasks, with a break between them, when required. For both tasks, infants were assigned, randomly, to either of the four presentation order lists. Both tasks were gaze-contingent automatically monitored by the eye-tracker.

In the word recognition task, at the beginning of each trial (eight in total), a spinning circle (accompanied by a tinkle) appeared, on a black background, in the middle of the screen. As soon as the infant fixated the circle for 500 ms, the program initiated the first word list in the presentation order, together with an image of a colorful checkerboard on the screen. The list was played until the infant looked away for 2 s or until the maximum trial length of 35.09 s (stimulus duration) was reached (van Heugten & Johnson, 2017). Then, next word list from the presentation order was initiated. The task stopped after all eight lists had been presented to the child.

In the word comprehension task, at the beginning of each trial (32 in total), a spinning flower (accompanied by a bird tweeting) appeared, on a gray background, in the middle of the screen and was replaced by the test stimuli after that the child fixated the flower for 500 ms. On each test trial, infants saw two pictures displayed on the right and left sides of the screen and heard, after 1.5 s, a target sentence prompting them to look at either of the two pictures. The pictures remained on the screen for 3.5 s after the target-word onset. The trials were triggered automatically by the eye-tracker. The task stopped after that all 32 trials were presented to the child.

At the end of the experiment, parents were able to choose a small gift for their infant (e.g., a toy) and were reimbursed for travel costs. The experimental protocols and the materials can be found on the Open Science Framework depository https://osf.io/6btq2/.

2.4 | Eye-tracking data processing

2.4.1 | Exclusion criteria

The following criteria (as in Kartushina & Mayor, 2019) were used to exclude infants based on their behavior in both tasks: (a) failed calibration of the eye-tracker; (b) software problem (e.g., technical reasons: software stops displaying images or playing sounds for more than 50% of the trials); (c) the child did not contribute to at least 50% of the experimental data (Bergelson & Aslin, 2017a; Frank et al., 2020).

The following criteria were used to exclude single trials in the word recognition task: trials with no continuous looking at the screen for at least 2 s during the test trial (Frank et al., 2020). The following criteria were used in the word comprehension task: first, no continuous looking at either image for at least 0.5 s in the postnaming period and, second, no looking was recorded in the prenaming period, due either to the child not looking at the pictures or to the eye-tracker's failure to track the child's gaze (Bergelson & Aslin, 2017a, 2017b). In addition, similar to Tincoff and Jusczyk (2012) study, individual item trials were removed from individual child data if parents reported in the word knowledge questionnaire that they did not use the produced word with the child (or in her presence), since the child was born. Finally, for both tasks, we excluded trials in which the experimenter would have reported that the parent interfered (e.g., pointed to the screen, shifted his/her body, or moved his/her chair), or the trial was interrupted by a third person or due to a technical error. If the experimenter heard audible crying then she terminated the experiment.

2.4.2 | Dependent measures

Word recognition task

Our dependent measure was looking time (*LT*), defined as time spent fixating the screen (the area of the checkerboard) during the test trials, excluding the time when the child looked away from the screen even though the looks away were below the threshold for terminating a trial (Frank et al., 2020). Given that looking times were not normally distributed, we log transformed them prior to the analyses (Csibra et al., 2016).

Word comprehension task

(1) Mixed-effects regression analysis

Similar to previous research (Bergelson & Swingley, 2012), on each trial, we identified two naming windows: prenaming (from the start of the trial to the target word onset) and postnaming (367–3500 ms after target onset). The target and the distractor areas of interest were limited to an invisible 800 × 680 pixel rectangle around each object. Our dependent measure was a baseline-corrected proportion of target looking (*Prop_target*). Similar to previous research (e.g., Bergelson & Aslin, 2017a), it was computed by subtracting the proportion of time that infants looked at the target at prenaming window from the proportion of looking time at the target during the postnaming period (postnaming_T/(postnaming_T + postnaming_D) − (prenaming_T/(prenaming_T + prenaming_D)), T = Target, D = Distractor). Therefore, the dependent measure Prop_target varied between −1 and 1; the chance level was 0.

(2) Cluster permutation analysis

To provide insights into the differences (if any) in dynamics of word comprehension in bidialectal as compared to mono-dialectal infants, we performed cluster-permutation analyses. The dependent measure, the target proportion looking metric *Prop_target_bin*, was computed, in 10 ms time bins, as the proportion of target looking [target/(target+distractor)] from the beginning of the trial to its end.

2.5 | Dialectal similarity and language exposure

In total, raters assessed the similarity between parental dialects in 76 family dyads (the highest number of participants successfully completing at least one task). There were 80 trials (note that for three parents, recordings were very noisy, thus impossible to assess perceptually), divided into two lists with 40 trials in each, plus four control trials (recorded stimuli by our research assistant presenting clear-cut dialectal differences in each of them).[11] It took around 40 min to complete one list. Similarity scores for five sentences from the rating task were averaged across raters to obtain one similarity score between parental dialects for each infant. The *similarity* score varied between 1: very similar and 10: very distinct. For the statistical analyses, the similarity score was recoded (1 = 0, 10 = 9). There was one similarity measure per infant. Bidialectal infants' *exposure* to Oslo dialect was collected from the language background questionnaire; it varied between 0% and 70%.

3 | RESULTS

All analyses were performed in R (R Core Team, 2020) using the lme4 package (Bates et al., 2015); *p*-values were computed using the lmerTest package (Kuznetsova et al., 2017). Lsmeans (Lenth, 2016) function in R was used to perform follow-up tests from the interactions, if needed. The package *sjPlot* was used to visualize the output of the regression models (Lüdecke, 2021).

