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# Slowly but Surely: Adverbs Support Verb Learning in 2-Year-Olds

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# Slowly but Surely: Adverbs Support Verb Learning in 2-Year-Olds

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To acquire the meanings of verbs, toddlers make use of the surrounding linguistic information. For example, 2-year-olds successfully acquire novel transitive verbs that appear in semantically rich frames containing content nouns ("The boy is gonna pilk a balloon"), but they have difficulty with pronominal frames ("He is gonna pilk it") (Arunachalam & Waxman, 2010). We hypothesized that adverbs might facilitate toddlers' verb learning in these sparse pronominal frames if their semantic content directed toddlers' attention to aspects of the event that are relevant to the verb's meaning (e.g., the manner of motion). As predicted, the semantic information from a specific manner-of-motion adverb (*slowly*) supported verb learning, but other adverbs lacking this semantic content (*nicely, right now*) did not. These results provide the first evidence that adverbs can facilitate verb learning in toddlers and highlight the interaction of syntactic and semantic information in word learning.

## INTRODUCTION

When a child acquires a new word, she must attend to both its linguistic and extralinguistic context in order to identify its meaning and grammatical properties. This is no small feat, since both of these sources of information are plagued with ambiguity (e.g., Bloom, 2002; Gleitman, 1990; Pinker, 1984; Quine, 1960). Verb acquisition can be particularly challenging, especially in comparison to nouns (e.g., Gentner, 1982; Gentner & Boroditsky, 2001; Gleitman et al., 2005; Gleitman & Gleitman, 1992; Golinkoff & Hirsh-Pasek, 2008; Tomasello, 1992). While toddlers produce their first words around their first birthday, verbs tend to lag behind other kinds of words, entering the lexicon in significant numbers only later (Fenson et al., 1994).

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Experimental studies document that verb acquisition is challenging at least in part because acquiring the meaning of a novel verb requires more informational support than acquiring the meaning of a novel noun (Arunachalam & Waxman, 2011; Gillette, Gleitman, Gleitman, & Lederer, 1999; Imai, Haryu, & Okada, 2005; Imai et al., 2008; Snedeker & Gleitman, 2004; Waxman, Lidz, Braun, & Lavin, 2009). One powerful source of informational support is the verb's linguistic context (Gleitman, 1990; Landau & Gleitman, 1985). Children as young as 2 years of age can gather information about a novel verb's meaning from the number and position of its surrounding arguments (e.g., Fisher, 2002; Hirsh-Pasek & Golinkoff, 1996; Naigles, 1990), as well as the semantic content of the words and phrases occupying those argument positions (e.g., Arunachalam & Waxman, 2010, 2011; Fisher, Hall, Rakowitz, & Gleitman, 1994; Piccin & Waxman, 2007; Pinker, 1994).

In some verb learning situations, the semantic content of the phrases surrounding the verb is crucial (Arunachalam & Waxman, 2010, 2011). Arunachalam and Waxman taught 2-year-olds novel transitive verbs in one of two conditions. In both conditions, toddlers viewed the same video of an agent performing an action on an inanimate object (e.g., a boy waving a balloon). In the *Rich Content* condition, the verb was flanked by content nouns (DPs) ("A boy is gonna pilk a balloon"). In the *Sparse Content* condition, the verb was instead flanked by pronouns, and the content nouns appeared in the previous sentence to establish reference ("Let's see a boy, and a balloon. He's gonna pilk it").[1] Toddlers succeeded (i.e., patterned significantly above chance) in the *Rich Content* condition, but not the *Sparse Content* condition, indicating that they benefit when the arguments of novel verbs are expressed as content nouns and that they have difficulty when the arguments are expressed as pronouns. Arunachalam and Waxman reasoned that the rich semantic information available in the content nouns helped toddlers to identify the event participants (the agent: the boy, and the patient: the balloon), and in turn, to zoom in on the relation between them (waving). Put differently, nominal expressions serve as one entry point to identifying verb meaning, when they occupy the verb's argument positions (e.g., Gillette et al., 1999; Snedeker & Gleitman, 2004).[2]

Notice however, that this outcome, interesting in itself, also presents a challenge for theories of acquisition because pronouns are extremely frequent in speech to young children (Cameron-Faulkner, Lieven, & Tomasello, 2003; Mintz, 2003; Valian, 1991).[3] Moreover, even with contentful nouns there will be instances of referential uncertainty in which further informational support is necessary to narrow down the hypothesis space (e.g., when 'the boy' cannot pick out a unique individual).

