Bilingualism affects 9-month-old infants’ expectations about how words refer to kinds

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Research highlights

- Monolinguals and bilinguals differ in whether they encounter one or two labels for each object in their environments.
- Monolingual 9-10 month-olds expected distinct labels to refer to distinct object kinds, but bilingual infants did not.
- Language experience alters infants’ expectations about the relationship between words and their referents within the first year of life.
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Abstract

Infants are precocious word learners, and seem to possess systematic expectations about how words refer to object kinds. For example, while monolingual infants show a one-to-one mapping bias (e.g., mutual exclusivity), expecting each object to only have one basic level label, previous research has shown that this is less robust in bi- and multilinguals aged 1.5 years and older. This study examined the early origins of such one-to-one mapping biases by comparing monolingual and bilingual 9–10 month-olds’ expectations about the relationship between labels and object kinds. In a violation of expectation paradigm, infants heard a speaker name hidden objects with either one label (“I see a mouba! I see a mouba!”) or two labels (“I see a camo! I see a tenda!”). An occluder moved to reveal two objects that were either identical or of different kinds. Monolingual infants looked longest when two labels were associated with identical objects, and when one label was associated with objects of different kinds, showing that they found these outcomes unexpected. This replicated previous findings showing that monolinguals expect that distinct words label distinct object kinds (Dewar & Xu, 2007). Bilinguals looked equally to the outcomes regardless of the number of labels, showing no such expectations. This finding indicates that bilingualism influences young infants’ expectations about how words refer to kinds, and more broadly supports the position that language experience contributes to the development of word learning heuristics.
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Bilingualism affects 9-month-old infants’ expectations about how words refer to kinds.

Human infants possess remarkable word learning abilities. Infants produce their first words around age 12 months (Fenson et al., 2007), and show evidence of understanding some words much earlier. Research has shown that infants as young as age 6–9 months understand the meaning of numerous words, including words for foods and body parts (Bergelson & Swingley, 2012; 2013; McMurray, Horst, & Samuelson, 2012a). How are infants such successful word learners from such a young age?

One proposal is that infants approach the task of word learning equipped with heuristics that help them determine the likely meaning of new words. One of the best studied examples is mutual exclusivity, the assumption that each object only has one basic-level label (Markman & Wachtel, 1988). A related proposal is the novel-name-nameless category principle (N3C), which posits that when children hear a novel word, they seek an object for which they do not already have a name (i.e., a nameless category; Golinkoff, Mervis, & Hirsh-Pasek, 1994; Mervis & Bertrand, 1994). While these proposals differ in children’s underlying motivations (rejecting a familiar referent in the case of mutual exclusivity, versus seeking a novel referent in the case of N3C), they both bias the learner towards one-to-one mappings between words and objects.

In looking-based disambiguation paradigms used to test the use of such heuristics, infants are shown a pair of objects, one familiar and one unfamiliar, and hear a novel word (e.g. “Look at the [object name]”). Monolinguals aged 17–18 months, but not younger infants, look more at the novel object than at the familiar object (Halberda, 2003; but see Mather & Plunkett, 2010). However, it is not until several months later that infants show evidence of actually retaining the mapping between the word and the object (Bion, Borovsky, & Fernald, 2013; Horst &
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Samuelson, 2008). While such studies are rarely able to disentangle precisely which one-to-one mapping bias (e.g., mutual exclusivity or N3C) might be underlying children’s behavior, the results do suggest that 1.5-year-old monolinguals expect one-to-one mappings between words and object kinds.

The usefulness of word learning heuristics depends on how well they match children’s language learning situation. Monolingual children’s language input is largely consistent with one-to-one mappings: most object kinds have only one label (e.g., synonyms such as “couch” and “sofa” are rare). Thus, assuming a one-to-one mapping between labels and object kinds would be adaptive in helping monolingual children learn new words. However, unlike monolinguals, bilinguals regularly encounter two labels for each kind, one in each language (e.g. English “dog” and French “chien”). These cross-language synonyms are known as translation equivalents, and are learned by bilinguals from early in development (De Houwer, Bornstein, & De Coster, 2006). Because of translation equivalents, bilingual children’s language environments have a many-to-one relationship between words and objects (see Byers-Heinlein & Werker, 2013 for a discussion of whether bilingual infants recognize the one-to-one structure within each language), and thus word learning biases that favor one-to-one mappings could impede word learning.