3.1 | Assessment of perceived similarity between parental dialects

Forty native Norwegian speakers (20 for each list) rated the perceived similarity between parents' dialects. Similarity scores for each family (n = 70 in the final sample) were averaged across 20 participants (mean = 4.0, range between 1.25 and 8.4) and compared to the perceived similarity reported by parents (mean = 3.9, range between 1 and 10). A correlation analysis revealed a significant positive relationship between the assessment of dialect similarity reported by the parents and by the raters ($r = 0.83$, $t = 12.25$, df = 67, $p < 0.001$).

TABLE 2 Summary of the mixed-effect regression model run on fixation time for the word recognition task

	log(Fixation)		
Predictors	**Estimates**	**CI**	***p***
(Intercept)	9.88	9.69 to 10.06	**<0.001**
Trial	−0.09	−0.13 to −0.05	**<0.001**
Type [nonwords]	−0.09	−0.26 to 0.09	0.331
Group [Bidialectal]	−0.07	−0.30 to 0.16	0.544
Trial * Type [nonwords]	0.04	−0.01 to 0.09	0.155
Trial * Group [Bidialectal]	0.03	−0.02 to 0.08	0.201
(Trial * Type [nonwords]) * Group [Bidialectal]	−0.03	−0.08 to 0.02	0.298
Random effects			
σ^2	0.30		
$\tau_{00\ ChildID}$	0.10		
$\tau_{00\ List}$	0.00		
$N_{ChildID}$	70		
N_{List}	8		
Observations	474		
Marginal R^2/ Conditional R^2	0.074 / NA		

3.2 | Word recognition

Following preregistration, we performed mixed-effects regression analyses that included the main effects of trial type (known vs. nonsense word), group (mono- vs. bidialectal), and trial number, capturing the basic effects of each on looking time (we expected longer looking times for known words, possibly longer looking times in monodialectal group and shorter looking times on later trials). In addition, we included two-way interactions of trial type with trial number (to model faster habituation to nonsense words) and of trial type with group (to model possible longer looking times for known words in mono-dialectal infants as compared to bidialectal), and one three-way interaction between trial type, group, and trial number (to model possible faster habituation to nonsense words in bidialectal infants). The random structure included by-subject intercept (a model with a slope did not converge) and by-item (list) intercept. Trial number was recoded to range from 0 to 7 (instead of 1 to 8). Trial type was dummy-coded, with real word trials as the reference level; monolingual infants were set as the reference level for group.

As can be seen in Table 2, there was a significant effect of trial, indicating that infants looked to the screen less by the end of the study (cf. Figure 2). Other factors were not significant. Hence, the results of this model indicate that: (1) 12-month-old Norwegian infants did not show preference for listening familiar words as compared to nonsense nonwords (Bayes Factor *t*-test analysis confirmed that our data presented no evidence in favor of word recognition in Norwegian 12-month-old infants, $BF = 0.1$), (2) overall, there were no differences in looking behavior between monodialectal and bidialectal infants; and,

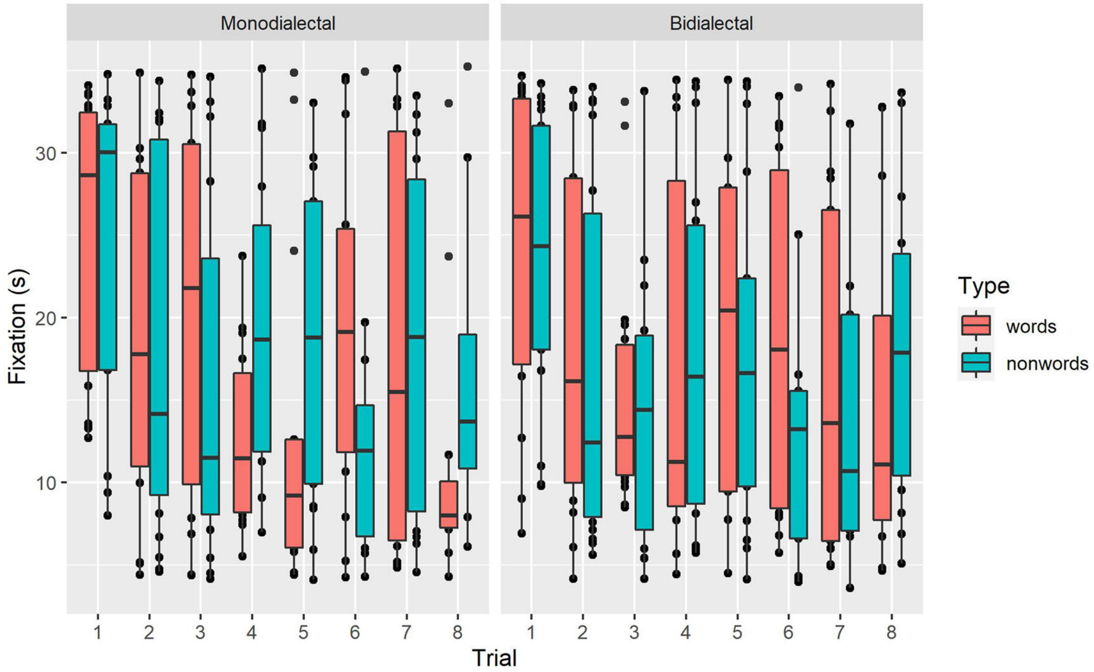

FIGURE 2 Fixation time in seconds for words and nonwords across trials in monodialectal and bidialectal infants (word recognition task)

importantly, (3) there were no difference in looking behavior between monodialectal and bidialectal infants for either words or nonwords, that is, nonsignificant trial × group interaction.