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[1]Corresponding A&W conditions: *Rich Content* = Experiment 1 '+ Nouns + Syntax'; *Sparse Content* = Experiment 2'+Nouns +Syntax'

[2]Note that pronoun contexts are beneficial in some situations, such as determining a word's grammatical category (Mintz, 2004) or broad semantic class (e.g., Fisher, 2002), or extending it syntactically (Childers & Tomasello, 2001). Zooming in on the meaning, or relation between two participants, however, appears to be difficult in sparse linguistic contexts.

[3]A reviewer points out that pronouns may be easier to resolve in naturalistic conversations, especially because many pronouns are first or second person pronouns. We agree. However, toddlers must still be able to resolve verb meanings in situations in which an adult is commenting on an ongoing event in the world that does not involve the child or adult as participants. These situations, similar to those presented in our study, are likely to invoke third person referring expressions, whether pronouns or full noun phrases.

The question that arises, then, is what additional linguistic information could provide toddlers with the requisite semantic support for verb learning. Here, we focus on one linguistic element in particular: adverbial modifiers. By virtue of their lexical semantics, certain adverbs can provide information about the event that could prove useful to the language learner, such as whether or not the event has an endpoint, whether or not the event stretches over time and space, whether or not there are subevents, and the manner in which the event transpires.

Note that adverbs can do more than simply provide additional semantic content in the sentence in which the verb appears, allowing the learner to make use of associations and real-world knowledge such as deducing that a novel word means 'eat' from the fact that it co-occurs with words for food and *hungry* (cf. Pinker, 1994). Adverbs also carry selectional restrictions that constrain the type of verb that they can modify. For example, one cannot 'be a painter *slowly*' (because 'being a painter' is a state, and *slowly* refers to a manner of motion of an activity or accomplishment) or 'sleep *completely*' (because sleeping is an activity, and *completely* requires an event with an endpoint or maximum) (cf. Vendler, 1957). The information contributed by an adverb thus has the potential to impose important constraints on hypotheses about verb meaning.

Because Arunachalam and Waxman (2010, 2011) asked toddlers to learn the meaning of a novel verb describing a manner of motion (e.g., waving), in the current study we test whether a manner-of-motion adverb (*slowly*) can support toddlers in their efforts to acquire such verbs. We test the hypothesis that because manner-of-motion adverbs make specific reference to a key aspect of the event, that is, the motion of the action (Shäfer, 2002; Tenny, 2000; Thomason & Stalnaker, 1973), such adverbs will increase toddlers' success at acquiring novel motion verbs. We further hypothesize that other adverbial expressions, even those that are familiar and frequent, will not provide the requisite support for acquiring motion verbs unless they specifically highlight motion aspects of the event.

Of course, because adverbs themselves tend to be late acquired, the first question is whether toddlers attend to adverbs at all in the service of word learning. Recent evidence (Syrett, 2007; Syrett & Lidz, 2010) demonstrates that they can. Specifically, adverbs support 30-month-olds' acquisition of novel adjectives. In these studies, toddlers viewed, for example, a container that was both tall and clear, and heard a novel adjective describing it. Those that heard the object described as *completely pelgy* assigned the novel adjective *pelgy* the meaning 'clear' rather than 'tall.' The opposite pattern was found for toddlers who had heard the object described as *very pelgy*. Syrett and Lidz proposed that these toddlers used the semantic properties of the adverbs to identify the meaning of the adjectives they modified: While an object can be completely or maximally clear, it cannot be completely or maximally tall.

In the current study, we propose that adverbs may also confer an advantage in verb learning. Surprisingly, the evidence on the role of adverbs in verb learning is quite thin. Prior work reveals that 5-year-old German learners can recruit the adverb *wieder* 'again' to learn about novel verbs (Wittek, 2002), but to our knowledge no studies have examined the role of adverbs in verb learning at younger ages. In the current research, we adapted Arunachalam and Waxman's paradigm, using their *Sparse Content* condition (in which toddlers performed at chance, showing no evidence that they had learned the meaning of the novel verb) as a testing ground for our hypothesis. We reasoned that a manner-of-motion adverb such as *slowly,* whose lexical semantics highlights a specific aspect of the event (the pace at which the event is unfolding), would direct toddlers' attention to the motion in the scene, leading them to focus on aspectual information related to the event itself, and therefore support acquisition of the verb's meaning.