For example, picture a young French-English bilingual who encounters two fruits: one familiar (an apple) and one novel (a pineapple). Imagine that the child had already learned the French word for apple (“pomme”), but not the English word for apple (“apple”), and does not know any words at all for the pineapple. What happens when the child hears the unknown English word “apple”? If the child uses mutual exclusivity, assuming that each object has only
one label, the child would incorrectly infer that “apple” refers to the pineapple, as the object apple already has a label (“pomme”). Similarly, applying N3C, the object “apple” is no longer from a nameless category, so the child would again incorrectly infer that that novel label “apple” refers to the only nameless category available: pineapple. As this example illustrates, either heuristic would impede the bilingual child in mapping a second label to a familiar object that already has a label, making learning translation equivalents difficult.

A number of studies have observed differences in monolinguals’ and bilinguals’ use of one-to-one mapping biases. Monolinguals aged 17–22 months disambiguate the meaning of a novel label by looking towards a novel object (Halberda, 2003), but bi- and multilinguals do not (Byers-Heinlein & Werker, 2009; Houston-Price, Caloghiris, & Raviglione, 2010). Further, in studies of preschool-aged bilinguals’ use of one-to-one mapping biases, the majority have found that bilinguals are less consistent than monolinguals (Au & Glusman, 1990; Davidson, Jergovic, Imami, & Theodos, 1997; Davidson & Tell, 2005; Kalashnikova, Mattock, & Padriac, 2014), although some studies have not found any differences between the two groups (Byers-Heinlein, Chen, & Xu, 2014; Frank & Poulin-Dubois, 2002).

One question that remains unanswered is just how early monolingual versus bilingual language experience affects children’s language learning heuristics. One possibility is that monolinguals and bilinguals initially operate with similar language learning heuristics, and the two groups only begin to differ later in development with mounting knowledge of how words and objects relate in their environments. Another possibility is that monolingual versus bilingual language experience alters the development of infants’ language learning heuristics from very
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early in development — even before infants have acquired a sizeable vocabulary. To date, no studies have compared monolinguals and bilinguals younger than 1.5 years.

The current study investigated whether, by age 9–10 months, monolinguals and bilinguals differ in their expectations about how words refer to object kinds. Using a violation of expectation method adapted from Dewar & Xu (2007), infants heard an actor label objects hidden by an occluder with either one label (“I see a mouba! I see a mouba!”) or two labels (“I see a camo! I see a tenda!”) The occluder then moved to reveal either two identical objects or two objects of different kinds. Previously, Dewar & Xu found that monolingual 9-month-old infants expected distinct labels to refer to distinct object kinds, looking longer to unexpected outcomes. Specifically, when infants heard only one label, they looked longer when two different objects were revealed. Conversely, when they heard two labels, they looked longer when two identical objects were revealed. This suggests that monolingual infants expect different words to label different object kinds. The current study compared monolingual and bilingual infants’ performance on this task. If language experience contributes to the early development of word learning heuristics, then unlike monolinguals, bilinguals should have less consistent expectations about how words refer to object kinds, and should show similar looking across outcomes. Conversely, if language experience only affects word-learning heuristics once infants have amassed a sizeable enough vocabulary, then both monolinguals and bilinguals should share the expectation that different words refer to different kinds.
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Methods

Participants

Forty-four healthy, full-term 9–10 month-old infants were included in the final sample. Twenty-one infants (12 female) were monolingual ($M_{age} = 9m25d$, range = 9m5d – 10m14d), exposed to English ($n = 11$) or French ($n = 10$) at least 90% of the time. Twenty-three infants (14 female) were bilingual ($M_{age} = 9m24d$, range = 8m22d – 10m25d), exposed to two languages regularly from birth. All bilinguals were exposed to English or French at least 25% of the time, and a second language 25% of the time, according to the Language Exposure Questionnaire (Bosch & Sebastián-Gallés, 2001). A few bilinguals had some exposure to a third language. Table 1 provides details about each bilingual participant’s language background.