As preregistered, we performed mixed-effects regression analyses to examine the role of dialectal similarity and exposure to the dominant (Oslo) dialect in bidialectal infants' early word recognition. The model was similar to the one used in the above analyses on word recognition, with the following differences: the factor *group* was omitted from the model while *perceived similarity*, as rated by native Norwegian speakers (which was recoded to range from 0 to 9), the categorical variable *exposure*[12] – and their interaction with trial type (to model possible worse word recognition in infants exposed to very dissimilar dialects and only little to the Oslo dialect) were included in the model. The random structure was identical to the original model (i.e., by-child and -list intercepts). The results are summarized in Table 3. Similar to previous analyses, there was a significant effect of trial. In addition, there was a marginally significant effect of exposure, suggesting that bidialectal infants with no exposure to the Oslo dialect at home listened to word lists less than those who were exposed to the Oslo dialect at home. A marginally significant effect of rated similarity suggests that bidialectal infants exposed to more dissimilar dialects at home displayed less interest in listening to words.

3.3 | Word comprehension

First, before running the analyses, we removed individual trials where the target word was reported as never used in a child's presence by the parents. Then, we fitted, as preregistered, mixed-effect regression analyses on the dependent measure Diff_prop_looking (cf. Section 2 for details), with the fixed factors group (monodialectal and bidialectal) and trial number, mean-centered (modeling possible shorter looking times on last trials); the random structure included by-subject and by-item (picture) intercepts. The results of the model are summarized in Table 4.

As can be seen, there were no differences between the two groups of infants and the effect of trial was not significant either. However, the intercept of the model approached significance, suggesting that monodialectal infants had larger proportion of looks to the target as compared to the distractor, at the reference level of trial (mean), hence, displaying evidence of word comprehension (cf. Figure 3). Follow-up analyses showed a significant difference from zero in monodialectal infants ($m = 0.026$, $t = 2.26$, $df = 34$, p-value $= 0.015$) and no difference in bidialectal infants ($m = 0.003$, $t = 0.25$, $df = 34$, p-value $= 0.40$. In sum, the results show that while 12-month-old Norwegian infants exposed to one dialect at home looked significantly above chance at the target when hearing the matching label as compared to when hearing the name of a distractor (evidence of word comprehension), bidialectal infants, on the other hand, did not show evidence of word comprehension. Yet, the difference between monodialectal and bidialectal infants was not significant. The intercept only model (as per preregistration) was not significant ($\beta = 0.015$, $se = 0.009$, $df = 19.6$, $t = 1.52$, $p = 0.145$).

Similar to the analyses of word recognition, and as preregistered, mixed-effects regression analyses were performed to examine the role of dialectal similarity and exposure on bidialectal infants' early word comprehension. The model was similar to the one used in the above analyses of word comprehension, with the following, preregistered, differences: we removed the factor *group* and added a continuous variable *similarity* (from 0 to 9) and a categorical variable *exposure*, and their interaction. The results revealed marginally significant intercept

TABLE 3 Summary of the mixed-effect regression model run on fixation time in the word recognition task, for bidialectal infants

	log (Fixation)		
Predictors	**Estimates**	**CI**	***p***
(Intercept)	10.32	9.78 to 10.87	**<0.001**
Trial	−0.06	−0.10 to −0.02	**0.002**
Type [nonwords]	−0.14	−0.65 to 0.36	0.572
Rated_sim_zero	−0.11	−0.24 to 0.01	0.070
Exposure_binom [No]	−0.88	−1.80 to 0.03	0.059
Trial * Type [nonwords]	0.01	−0.05 to 0.07	0.706
Type [nonwords] * Rated_sim_zero	−0.01	−0.12 to 0.10	0.904
Rated_sim_zero * Exposure_binom [No]	0.19	−0.03 to 0.40	0.097
Type [nonwords] * Exposure_binom [No]	0.51	−0.30 to 1.33	0.217
(Type [nonwords] * Rated_sim_zero) * Exposure_binom [No]	−0.07	−0.27 to 0.12	0.460
Random effects			
σ^2	0.27		
$\tau_{00\ ChildID}$	0.12		
$\tau_{00\ List}$	0.00		
$N_{ChildID}$	35		
N_{List}	8		
Observations	238		
Marginal R^2/ Conditional R^2	0.138/NA		

TABLE 4 Summary of the mixed-effect regression model run on difference in looking proportion for the word comprehension task

	Diff_prop_looking		
Predictors	**Estimates**	**CI**	***p***
(Intercept)	0.02	−0.00 to 0.05	0.053
Group [Bidialectal]	−0.02	−0.05 to 0.01	0.235
Trial_c	0.00	−0.00 to 0.00	0.138
Random effects			
σ^2	0.10		
$\tau_{00\ ChildID}$	0.00		
$\tau_{00\ trial}$	0.00		
ICC	0.02		
$N_{ChildID}$	70		
N_{trial}	16		
Observations	1956		
Marginal R^2/ Conditional R^2	0.002/0.018		

and effect of rated similarity, suggesting that both bidialectal infants exposed to the dominant accent at the similarity reference level of zero, that is, very similar, and infants exposed to similar dialects showed marginal word comprehension (see Table 5).

An exploratory analysis with the fixed factors similarity, groups and their interactions, and a random structure identical to the above analyses, examined the role of dialect perceived similarity on infants' word comprehension in both groups (Table 6). As expected and revealed by a significant group by similarity interaction, given that monodialectal infants are raised in a homogeneous dialectal home environment, monodialectal infants' word recognition was not affected by similarity between parents' dialects, Spearman $r = 0.20$, $p = 0.12$, whereas bidialectal infants' performance was negatively affected by an increase in dissimilarity between parental dialects, Spearman $r = -0.28$, $p = 0.05$ (see Figure 4 for results in perceived similarity between parents' dialects, as reported by native Norwegian speakers and parents themselves).