To foreshadow, this is precisely what we found. Toddlers succeeded when encountering verbs in transitive pronominal frames modified by *slowly*. But crucially, not just any adverb was sufficient: toddlers did not learn the verb meanings in sentences including either the vague manner adverb *nicely* (Experiment 1a), or the frequent temporal indexical adverbial expression *right now* (Experiment 1b). This study therefore provides the first evidence that adverbs with relevant semantic content – even those that may not yet be in toddlers' productive vocabularies – provide informational support for the acquisition of verb meaning.

## EXPERIMENT 1A

We began our inquiry by comparing toddlers' performance with the adverbs *slowly* and *nicely* for two reasons. First, both have similar surface-level form (i.e., they are bisyllabic and have the transparent adverbial *–ly* ending) and are relative (what counts as *slowly* or *nicely* can vary from context to context) (Kennedy, 1999; Sapir, 1944). Second, while both are manner adverbs, they differ crucially in the level of specificity about the event that they encode. *Slowly* obligatorily picks out the pace with which the motion is taking place, but *nicely* is vague (or indeterminate): what counts as *nice* can vary widely and can be seen from multiple perspectives, including the speaker, the agent, or the observer of the event (see related discussion in Lasersohn, 2005.) Thus, comparing these two adverbs allows us to zero in on the contribution of *specific* semantic information encoded in the adverbial expression and its relation to the particular verb being acquired in each trial. That is, we predict that an adverb encoding specific information about manner of motion (*slowly*) should facilitate acquisition of semantically compatible verbs involving an observable motion, while an adverb that is much less direct and informative should not provide the informational support the toddler needs for verb learning.

### Method

#### *Participants*

Forty typically developing toddlers (20 males; mean age: 27.3 months, age range: 24.9 to 29.4 months) participated and were randomly assigned to one of two between-subject conditions. Fifteen additional toddlers were excluded from the sample for: failure to meet selectional criteria (correct pointing on at least one of two training trials and pointing to one of the test scenes on at least one test trial) (11), coder disagreement (see below) (1), parental interference (2), or fussiness (1).

Toddlers were recruited from Evanston, Illinois, and surrounding areas. All were acquiring English as a native language and were exposed to another language less than 25% of the time. Parents completed the MacArthur-Bates CDI Short Form: Words and Sentences (Fenson et al., 1994). Mean vocabulary production was 73 words (range: 22 to 99 words); there were no differences in vocabulary between conditions or genders.

### Materials

Materials were adapted from Arunachalam and Waxman (2010, 2011). Each toddler participated in six trials, each with stimuli as described below.

### Visual stimuli

Visual stimuli were digital video recordings of live actors performing actions with inanimate objects, such as waving a balloon. Videos were edited using Final Cut Pro and presented to toddlers on a 20-in. television screen. The dynamic scenes (e.g., boy waving a balloon) were each 5 x 4.5 in. and appeared on a black background.

### Auditory stimuli

Auditory stimuli were produced by a female native speaker of American English in a sound-attenuated recording booth. Utterances were edited, controlling for duration and intensity using Praat software (Boersma & Weenink, 2005), and synchronized with the visual stimuli. Sound was presented through a hidden speaker located directly below the center of the screen.

### Apparatus and procedure

Toddlers and caregivers were welcomed into the lab's waiting area. While the toddler played with toys, the caregiver completed a consent form and the CDI checklist. They were then brought into an adjoining room, where the toddler sat in a booster seat, approximately 14-inch from the screen. The caregiver, seated behind the toddler, was asked not to interact with him/her during the session.

One experimenter controlled the video presentation from behind a curtain while another sat beside the toddler to elicit responses. Toddlers were asked to indicate their choices by pointing. Several studies have used pointing tasks with participants at this age (Arunachalam & Waxman, 2010, 2011; Bernal, Lidz, Millotte, & Christophe, 2007; Dittmar, Abbot-Smith, Lieven, & Tomasello, 2011; Fernandes, Marcus, DiNubila, & Vouloumanos, 2006; Fisher, 2002; Maguire, Hirsh-Pasek, Golinkoff, & Brandone, 2008; Noble, Rowland, & Pine, 2011; Syrett, Musolino, & Gelman, 2012). Pointing was recorded with a video camera located directly above the screen.

Before the test trials, toddlers engaged in a brief training session, designed to encourage pointing. They viewed two training trials, each introducing two dynamic scenes side-by-side on the screen. The experimenter asked the toddler to point to either a familiar character (e.g., Elmo) or activity (e.g., dancing). No novel words were used. Toddlers who pointed incorrectly or who were reluctant to point were gently encouraged to point again. Those who failed to point or pointed incorrectly on both training trials were replaced in the design.