Infants’ socio-economic background was assessed via mothers’ educational attainment. The monolingual and the bilingual groups were comparable, and were largely born to mothers who had participated in post-secondary education. Amongst the mothers of the monolinguals, 76% had completed a bachelor’s degree or higher, 19% had completed some college or had obtained a trade school diploma, and 5% had not completed high school. Amongst the mothers of the bilinguals, 61% had completed a bachelor’s degree or higher, 26% had completed some college or had obtained a trade school diploma, 9% had completed high school, and 4% had not completed high school.

Fourteen monolinguals and 15 bilinguals were tested and excluded prior to analyses due to fussiness (11 monolinguals, 5 bilinguals), experimenter error (1, 6), and technical failure (2, 4). Additionally, to ensure that infants had encountered both the auditory and visual stimuli for test trials, an a-priori decision was made that infants who had a test trial with less than 1s
looking during the window of analysis would be excluded once data had been examined. Data from an additional 10 monolinguals and 9 bilinguals were excluded for this reason.

**Stimuli**

Two parallel sets of video stimuli were created, one in English and one in French. Stimuli were produced by a balanced bilingual female actress who had learned both languages from birth, used both languages regularly in her everyday life, and spoke without a perceptible accent in either language. Following Dewar & Xu (2007), three types of trials were created: pre-familiarization trials, familiarization trials, and test trials. Each trial followed the same basic order of events. At the beginning of each trial, a curtain raised to reveal the actress. She then spoke to the infant while alternating her gaze between the viewer and an occluder located at the bottom of the screen. The curtain then fell, and the occluder slid towards the left to reveal an object outcome. Trials varied according to what the actress uttered and what was revealed behind the occluder.

Infants saw one pre-familiarization trial, which introduced the basic trial timing to the infant. On these trials, the actress said, “There’s nothing there! There’s nothing there! Look baby, baby look!” and no objects were hidden behind the occluder.

Infants saw four familiarization trials, which showed the infants the different possible object outcomes. On these trials, the actress said, “I see something! There’s something there! Look baby, baby look!” , and two objects were revealed behind the occluder. On half of familiarization trials (2), they were two identical objects, and on the other half of familiarization trials (2), they were two objects of different kinds. The objects were taken from a novel object database (Horst, 2009), and were expected to be unfamiliar to the infants.
Infants saw four test trials. On each trial, the actress named the objects with either identical nonsense labels, such as “I see a moub! I see a moub! There’s a moub! There’s a moub! Baby, a moub! Baby, a moub! Look baby, baby look!” or different nonsense labels, such as “I see a camo! I see a tenda! There’s a camo! There’s a tenda! Baby, a camo! Baby, a tenda! Look baby, baby look!” The nonsense labels were different on each trial, and included camo, fid, moub, ret, tac, and tenda. These labels were chosen because they were phonotactically legal in both French and English. However, they have somewhat different realizations in each language, which would allow bilingual infants to perceive them in a language-specific way (e.g., Sundara, Polka, & Molnar, 2008). All labels were expected to be unfamiliar to infants. The occluder slid to reveal either two identical objects of the same kind, or two objects of different kinds, just as in the familiarization trials. Across the four test trials, infants saw each combination of labels (one, two), and objects (identical, different). If infants expect distinct labels to name distinct object kinds, then when they hear one label they should expect to see identical objects rather than different objects. Conversely, when they hear two labels they should expect to see different objects rather than identical objects. Under the violation of expectation paradigm, infants should look longer at the unexpected outcomes than at the expected outcomes. See Figure 1 for a schematic of the four types of test trials.

Procedure

Infants were tested in a dark sound-attenuated room, where they sat in a high chair or on their parents’ lap approximately 60 centimeters away from a Tobii T-60XL eyetracking monitor. Parents wore darkened sunglasses and/or headphones with masking music, to ensure that their reaction to the stimuli did not influence the infants’ reactions. Prior to the beginning
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of the study, the eyetracker was calibrated to each infant’s eyes using a built-in five-point infant calibration routine.