3.4 | Time-course analysis of looking behavior in the word comprehension task

As per registration, we performed three cluster permutation analyses on looking preference to examine the dynamic of word recognition in monodialectal and bidialectal infants and reveal their potential differences. For that, we compared the average proportion of looks at the target object to 50% (the chance) (1) in monodialectal infants, (2) in bidialectal infants, and (3) between monodialectal and bidialectal infants. Similar to previous research (Dautriche et al., 2018), averaged Prop_target_bin scores were transformed via the arcsin square function to align with the t-test assumptions. Time bins with significant effects ($t > 1.69$ for one-tailed test with 35 subjects, $p < 0.05$) over a window from −350 to 3500 ms were grouped into a cluster. Then, we computed the size of the cluster, as the sum of all *t*-values within this cluster and evaluated, by simulation, the probability of observing a cluster of the same size by chance. For that, we ran 1000 simulations, where the type of word, target versus chance (for the analyses [1] and [2]) and monodialectal versus bidialectal (for the analysis [3]) were assigned randomly for each infant. Then, for each simulation, we computed the size of the biggest cluster using the same procedure as the one that was used to compute the size for the real data. If the probability of observing a cluster of this size, or bigger, was smaller than 5% ($p < 0.05$) in the simulated dataset, we would then conclude that the differences (target vs. chance in [1] and [2]; and monodialectal vs. bidialectal in [3]) were significant.

The results of the cluster permutation analysis for monolingual infants revealed the biggest cluster $t = 35.54$, occurring between 890 and 1060 ms after word onset, was not significant ($p = 0.19$). No cluster was identified for bidialectal infants, and no cluster was significant in the comparison between monodialectal and bidialectal infants, with the biggest cluster of $t = 7.3$, occurring between 860 and 890 ms (Figure 5).

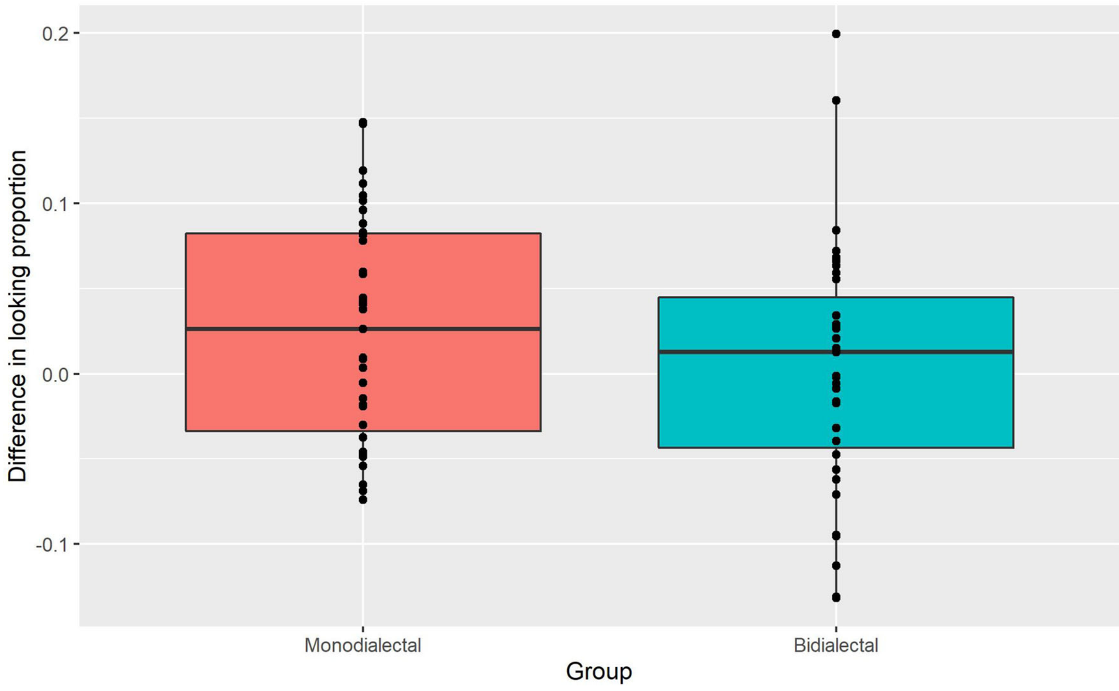

FIGURE 3 Difference in looking proportion in bidialectal and monodialectal infants for the word comprehension task

TABLE 5 Summary of the mixed-effect regression model run on difference in looking proportion in bidialectal infants for the word comprehension task

	Diff_prop_looking		
Predictors	**Estimates**	**CI**	***p***
(Intercept)	0.09	−0.01 to 0.20	0.067
Rated_sim_zero	−0.02	−0.04 to 0.00	0.077
Exposure_binom [No]	−0.08	−0.25 to 0.08	0.322
Rated_sim_zero * Exposure_binom [No]	0.01	−0.02 to 0.05	0.388
Random effects			
σ^2	0.09		
$\tau_{00\ ChildID}$	0.00		
$\tau_{00\ trial}$	0.00		
ICC	0.03		
$N_{ChildID}$	35		
N_{trial}	16		
Observations	958		
Marginal R^2/ Conditional R^2	0.005/0.038		

TABLE 6 Summary of the mixed-effect regression model on the role of perceived similarity between parents' dialects on difference in looking proportion in bidialectal and monodialectal infants for the word comprehension task

	Diff_prop_looking		
Predictors	**Estimates**	**CI**	***p***
(Intercept)	0.00	−0.03 to 0.04	0.842
Rated_sim_zero	0.02	−0.01 to 0.06	0.159
Group [Bidialectal]	0.06	−0.02 to 0.14	0.161
Rated_sim_zero * Group [Bidialectal]	−0.04	−0.07 to 0.00	0.051
Random Effects			
σ^2	0.10		
$\tau_{00\ ChildID}$	0.00		
$\tau_{00\ trial}$	0.00		
ICC	0.02		
$N_{ChildID}$	69		
N_{trial}	16		
Observations	1924		
Marginal R^2/ Conditional R^2	0.004/0.020		