## Test Session and Trial Structure

There were six different test trials, each featuring an agent engaged in an action with an object, described by a novel verb. See Appendix A for a complete list. Each trial lasted a little over half a minute, for a total time of just under five minutes. Participants were randomly assigned to one of two conditions. All toddlers viewed the same visual materials; the only difference was the adverb they heard during the Linguistic Familiarization Phase (*slowly* or *nicely*). Each trial had the same structure (see Figure 1) and is described in more detail below.

| | Linguistic Familiarization (5 sec) | Event Familiarization (12 sec) | Test Phase (20 sec) | |
|---|---|---|---|---|
| visual stimuli |  (still image) |  (dynamic scene) |  Familiar Object (new action) |  Familiar Action (new object) |
| auditory stimuli | Let's see a boy, and a balloon. He's gonna pilk it *slowly / nicely.* | Look! Pilking! Wow! | Now look. They're different! [black screen] Do you see pilking? Find pilking! | |

FIGURE 1   Example of visual and auditory stimuli for a representative test trial. (Color figure available online.)

### Linguistic familiarization phase

During the Linguistic Familiarization Phase, toddlers saw a 5-second still frame of a live action scene (e.g., a boy holding a balloon) and heard one of two versions of the auditory stimuli, as indicated in the Figure. The stimuli were identical to A&W's *Sparse Content* condition, with the sole exception of the utterance-final adverb (either *slowly* or *nicely*).

### Event familiarization phase

Next, during *Event Familiarization* (12 seconds), toddlers saw a dynamic scene in which the agent performed an action with an object (e.g., waving a balloon). The scene appeared first on one side of the screen, accompanied by the novel verb in a bare syntactic frame (*Look! Pilking!*), and then on the other side, accompanied by a general exclamation (*Wow!*) (order counterbalanced across trials).

### Test phase

Finally, during *Test*, two new dynamic scenes appeared simultaneously. In the Familiar Action scene, the agent performed the *now-familiar action* with a *new object* (e.g., a toy rake); in the Familiar Object scene, he performed a *new action* on the *familiar object* (e.g., tapping the balloon). Toddlers were first given an opportunity to inspect both scenes with no novel words (6 sec). The screen then went black for 2 seconds, and toddlers heard, *Do you see pilking?* The scenes reappeared in their original locations for 12 seconds and toddlers heard, *Find pilking!* The experimenter encouraged the child to point by saying *Can you show me? Where's pilking?* and gave neutral encouraging feedback (*Thanks for pointing!*) regardless of where the child pointed.

## Coding and Analysis

All pointing responses were recorded by the experimenter who could see the television screen but was blind to the study hypotheses. Toddlers generally had no difficulty pointing and did not typically require further clarification of the task. Pointing responses were independently verified by a condition-blind coder from the recorded video. The coders agreed on all points except for a single trial from one toddler, and three trials from another toddler. The single trial from the first toddler and all trials from the second toddler were excluded. In addition, four toddlers, each on one of their six trials, pointed first to one scene and then the other. We used only their first point on these trials as the dependent measure. For each toddler, we calculated the number of trials on which she pointed to the Familiar Action scene, divided by the total number of trials on which she pointed.[4] Given the binary forced-choice design, chance performance is .5. Previous pointing studies with nearly identical stimuli have used .5 a chance level (Arunachalam & Waxman, 2010, 2011). Toddlers in a baseline condition, who heard no novel verb accompanying the two test scenes, but rather heard simply, *Which one do you like?* chose between the two scenes at chance (Arunachalam & Waxman, in preparation).

## Predictions

To succeed, toddlers needed to use the information presented during Linguistic and Event Familiarization to identify the action (e.g., waving) and map the novel verb to an abstract category of waving events, which can include different objects. Critically, the waving events presented during Familiarization and during Test involve the same manner of motion. We therefore predict that an adverb encoding specific information about manner of motion (*slowly*) should promote learning and lead to above-chance performance, but that adverbs that do not specifically refer to this event component (*nicely*) should not. If, however, the mere presence of any sentence-final adverb is sufficient, then toddlers in both conditions should perform above chance level, despite the fact that the novel verb appears in the pronominal frame, which they struggled with in Arunachalam and Waxman (2010, 2011).