Infants were tested in either French or English. Monolinguals were tested in their native language, and bilinguals were tested in whichever language they heard more often (see Table 1 for language of testing for bilingual infants). Infants with equal or near-equal exposure to English and French were randomly assigned to a test language. Each infant was randomly assigned to one of four possible trial orders. Orders counterbalanced pairings between labels, objects and test trial order using a Latin square approach. Stimulus presentation was controlled by an experimenter located in an adjacent room using Tobii Studio Software. The experimenter was blind to the auditory stimuli being presented. Each infant was shown nine trials: one pre-familiarization trial, four familiarization trials, and four test trials. An attention-getting video was shown between each trial to reorient the infant to the screen.

The length of each trial was controlled online using JHab software (Casstevens, 2007), as the Tobii Studio software used to present the stimuli was not able to terminate the trial contingent on the infants’ behavior. Once the object outcome was revealed at the end of each trial, the experimenter pressed a key on the keyboard when the infant was looking at the screen and released it when the infant was looking away from the screen. If the infant looked away for two consecutive seconds, or if he/she looked for more than 30 seconds, JHab signalled the experimenter with a beeping noise, and the experimenter ended the trial. Looking times used for analysis were unfiltered, and were obtained directly from Tobii Studio software, which collected infant eye gaze data at a rate of 60 Hz.
Results

Preliminary analyses

The main variable of analysis was infants’ looking time towards the area of the screen containing the two objects during the time window beginning when the occluder was removed until the end of the trial.

The first set of preliminary analyses concerned infants’ looking during familiarization trials. A 2 (objects: identical, different) x 2 (language group: monolinguals, bilinguals) mixed ANOVA showed no significant main effects or interactions. This indicates that prior to the introduction of labels, monolinguals and bilinguals were similarly interested in both outcomes.

The second set of preliminary analyses investigated potential effects of the language of testing (English or French) and infant gender on infants’ looking during test trials. Two mixed ANOVAs were performed with factors that included labels (one, two), objects (identical, different), and language group (monolingual, bilingual), and either gender or language of testing. There were no significant main effects or interactions, thus data were collapsed across these factors for the main analyses.

Main analyses

To investigate whether infants expected distinct labels to refer to distinct kinds, and whether this is affected by infants’ language group, a 2 (labels: one, two) x 2 (objects: identical, different) x 2 (language group: monolingual, bilingual) mixed ANOVA was performed, with infants’ looking time during test trials (after the objects were revealed) as the dependent variable. The three-way interaction between labels, objects, and language group trended towards statistical significance, $F(1, 42) = 2.88, p = .097, \eta^2 = .064$. This suggests that
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monolinguals and bilinguals might have different patterns of looking across trial types. Results by infants’ language group and trial type are displayed in Figure 2.

To follow-up, separate 2 (labels: one, two) x 2 (objects: identical, different) within-subject ANOVAs were performed for the monolingual and bilingual groups. Monolinguals showed a significant interaction between labels and objects, $F(1, 20) = 11.0, p = .003, \eta^2 = .35$, but no significant main effects of labels, $F(1, 20) = .14, p = .72$, $\eta^2 = .007$, nor of objects, $F(1, 20) = .033, p = .86$, $\eta^2 = .002$. One-tailed single-sample t-tests revealed that when one label was used, monolinguals looked significantly longer to the unexpected different objects outcome ($M = 5.63, SD = 3.39$) than to the expected identical objects outcome ($M = 4.32, SD = 2.52$), $t(20) = 1.94, p = .034, d = .42$. Conversely, when two different labels were used, monolinguals looked significantly longer to the unexpected identical objects outcome ($M = 5.96, SD = 4.18$) than to the expected different objects outcome ($M = 4.21, SD = 2.36$), $t(20) = 2.17, p = .021, d = .47$. This pattern of results replicates previous findings that monolingual infants find it unexpected for the same label to refer to two objects of different kinds, or for different labels to refer to two identical objects (Dewar & Xu, 2007).