3.5 | Relationship between word recognition and word comprehension tasks

Finally, and as preregistered, we examined the relationship between word recognition and word comprehension tasks. For that, for each infant, in both monodialectal and bidialectal group, we computed an average word recognition/preference score, as the difference between average fixation times on known and nonsense trial types, and an average word comprehension score. A Pearson correlation analysis revealed that while monodialectal infants showed a strong relationship between these two variables ($r = 0.53$, $t = 3.58$, $df = 33$, $p = 0.001$), bidialectal infants showed no relationship at all ($r = -0.02$, $t = -0.11$,

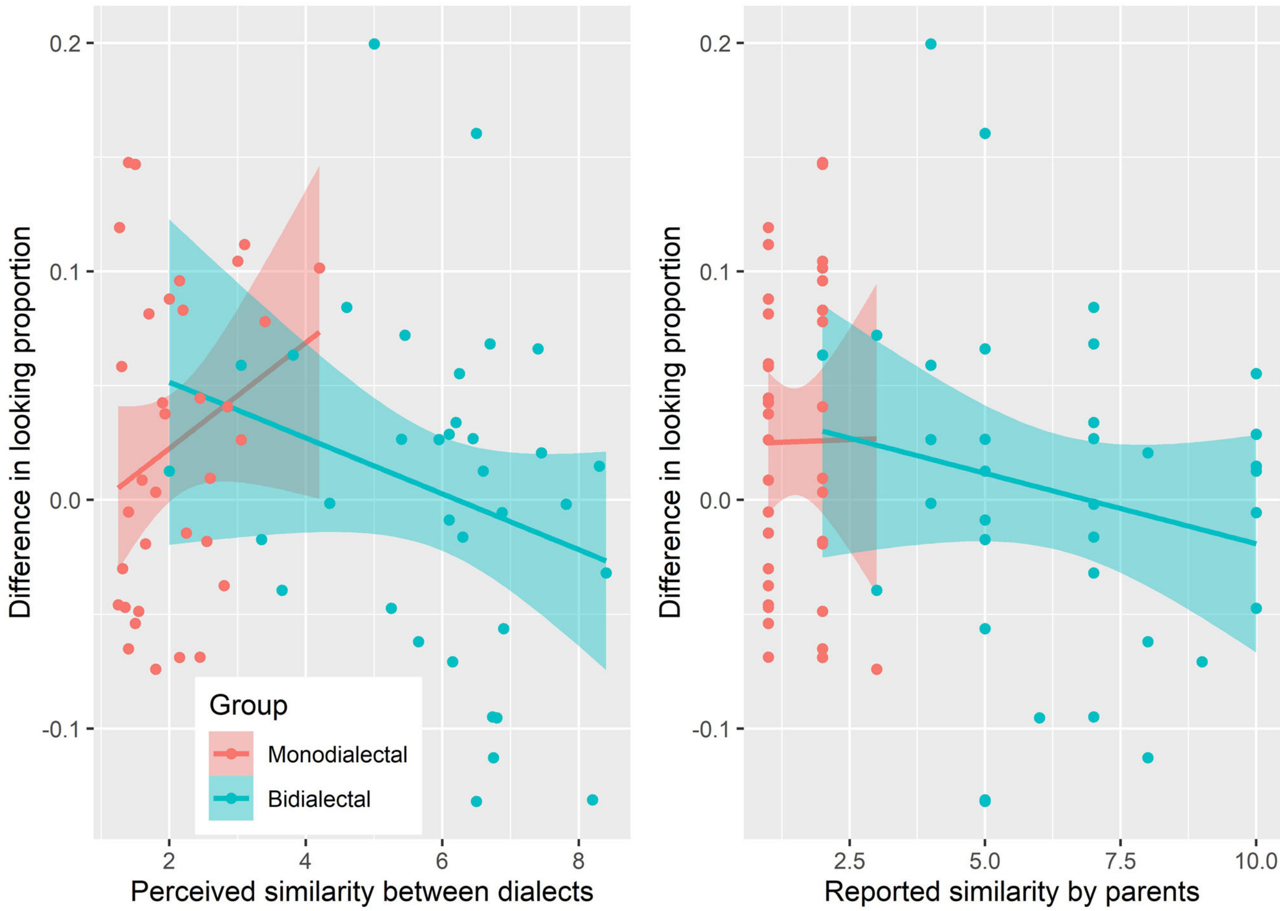

FIGURE 4 Difference in looking proportion in the word comprehension task for monodialectal and bidialectal infants as a function of perceived similarity between parents' dialects, as reported by native Norwegian speakers (left panel) and parents themselves (right panel). The shaded area represents 95% confidence interval

FIGURE 5 Time-course representation (mean and standard error) for the proportion of looks at the target during the trial in monodialectal and bidialectal infants in the word comprehension task. Zero indicates word onset and the gray vertical line indicates the start of the postnaming window, that is, 367 ms after word onset