## Results

The results are presented in Figure 2. Given the nature of the dependent measure (pointing in a binary forced-choice task), we ran nonparametric analyses (Mann-Whitney and Wilcoxon tests). As predicted, toddlers who heard *slowly* pointed to the Familiar Action scene significantly more ($M = .65$) than those who heard *nicely* ($M = .49$) ($U_A = 3870$, $z = 2.13$, $p = .03$), and significantly more than predicted by chance ($W = 2.565$, $p = .01$). Toddlers who heard *nicely* performed at chance level ($W = -.905$, $p = .01$). As a point of comparison, we note that toddlers' success in the *slowly* condition matched the success in Arunachalam and Waxman's *Rich Content* condition ($M = .65$), and that toddlers' chance performance in the *nicely* condition echoed that of

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[4]Only four participants out of all three conditions pointed on fewer than half of the trials . Removal of these children from analysis yields comparable results.
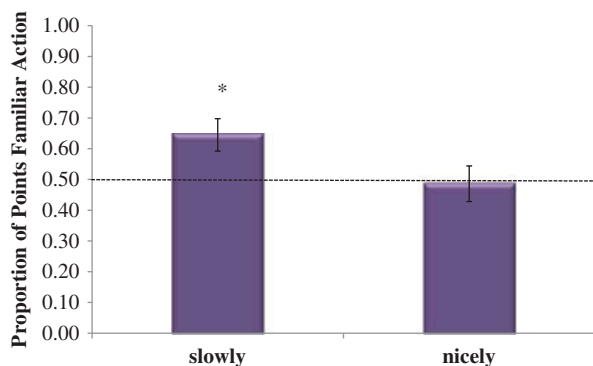
FIGURE 2  Average proportion of points to the Familiar Action scene across trials and toddlers for Experiment 1a. (Color figure available online.)

TABLE 1
Number of toddlers displaying a proportion of points to the Familiar Action scene greater than or less than chance

|  | Mean proportion points to Familiar Action scene | |
| --- | --- | --- |
|  | *x > .50* | *x < .50* |
| *nicely* | 7 | 9 |
| *slowly* | 14 | 4 |

Arunachalam and Waxman's *Sparse Content* condition ($M = .50$). Therefore, despite their difficulty learning novel transitive verbs when they are presented in a sparse linguistic frame, toddlers can successfully learn verbs in such frames if they are supplemented with additional semantic information.

An analysis of individual toddlers' performance offers strong converging evidence for this interpretation. We tallied the number of toddlers in each condition who favored the Familiar Action scene on a majority of their six trials (see Table 1). Those in the *slowly* condition were significantly more likely than those in the *nicely* condition to reveal this pattern (Pearson $\chi^2(1) = 4.15$, $p < .05$). Thus, the individual patterns reflect the overall trend captured by the overall analysis.

## DISCUSSION

These results offer the first evidence that toddlers can take advantage of the semantic content of adverbial expressions to learn the meanings of novel verbs under otherwise challenging conditions. Despite their failure to learn novel transitive verbs in sparse linguistic conditions (i.e.,

when flanked by pronouns rather than contentful nouns in Arunachalam & Waxman's [2010, 2011] experiments), they succeed in precisely this condition, if the frame was supplemented by an adverb (*slowly*) that specifically highlights a key element of the event depicted in the scene. The results also reveal that not any adverb will do: toddlers succeeded when the novel verbs were modified by *slowly*, and remained at chance when they were modified by *nicely*. Why might *slowly*, but not *nicely*, facilitate verb learning? There are two main possibilities.

First, as we have argued, these results may reflect a core difference in the lexical semantics of these adverbs. *Slowly*, but not *nicely*, refers to a specific manner of motion that takes place along one specific dimension (the temporal dimension), thereby highlighting aspects of the event that support verb learning. The learner can recruit this information to home in on an aspect of the unfolding event that can be occurring slowly. This allows the learner to search for a motion occurring in a particular manner. *Nicely* does not pick out a specific manner, and therefore leaves the learner searching for meaning in the scene. Note, however, that we are not claiming that *slowly* will *always* support verb learning in every context. This adverb elicited successful performance here, because the verb to be acquired encoded manner of motion information. For another type of verb, particularly one describing a punctual event or a state, such an adverb might be completely uninformative and another one might be more effective.