The ANOVA for bilingual infants did not reveal a significant interaction, $F(1, 22) = .12, p = .73, \eta^2 = .006$. Further, there was no significant main effect for labels $F(1,22) = .002, p = .97, \eta^2 < .001$, nor a main effect for objects $F(1, 22) = .094, p = .76, \eta^2 = .004$. Follow-up t-tests confirmed that when one label was used, bilinguals looked similarly to the unexpected different objects outcome ($M = 5.75, SD = 3.85$) as to the expected identical objects outcome ($M = 5.51, SD = 3.53$), $t(22) = .23, p = .41, d = .047$. When two different labels were used, bilinguals also looked similarly to the unexpected identical objects outcome ($M = 5.53, SD = 2.71$) than to the
expected different objects outcome \((M = 5.35, SD = 2.69)\), \(t(22) = .29, p = .39, d = .059\). Bilingual infants showed similar interest in each of the outcomes, regardless of the labels they heard. This suggests that bilinguals did not have expectations about whether one versus two labels should refer to identical versus different objects.¹

**Discussion**

The current study investigated whether growing up bilingual alters 9–10 month-old infants’ expectations about how words refer to object kinds. Using a violation of expectation method, infants heard an actress utter either one or two distinct labels, and then saw an outcome with either two identical objects or two objects of different kinds. Replicating previous work (Dewar & Xu, 2007), monolingual infants looked longest when one label was used to name objects of different kinds, and when two labels were used to name identical objects. Young monolinguals already show expectations about how words and objects correspond, specifically that unique labels name distinct object kinds. However, bilingual infants did not show any differences in their pattern of looking as a function of the number of different object labels used, and the number of different object kinds revealed. These results demonstrate that 9–10 month-old bilingual infants do not share monolingual infants’ expectations.

¹ While the majority of bilinguals were tested in their dominant language \((n = 17)\), a minority \((n = 5)\) were tested in a non-dominant language because their dominant language was neither English nor French. To ensure that the results were not driven by this subset of infants, analyses were rerun with their data excluded. The pattern of results was the same as with the full sample of bilinguals. The key statistic showed that there was no significant interaction between labels and objects, \(F(1, 17) = 1.29, p = .67, \eta^2 = .011\). Follow-up t-tests confirmed that when one label was used, bilinguals looked similarly to the unexpected different objects outcome \((M = 5.65, SD = 3.99)\) as to the expected identical objects outcome \((M = 5.35, SD = 3.49)\), \(t(17) = .25, p = .40, d = .060\). When two different labels were used, bilinguals also looked similarly to the unexpected identical objects outcome \((M = 5.08, SD = 2.68)\) than to the expected different objects outcome \((M = 4.84, SD = 2.50)\), \(t(17) = .33, p = .38, d = .078\).
expectations that distinct labels refer to distinct object kinds. Language experience alters infants’ word learning expectations even before they have acquired a sizeable vocabulary.

It is important to note that the current study did not test word learning per se, nor the use of specific word learning heuristics such as mutual exclusivity or N3C. Rather, this study revealed early-emerging differences in monolingual and bilingual infants’ expectations about how words and objects relate. Nonetheless, such expectations could serve as a developmental precursor to later word learning strategies. Indeed, these results foreshadow findings from word learning and disambiguation tasks with older infants and preschoolers, showing that bilinguals and multilinguals are less likely than monolinguals to expect a one-to-one correspondence between words and object kinds (Byers-Heinlein & Werker, 2009; 2013; Davidson et al., 1997; Davidson & Tell, 2005; Houston-Price et al., 2010; Kalashnikova et al., 2014). Together, these studies reveal that the effects of language experience on infants’ language learning biases are early-emerging and persistent. Experience hearing most object kinds labeled with a single word may contribute to monolinguals’ early-developing expectation that distinct words refer to distinct kinds, in turn supporting the development of biases such as mutual exclusivity or N3C. Bilinguals’ experience hearing two labels for each object as they learn translation equivalents may not always support the development of the same word learning biases and expectations.