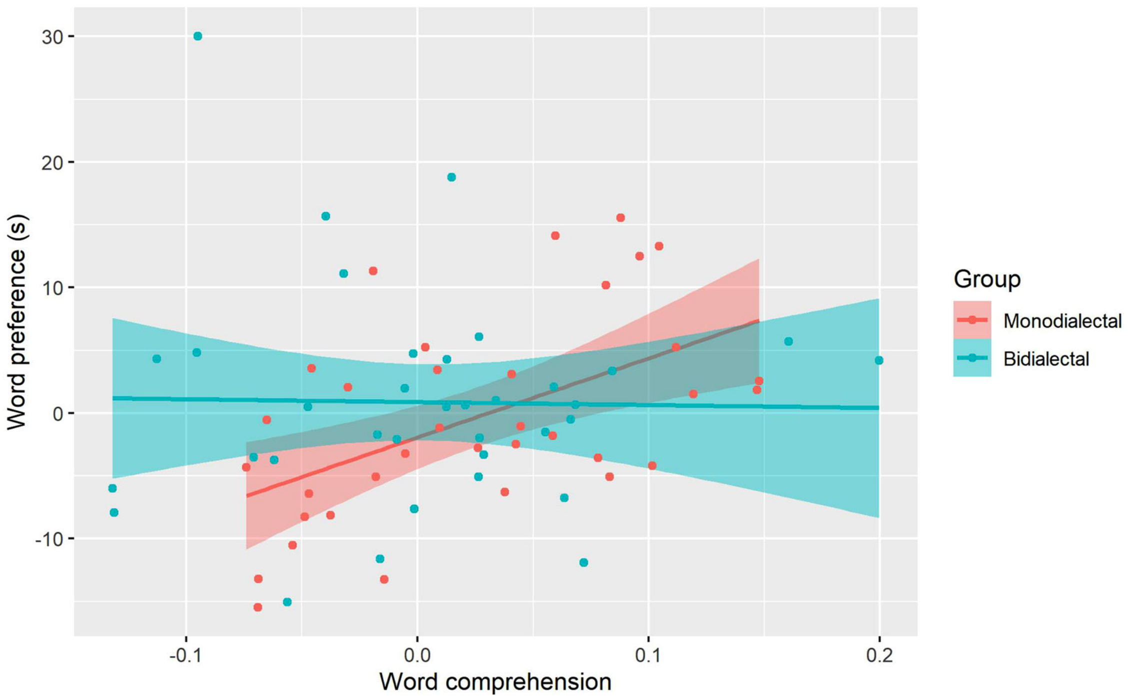

FIGURE 6 Relationship between word comprehension (difference in looking proportion) and word recognition (listening preference, in seconds) in monodialectal and bidialectal infants. The shaded area represents 95% confidence interval

$df = 33$, $p = 0.91$). An additional linear regression analysis on word preference as a function of difference in looking proportion and group confirmed this significant interaction between group and word preference, $\beta = -65296.0$, $se = 27359.3$, $t = -2.39$, $p = 0.019$ (see Figure 6).

4 | DISCUSSION

The main aims of the current preregistered study were to examine word recognition and word comprehension in Norwegian 12-month-old infants and to assess whether exposure to two dialects at home (as frequently encountered in Norway and Oslo, in particular) modulates their performance. Seventy monolingual Norwegian infants exposed to native Norwegian speakers at home, were assessed, in an eye-tracking paradigm on listening preference for familiar words and word comprehension with an IPL paradigm. Half of them were exposed to two different Norwegian dialects at home, whereas the other half were exposed to one dialect (i.e., both parents spoke the same dialect). In brief, our results revealed (1) no listening preference for words, as compared to nonwords, in Norwegian 12-month-old infants; (2) evidence of word comprehension in monodialectal infants, but not in bidialectal infants; (3) a strong relationship between word recognition and comprehension in monodialectal infants and the absence of such a relationship in bidialectal infants. It what follows we will discuss these results together with the results on the role of accent exposure and similarity between parental dialects.

First, our results revealed that Norwegian 12-month-old infants (n = 70) did not show word recognition, as indicated by an absence of listening preference for Norwegian familiar words as compared to nonwords, composed of the same sounds. These results are at odds with previous research in English (Vihman et al., 2007), French (Hallé & Boysson-Bardies, 1994), and Japanese (Tamekawa et al., 1997) 10 to 12-month-old infants, who display a modest effect size (Hedge's) of d = 0.53 in word recognition. We offer three possible interpretations of our result.

According to the first interpretation, Norwegian infants do not recognize familiar words without their referents, because they have not yet established stable phonological forms for Norwegian words, suggesting cross-linguistic differences in the onset of phonological word (form) recognition. Norwegian language is a phonologically complex language, for instance, to differentiate vowel minimal word pars, it uses vowel lengthening, formants and voice pitch. Given that words were embedded in lists, we cannot tell how many words need to be acquired to trigger word recognition, however, a recent meta-analysis reported larger effect sizes with higher word familiarity (Carbajal et al., 2021). In line with this result, our analyses revealed a marginally significant effect of exposure to the Oslo dialect at home in bidialectal infants, suggesting that familiarity with the accent promotes word recognition (although note that words used in the task had very similar segmental pronunciation across Norwegian dialects, they might slightly differ in terms of suprasegmental features, i.e., tones in disyllabic words). It is, therefore, possible that Norwegian infants require more time to establish stable phonological word representations and to recognize familiar words in a list of word forms. Other studies have similarly reported cross-language differences in word recognition: for instance, Vihman et al. (2007) revealed no word recognition in 12-month-old

(British) English and Welsh infants, and Carbajal and colleagues, in a recent meta-analysis on word recognition, reported larger effect sizes in Romance languages and in "older" infants (Carbajal et al., 2021), suggesting that the absence of word recognition in our study can be accounted by cross-linguistic differences in infants' onset of phonological word form recognition.

According to the second interpretation, the lack of word recognition can be due to methodological differences (e.g., paradigms, statistical analyses) between the current study and previous research. For instance, the head-turn preference paradigm, mainly used in previous research, can lead to larger effect sizes than a central fixation design (Frank et al., 2020) used in the current study, which might have prevented us from detecting an effect. In addition, although the study has been preregistered and had a sample size three times more than typically used in word recognition studies, it is not impossible that the power analysis estimates for the current study were too optimistic given the larger effect sizes in central fixation designs and overall modest sample sizes used in previous research. As far as the statistical analysis is concerned, Carbajal and Peperkamp (2017) have shown that mean looking times, as traditionally used in word recognition research, disregard time dependencies and might not describe infants' attention adequately; in their work with a central fixation paradigm (as in the current study), while an analysis of mean looking times revealed word recognition in 11-month-old French infants, a trial-by-trial analysis (as in the current study) revealed no effect of word type when controlling for effect of trial order and infant and list variability. More research is needed to investigate the roles of the method, analyses and language on the onset of word form recognition in infants, by using, eventually, a large cohort of infants' ages (e.g., from 11 to 15 months) and the same study design (e.g., stimuli, procedure, sampling, etc.) across different languages. A recent ManyBabies Consortium initiative (Frank et al., 2020) examined infants' preference for infant-directed speech across 67 labs and dozens of countries using the same stimuli and centrally performed analyses, and reported that the effect sizes were substantially lower than in the meta-analysis of previous literature, and that they varied considerably across methods used to collect infants' preference, suggesting, first, that the effect sizes retrieved from published studies might be overestimated and, second, that they depend crucially on the experimental method used.