Complementing the lexical semantics of the adverbs is an asymmetry in the lexical semantics of the adjectives at the root of these adverbs, which are often used in place of their adverbial counterparts. *Nice* describes a static property, while *slow* inherently makes reference to events or motion, even when referring to an entity. A search of the spoken transcripts of the Corpus of Contemporary American English (COCA) (Davies, 2008) indicates that *nice* occurs with a wide range of nouns, particularly those referring to objects, such as *person, man, girl, lady, house, story, clothes*, and *picture*. By contrast, *slow* appears with a smaller range of nouns, many of which are nominals such as *process, motion, progress, growth, start*, and *speed*. Thus, there is a fundamental difference in the kind of information these words encode, and the range of expressions they modify.

But a second explanation of this pattern of results is also possible: perhaps lexical frequency is responsible. While a search of 34 CHILDES corpora of American child-directed speech reveals that *slowly* and *nicely* are comparable in frequency (*slowly* occurs 169 times and *nicely* 165), a COCA search (capturing the exposure language beyond child-directed speech) reveals that *slowly* is approximately four times as frequent as *nicely* (*slowly*: 2192 overall occurrences, or 24.32 per million; *nicely*: 536, or 5.95 per million). It is therefore possible that the result we witness with *slowly* is a result of toddlers being more familiar with that adverb than they are with *nicely*. Thus, we must entertain the possibility that other frequent adverbial expressions, whose semantics and structural position in the syntax are also linked to the verb, might also provide the learner with a foothold for making a connection between event semantics, verb form, and verb meaning.

We pursue this possibility in Experiment 1b by replacing *slowly* and *nicely* with the highly frequent indexical expression, *right now*. We reasoned that this highly frequent adverbial expression, which also highlights temporal information, but not manner of motion, could help us tease apart the two alternatives of lexical semantics and frequency. Because we are presenting toddlers with a novel verb that describes a motion (e.g., waving), an adverbial expression whose semantics specifically highlights manner of motion should support learning more than an adverbial expression—even a frequent one—that highlights other aspects of meaning that are less relevant to the core meaning of the particular verb being acquired.

## EXPERIMENT 1B

In Experiment 1b, in place of *slowly* or *nicely*, we used the temporal indexical expression *right now*. Because the semantics of *(right) now* depends on the context to situate the event in time and space (Kaplan, 1989), it may call toddlers' attention to the scene generally. However, unlike *slowly*, it does not specifically modify the *manner* of motion described by the verb, and just indicates that the event is occurring at a time *t* that is linked or co-indexed with the time that the speaker's utterance is delivered. *Right now* is certainly a frequent expression: compared with the other adverbs we targeted, *right now* has a COCA frequency of 34,972 tokens, or 365.9 per million. Moreover, tallying the number of appearances over 34 corpora of American child-directed speech in CHILDES, *right now* results in 959 hits (compared to *slowly*'s 169, and *nicely*'s 165). (*Now* overshadows them all with 16,097 hits.) If what matters for toddlers to be successful in the mapping from form to meaning is only that the adverbial expression is highly frequent (thereby drawing attention to the scene at hand), then toddlers in the *right now* condition should perform above chance, like *slowly*. If, however, *slowly* distinguishes itself from these other adverbs by providing semantic information specific to the manner of motion (inviting the toddler to inspect the event itself for a motion occurring in a particular manner), then toddlers in the *right now* condition should struggle.

## Method

### *Participants*

Twenty typically developing toddlers (10 males; mean age: 27.2 months, age range: 25.5 to 29.8 months) participated. Five additional toddlers were excluded for failure to meet pointing criteria (3), parental interference (1), or fussiness (1). Mean vocabulary production was 67 words (range: 21 to 100 words), comparable to the toddlers in Experiment 1a. There were no differences in vocabulary between genders.

### Materials and Procedure

The materials were identical to the previous experiment, with the exception of the adverbial expression.

### Coding and Analysis

Coding and analysis were as in Experiment 1a.

### Predictions

If by virtue of being highly frequent and an indexical expression, *right now* can direct participants' attention to the unfolding scene, then toddlers should learn the novel verb as they did with *slowly*. However, if the adverbial expression must draw participants' attention to *specific*
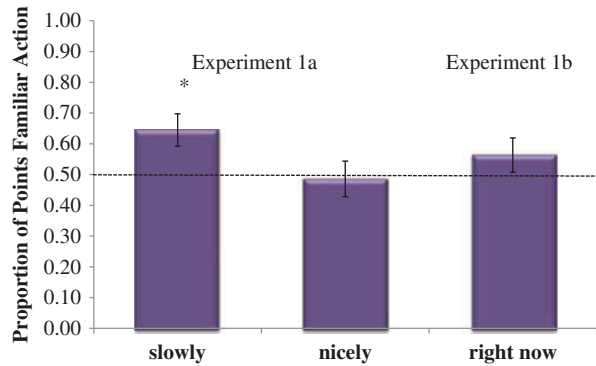
FIGURE 3 Average proportion of points to the Familiar Action scene across trials and toddlers for Experiments 1a and 1b. (Color figure available online.)

aspects of the event, such as manner of motion, in order to promote learning, then toddlers hearing *right now* should fail to learn the novel verb, mirroring performance in Experiment 1a with *nicely*.