Although this study and others have focused on the key role of translation equivalents (see also Byers-Heinlein, 2014), it is important to consider whether other differences between monolinguals and bilinguals could have contributed to observed differences in their performance. For example, because their experience is divided between two languages, bilinguals could have less proficiency in each language than same-aged monolinguals. To test
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whether this might have affected their performance in the current study, correlations were calculated between bilinguals’ exposure to the language of testing and their performance on each trial type, as measured by a difference between looking at the two outcomes. Correlations were very small and not statistically significantly different from zero (rs < .10). Moreover, results were identical when analyses were restricted to only those bilinguals who were dominant in the language of testing. Both of these analyses suggest that bilinguals’ proficiency in the language of testing was not related to their performance.

Converging evidence also suggests that it is the structure of bilinguals’ input and word knowledge, rather than other differences between monolinguals and bilinguals, which underlies differences in their use of word learning heuristics. In one study, bilinguals aged 17–18 months who knew relatively many translation equivalents (i.e., whose lexicons were thus characterized by a many-to-one structure) did not show disambiguation, while those who knew relatively few translation equivalents (i.e., whose lexicons were more consistent with a one-to-one structure) showed disambiguation similar to monolinguals (Byers-Heinlein & Werker, 2013). Another study showed a graded effect, whereby the more languages infants were learning (monolingual vs. bilingual vs. trilingual), the less likely they were to look towards a novel object upon hearing a novel noun (Byers-Heinlein & Werker, 2009). Finally, these empirical results are consistent with recent computational models showing how the structure of the input can support the development of one-to-one lexical biases in monolinguals but not in bilinguals (McMurray, Horst, & Samuelson, 2012b).

Rather than expecting that each object have a single basic-level label, might bilinguals expect each object to have exactly two labels, one in each language? This possibility was tested
in a recent study (Kandahai, Hall, & Werker, 2016), wherein 18 month-old monolinguals and bilinguals heard a novel word “zav” in the presence of a familiar object (a dog). Applying mutual exclusivity, monolinguals interpreted “zav” as referring to a salient property of the object — its bright color. However, bilinguals interpreted the word “zav” as a third label for the object category dog, even though they likely knew the word for dog in both of their languages. In other words, knowing a label in each of their languages did not prevent bilinguals from learning a third label for the dog. This result echoes the current finding: bilingual infants were not surprised that identical objects were given two different labels, even though the labels were both in the same language. Young bilinguals neither show strict mutual exclusivity (expecting one label for each object) nor mutual exclusivity within each language (expecting exactly two labels for each object, one in each language).

Why would bilinguals fail to leverage the one-to-one mapping structure within each language, when a multitude of studies have demonstrated that bilingual infants readily discriminate their languages (Bosch & Sebastián-Gallés, 2001; Byers-Heinlein, Burns, & Werker, 2010; Molnar, Gervain, & Carreiras, 2014)? Recent theoretical work has distinguished between bilingual infants’ perceptual categorization of their two languages (i.e., language discrimination), and conceptual categorization of their languages (i.e., deeper forms of “knowing” that there are two languages; Byers-Heinlein, 2014). A full conceptual understanding that they are learning two languages, including that objects have a basic-level label in each language, might emerge slowly across development. Our results suggest that as early as 9 months, bilinguals do not share monolinguals’ expectations about one-to-one mappings. Yet, it may take them much longer to discover the underlying two-to-one mapping
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structure of their lexico-semantic world (see also Byers-Heinlein & Werker, 2013). Further, new
evidence suggests that differences between monolinguals and bilinguals might persist
throughout development — even once bilinguals are able to notice the mapping structure of
each language. In a statistical word-learning paradigm, bilingual adults were more likely than
monolinguals to acquire two-to-one mappings (Poepsel & Weiss, 2016), despite all labels being
presented in English. Bilingualism appears to alter learners’ expectations across the lifespan,
and as the current findings show, as early as age 9 months.