According to the third interpretation, Norwegian infants did recognize familiar words; yet, they did not prefer listening to them more than to pseudowords, due to a likely overall large variability in overheard speech to which they can be regularly exposed in Oslo. Although half of our sample were exposed to one Norwegian dialect at home, it is still very likely that infants encountered other dialects elsewhere, for example, in the playgrounds, social/family gatherings, or on child TV, as regional dialects are used by people in all social strata, and their use is promoted across different domains of language use (Dragojevic et al., 2021). So, a mispronounced word (a pseudoword) in the Oslo dialect could be still entertained by young children as being potentially a meaningful word in a different Norwegian dialect. This interpretation is supported by a marginally significant effect of rated perceptual similarity between parental dialects in bidialectal infants and suggests that bidialectal infants exposed to more dissimilar dialects at home displayed less preference for listening familiar words. To summarize, a recent study has shown that already at 12.5 months of age infants exposed to dialect/accent variability at home display differences in language skills when compared to infants exposed to uniformly accented speech, by failing to show listening preference for familiar words (van Heugten & Johnson, 2017). In the current study, we failed to reveal any differences in familiar word recognition between monodialectal and bidialectal Norwegian 12-month-old infants. Future research needs to examine the onset of word recognition in Norwegian and other languages where regional dialect variability is prevalent.

Our second important result revealed that monodialectal infants looked significantly above chance at the target when hearing the matching label as compared to when hearing the name of a distractor (evidence of word comprehension), whereas bidialectal infants, on the other hand, did not show evidence for word comprehension. Our results are in line with previous research in older bidialectal infants (Buckler et al., 2017; Durrant et al., 2015; Floccia et al., 2012), suggesting that variability in speech affects early word comprehension (see below). The results of the cluster-permutation analyses of the looking gaze during the trial, however, did not reveal significant time windows in either group, due to likely a considerable variability across children and also across trials, which are not taken into account when averaging the data for each 10 ms bins across all trials (unlike in mixed-effect analyses of the difference in proportion data).

In the current study, we examined, in addition, the role of perceived similarity between parental dialects, as assessed by native Norwegian listeners, and exposure to the dominant Oslo dialect on bidialectal infants' performance in word recognition and word comprehension eye-tracking tasks. First of all, we noticed a strong relationship between perceived similarity between parents' dialects, as reported by parents and by an independent group of native Norwegian speakers, suggesting that parental evaluations (although slightly stricter, i.e., overall higher rating ranges) can be used reliably to assess infants' speech variability at home. To the best of our knowledge, this is the first study that assessed the role of similarity of parental dialects on early language development. Our results revealed that bidialectal infants exposed to similar dialects or to the Oslo dominant accent at home showed marginally significant word comprehension and listening preference for words (although not word recognition), suggesting that dialect familiarity and similarity between parents' dialects facilitate word comprehension (see van Heugten & Johnson, 2014 for similar results on the role of familiarity on accent adaptation in monodialectal infants) and might facilitate word recognition. Although at odds with previous studies in bidialectal infants, showing no relationship between the amount of dialectal exposure and infants' ability to recognize (van Heugten & Johnson, 2017) and understand words in this dialect (Buckler et al., 2017; Durrant et al., 2015), this result on the role of dialect exposure confirms our hypothesis and is in line with research in monodialectal infants exposed to unfamiliar accents.

A positive effect of perceived similarity between parental dialects on word comprehension is at odds with our original hypothesis, where we predicted that visual cues would facilitate object disambiguation (see van Heugten et al., 2018); yet, this result corroborates the hypothesis that infants exposed to little inconsistency in dialectal input are likely to use lexical top-down strategy to accommodate accents, which facilitates word recognition/comprehension (Schmale et al., 2010, 2012; White & Aslin, 2011). These results, together with the results in the word recognition task, suggest that Norwegian infants exposed to dialects that differ substantially along a number of acoustico-phonetic dimensions, including segmental and suprasegmental cues, are likely to use a general expansion strategy, which may require a "general" expansion (or relaxation) of phonemic categories (Schmale et al., 2012) to accommodate for deviating examples that can span phonemic boundaries. The general expansion strategy is opposed to top-down lexically guided strategy; it can be beneficial when exposed to unfamiliar speakers with various language or accent backgrounds, as even considerable deviations from the norms would trigger word comprehension; yet, general expansion can also lead to larger processing costs, due to less restricted lexical access (see Schmale et al., 2012). This strategy seems to affect, particularly, word comprehension, as infants exposed to perceptually highly dissimilar dialects showed impaired word comprehension. Similar findings were reported in slightly older 20-month-old bidialectal British English infants (Durrant et al., 2015), who showed similar looking times for mispronounced and for accurately pronounced words referring to the target picture. Although the lack of word comprehension in Norwegian 12-month-old bidialectal infants is in line with previous research in older bidialectal infants learning other languages and indicates that differences in language skills between monodialectal and bidialectal infants can be observed as early as at 12 months of age, this result needs to be taken with caution, due to the lack of difference between monodialectal and bidialectal Norwegian infants, and should be confirmed with older infants, as word comprehension even in monolingual Norwegian infants is not yet robust at 12 months of age, as compared, for instance, to same-age American English peers (Bergelson & Aslin, 2017a; Bergelson & Swingley, 2013; although word comprehension is more firmly established after 14 months of age, see Bergelson, 2020). A previous study has already revealed that Norwegian monodialectal infants might be lagging behind their American–English peers, who reportedly display evidence of word comprehension from as early as 6 months of age, whereas Norwegian infants' word comprehension only emerges by 8–9 months of age, provided that infants can exploit additional disambiguation cues (Kartushina & Mayor, 2019). Research with older Norwegian infants is needed to assess the onset of word comprehension in bidialectal infants.