## Results

The results are presented in Figure 3, along with the results from Experiment 1a.

In contrast to *slowly*, but much like *nicely*, toddlers who heard the adverbial expression *right now* were no more likely to point to the Familiar Action scene than the Familiar Object scene at test ($M = .56$) (W = 1.223, $p = .22$). An analysis based on totaling the raw number of points to the Familiar Action scene (rather than a proportion of the trials on which each toddler pointed) yields comparable results: *slowly* (63.2%), *nicely* (45.5%), *right now* (55.8%). The pattern of individual toddlers' performance echoes this null result: only 11 of the 20 toddlers patterned above chance. Whereas the results for *slowly* and *nicely* were significantly different from each other, neither condition was significantly different from *right now* (*nicely* vs. *right now:* $U_A = 6169$, z = -1.29, $p = .20$, *slowly* vs. *right now:* $U_A = 4970$, z = .92, $p = .36$), presumably because *right now* hovered above chance level, just above *nicely*.

## Discussion

Taken together with the results from Experiment 1a, the results from Experiment 1b demonstrate that only when the semantics of the adverb provide relevant semantic information are toddlers able to map form to meaning in this sparse linguistic context. An adverb that is simply highly frequent and/or familiar is not sufficient to support learning. That performance with *right now* appears to trend slightly above chance and slightly better than *nicely* suggests that lexical frequency may indeed provide *some* support for learning, perhaps encouraging toddlers to better attend to the scene. However, it is striking that performance with *right now* was not as strong as

with *slowly,* which is much less frequent. Lexical frequency cannot, therefore, fully explain this pattern of results. Instead, this pattern supports our claim that the semantic information inherent in the adverbial expression (and the level at which it applies) is crucial.

## GENERAL DISCUSSION

These results provide the first evidence that adverbial modifiers support verb learning in 2-year-olds. They also provide insight into the *kind* of adverbial information that is instrumental in toddlers' efforts to identify the meaning of a novel transitive verb presented in a sparse and otherwise difficult linguistic context. Like toddlers in Arunachalam and Waxman (2010), toddlers were introduced to novel transitive verbs flanked by pronouns. Unlike toddlers in Arunachalam and Waxman, who failed to map verbs to meaning in this sparse linguistic context, toddlers in this study who heard an accompanying adverb that highlighted manner of motion (*slowly*) succeeded.

Our findings are consistent with claims from previous research that the semantic content of known words can be used to acquire the meanings of novel words (e.g., Fennell & Waxman, 2010; Fisher et al., 1994; Gillette et al., 1999; Gleitman et al., 2005; Hirsh-Pasek & Golinkoff, 1996; Piccin & Waxman, 2007; Pinker, 1994; Portillo et al., 2005). For example, adults in Gillette et al. (1999) were often able to use the meaning and position of known content nouns to help them deduce the meaning of a novel verb (see also Piccin & Waxman, 2007, for converging evidence from 7-year-old children). Preschoolers in Fisher et al. (1994) used the content and position of a novel verb's accompanying noun phrases to determine what perspective the verb placed on the event (e.g., whether *giving* or *receiving*). In many of these previous cases, the authors either demonstrate experimentally and/or offer theoretical proposals concerning how children can combine their knowledge of familiar words, which they are most likely already producing, with knowledge of syntactic structure, the syntax-semantics mapping, and conceptual or linguistic biases, to arrive at a possible verb meaning.

Our results offer two new pieces of information. First, we show that in addition to other grammatical categories (most notably, nouns), adverbs can also make a semantic contribution. The presence of a manner-of-motion adverb such as *slowly* should call upon the learner to look for an event occurring at a particular pace, thereby narrowing down the hypothesis space of possible verb meanings. Our findings add to the list of elements of linguistic context beyond the number and position of noun phrases that can support verb learning (see also Choi & Arunachalam, 2013). In fact, going even beyond strictly linguistic context, Goodrich and Hudson Kam (2009) find that speaker *gestures* can direct a listener's attention to a scene in a particular way, and that, in conjunction with other cues, gestures serve to narrow down the space of hypothetical meanings for a target word. Second, we demonstrate that the facilitative effect of adverbs for verb learning can hold even for words like *slowly* that toddlers do not themselves yet produce. A search of the Brown, Gleason, Sachs, and Suppes corpora in the CHILDES database (Brown, 1973; Gleason, 1988; MacWhinney, 2000; Sachs, 1983; Suppes, 1974) revealed that *slowly* appears to enter toddlers' speech (beyond the occasional occurrence) only around or after three years of age (see also Kowalsky, 2009).