Studies showing differences between monolinguals and bilinguals raise important
questions about the role of word learning heuristics in successful language acquisition.
Bilinguals pass language milestones on a similar schedule to monolinguals (Werker & Byers-
Heinlein, 2008) and have similar-sized vocabularies as monolinguals when words across both
languages are counted (Core, Hoff, Rumiche, & Senor, 2013; Pearson, Fernández, & Oller,
1993). An open question is therefore how bilinguals keep pace with their monolingual peers if
they do not use all of the same word learning heuristics. To the degree that bilinguals do not
share word-learning expectations with monolinguals, these cannot be crucial to early language
development. Fortunately, young word learners access a wealth of cues as they infer the
meaning of words, and weigh these cues differently across development (Hollich, Hirch-Pasek,
& Golinkoff, 2000). From age 16 months, bilinguals show enhanced perspective taking skills in a
communicative situation (Fan, Liberman, Keysar, & Kinzler, 2015; Liberman, Woodward, Keysar,
& Kinzler, 2016). More sophisticated use of socio-pragmatic cues may allow young bilinguals to
keep pace with monolinguals without access to heuristics such as mutual exclusivity or N3C.
Additional research is needed that compares monolingual and bilingual infants’ word learning
strategies, investigating how each group weighs different sources of information across development. Further, it will be important for future research to determine how word learning heuristics observed in the lab relate to real-world language learning, exploring the degree to which they are drivers of language acquisition, bi-products of language acquisition, or both.

It is interesting to consider what expectations, if any, bilingual infants have about the relationship between words and objects. While the current study suggests that bilinguals do not share monolinguals’ expectation that distinct words label distinct kinds, this result does not preclude other generalizations. For example, hearing consistent labels allows monolingual infants as young as 3 months to form object categories (Balaban & Waxman, 1997; Ferry, Hespos, & Waxman, 2010; Fulkerson & Waxman, 2007; Waxman & Braun, 2005). Further, in laboratory word learning tasks, 1-year-old monolinguals privilege word forms and sound combinations characteristic of their native language (Mackenzie, Curtin, & Graham, 2012a; 2012b; May & Werker, 2014). Other work with monolingual infants has revealed expectations that emerge over the second and third year of life that words are better labels for objects than gestures (Namy, 2001; Namy & Waxman, 1998). Research to date has not tested bilinguals in these paradigms, but this would be an interesting direction for future research.

Finally, while this study has shown that bilingualism influences young infants’ expectations about the meanings of words, other research has shown that bilingualism also influences infants’ language-related social expectations. A recent series of studies investigated bilingual 13-month-olds’ expectations about whether knowledge of object labels would be shared across different speakers. Monolingual infants expected word knowledge to be shared across speakers who use the same language (Scott & Henderson, 2013), but bilingual infants did
not (Henderson & Scott, 2015). In a related study, monolingual but not bilingual 20-month-olds expected other people to be monolingual rather than bilingual (Pitts, Onishi, & Vouloumanos, 2015). Together, these findings reveal infants’ remarkable ability to match their language learning strategies to their early environment, be it monolingual or bilingual (see also Fennell & Byers-Heinlein, 2014; Mattock, Polka, Rvachew, & Krehm, 2010).

In sum, the current research has replicated findings that 9–10 month-old monolinguals expect distinct object labels to refer to distinct kinds, and has revealed that same-aged bilinguals do not share this expectation. This difference in monolinguals’ and bilinguals’ expectations about the relationship between words and objects may be a precursor to differences seen in behaviours related to one-to-one mapping (e.g., mutual exclusivity, N3C) at age 17–18 months. This study demonstrates that exposure to multiple languages affects infants’ language-related expectations from very early stages of language acquisition.
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Table 1

Language of test and percent exposure to each language for bilingual infants

<table>
<thead>
<tr>
<th>Test Language</th>
<th>Language 1</th>
<th>%</th>
<th>Language 2</th>
<th>%</th>
<th>Language 3</th>
<th>%</th>
</tr>
</thead>
<tbody>
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Figure 1. Schematic of test trials. Each infant saw all four outcomes in a counterbalanced order.

Looking time was measured to the bottom part of the screen once the objects were revealed.
**Figure 2.** Mean looking times as a function of group, the number of distinct labels heard, and whether identical or different objects were revealed. Error bars represent standard error of the mean.

* $p < .05$
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