Finally, our results revealed a significant correlation between two direct measures of early language development – word comprehension and familiar word recognition – in monodialectal infants, but not in bidialectal infants. These results suggest that monodialectal infants who recognize familiar words without their referents have established word-object mappings for some frequently used words and indicate that successful word comprehension aligns with or implies listening preference for words. The lack of such a relationship in bidialectal infants suggests either that these two skills do not necessarily align in infants exposed to more variable input, or that the alignment might occur at a later stage, when bidialectal infants start showing word comprehension. To the best of our knowledge, this is the first time when a relationship between these two skills is assessed in young infants.

Infants in many countries are exposed to dialectal variability, yet very little is still known about whether such variability in early language input impacts language development and, if so, how different levels of variability differentially impact language acquisition. The results of the current study, together with the results of previous research, suggest that exposure to dialect/accent variability impacts very early stages of language acquisition. In particular, our results for familiar word recognition and word comprehension suggest that early word representations in bidialectal infants are likely phonologically less specified (and/or broader) and vary in specificity/broadness as a function of dialect similarity in parental/family speech. However, already by 2 years of age, bidialectal infants show dialect-sensitive accurate knowledge of the phonological categories in both dialects: they adapt their phonological expectations based on the phonetic contrastive cues relevant for a speaker's dialect (van der Feest & Johnson, 2016), and flexibly adapt to variable input (van der Feest et al., 2022); by 2.5 years of age, bidialectal infants show an advantage in word learning in accented speech (Kartushina et al., 2021), and by roughly 3 years of age bidialectal infants show similar processing times as their peers, suggesting that difficulties related to processing inconsistent speech input might be overcome by 3 years of age (Buckler et al., 2017). Yet, more research is needed to examine the role of degree of dialect/accent similarity on language acquisition, as revealed in the current study. Overall, although bidialectal infants seem to essentially catch up with their monodialectal peers by 3 years of age, an impact on their speech processing seems to persist when the task demands are high (Buckler & Johnson, 2020), in line with the assumption that early exposure to accent variation continues to impact language processing into adulthood (Chen et al., 2017; Kirk et al., 2018), in addition to the beneficial effects of adapting better to regional dialects in children (Levy et al., 2019) and of better word learning from multidialectal input in toddlers (Kartushina et al., 2021).

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CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study (including stimuli, questionnaires, the consent form, results and analyses) is openly available in OSF at https://osf.io/6btq2/.

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ENDNOTES

[1]Note that in Buckler et al.'s (2017) study, infants were exposed to both Canadian English and a non-native variant of English (cf. footnote 2).

[2]Note that foreign-accented speech is qualitatively different from regional-accented speech produced by native speakers. The pattern of (mis)pronunciations in foreign-accented speech is unstable and unpredictable; the alternations are not limited to sounds, but include also prosodical, supra-segmental (co-articulation) and, importantly, segmental 'errors.

[3]Yet, 24-month-old infants exposed to bi-accented input, where one of the accents is spoken by a non-native speaker (e.g., non-native variants of English), showed less efficient word comprehension as compared to 24-month-old infants who received unimodal input, suggesting that regular exposure to foreign-accented speech might affect early word comprehension (Buckler et al., 2017).

[4]Although note that in this study bilingual infants were exposed to two quite distinct languages, English and Spanish, which might contribute to differences in the effect.

[5]For instance, Oslo dialect is a low pitch dialect, whereas Bergen is a high pitch dialect, meaning that pitch accents follow opposite patterns in Oslo and Bergen.

[6]It is also possible that bidialectal infants – who are used to hear inconsistent word production - are interested to the same degree in familiar and nonsense word forms, which might contribute to the null result in the word form recognition task. This alternative interpretation of the null result has been previously introduced in van Heugten and Johnson (2017), but challenged by the same authors, because (1) in their study, bidialectal infants *did* show word preference, only at a later age (at 18 months) and (2) bilingual infants (who can be expected to behave similarly in this design) show word recognition by the age of 11 months (Vihman et al., 2007).

[7]Note that in van Heugten and Johnson (2017) study, that used the HPP procedure, the effect size of Cohen's d = 0.71. In a paired two-sided *t*-test, 80% power to detect this effect requires 18 participants in each group, as revealed by the *pwr.t.test* function (Champely et al., 2018) in R (R Core Team, 2020).

[8]One child in the bidialectal group, who successfully completed both tasks had 20% of exposure to the Northern dialect. Parents made an error in the questionnaire and we kept this child after that we corrected the number.

[9]We selected a question-answer task rather than a reading task for the following reasons: first, we aimed to collect natural spontaneous speech (as typically addressed to a child), second, we wanted to capture phonological and lexico-semantical and morpho-syntactic (to a lesser extend) specificities of each dialect, and third, we wanted to avoid written language bias on speech production (as there is no standard writing system in Norwegian – words and morphosyntax vary across dialects – using any writing system, e.g., Bokmål for Oslo dialect or Nynorsk for Bergen dialect, would threaten the authenticity of dialectal production).

[10]In the original study, we planned to use Tobii TX300 eye-tracker; in the meantime, the lab acquired an Eye-link 1000 eye-tracker, so we adapted the task procedures to the new eye-tracker.

[11]These trials were used to check the quality of participants' ratings. None of the participants made errors on the control trials.

[12]Given that the variable "exposure" was bimodally distributed, that is, either 0 or 50%–80%, we dichotomized it into a categorical variable "no (exposure)" and "yes."

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