It will be important for future research to extend these claims with other adverbs. Although the evidence currently rests on patterns of performance with only three adverbs (one successful

and two that were not), the outcomes reported here are bolstered by a broader research program documenting that in tasks using nearly identical visual and auditory stimuli and similar procedures, toddlers have consistently benefitted from informative linguistic contexts in verb learning, and struggled when the linguistic context was insufficient (Arunachalam & Waxman, 2010, 2011; Arunachalam et al., in press; Geraghty, Arunachalam, & Waxman, 2011; Waxman et al., 2009). In these previous studies comparing rich vs. sparse linguistic contexts, the hypothesis was that toddlers would use the semantic information in the linguistic context (specifically, the NPs or DPs) to identify the verb's event participants (e.g., a boy and a balloon), then notice the relation between them (e.g., the agent and patient thematic roles supported by the syntax and the scene itself), and finally map the verb to its intended meaning. This information allowed them to extend the novel verb to apply to new objects during the test phase, because children had abstracted away the relevant relation.

In this research, we took a slightly different approach, hypothesizing that the semantically-informative adverb would draw toddlers' attention to an aspect of the event or action *itself*, allowing them to inspect the event for a candidate verb meaning compatible with the adverbial modifier's semantics. Thus we suggest a slightly different, but complementary, avenue to verb learning; rather than focusing toddlers' attention on the event participants, the adverbial modifier focuses their attention on the motion in the scene, thereby helping them resolve referential ambiguity and succeed in identifying verb meaning. Importantly, the success of adverbial modifiers as supports for verb learning is semantically specific: we found that toddlers mapped the novel verb onto its intended meaning more often than chance with *slowly*, but performed at chance levels with *nicely* and with *right now*.

This pattern raises questions for future research regarding the weighting of semantic and frequency information and the level of specificity of semantic information. Our results suggest that it is not the *frequency* of an adverb alone but rather the *semantic* information (perhaps in addition to elevated frequency and/or familiarity) it provides that helps toddlers constrain the hypothesis space for a novel verb's meaning. Of course, the fact that the facilitative effects of the adverb are semantically specific means that the semantics of the adverb must be informative with respect to the meaning of the particular verb being acquired. We predicted that *slowly* would be informative because the target verb described a manner of motion, and *slowly* could provide information about that manner of motion. In a different verb learning task, for example, if the verb expressed a state, then *slowly* might not support learning. Likewise, if a sequence of events or a change of state were highlighted, we would predict that *(right) now* would be semantically informative but *slowly* would not.

In recent decades, researchers have identified several components of the linguistic stream that young word learners take advantage of in verb learning. It is by now well established that the number and position of noun phrases accompanying a verb phrase provides important informational support for the acquisition of new verbs (Fisher et al., 1994; Landau & Gleitman, 1985; Naigles, 1990). We have demonstrated that when a verb's syntactic frame is underinformative, the presence of a manner-of-motion adverb such as *slowly* that specifically highlights a key aspect of the event can direct a toddler's attention to the event in such a way that supports verb learning. Future research should work to specify more precisely the source of this contribution and identify the advantages of other adverbial modifiers in learning other kinds of verbs beyond simple motion verbs.

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## APPENDIX A: Actions and objects for each trial

| Novel Word | Familiarization Scene | Test Scenes | |
| --- | --- | --- | --- |
| | | Familiar Object | Familiar Action |
| *dack* | Boy pushing chair | Boy lifting chair | Boy pushing box |
| *larp* | Girl stroking stuffed dog | Girl kissing dog | Girl stroking frisbee |
| *pilk* | Boy waving balloon | Boy tapping balloon | Boy waving rake |
| *wug* | Girl twirling umbrella | Girl twisting umbrella | Girl twirling pillow |
| *tope* | Boy pulling bunny | Boy tossing bunny | Boy pulling drum |
| *sem* | Girl scrubbing cup | Girl drinking from cup | Girl scrubbing plate |