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Mistakes weren't made: Three-year-olds' comprehension of novel-verb passives provides evidence for early abstract syntax

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Abstract

By about age three, English-learning children begin to understand passive sentences with familiar verbs. We probed the nature of children's linguistic representations by asking whether 3-year-olds promptly extend their emerging knowledge of the passive structure to novel verbs. In three preferential-looking experiments, 3-year-olds (N=124) interpreted novel verbs presented in short passives (Experiment 1, "She's getting snedded!") as transitive verbs, referring to causal-action rather than solo-action events, and used word-order in full passives, (Experiments 2 and 3, e.g., "She's getting snedded by the boy!"), to select a target event in which the subject was the patient, not the agent of action. Comprehension accuracy in Experiments 1 and 2 varied with vocabulary, but this vocabulary effect disappeared when children were given more time and more repetitions of the test sentences (Experiment 3). These findings support early-abstraction accounts of acquisition: 3-year-olds represent passive syntax in abstract terms, permitting extension to novel verbs. This, in turn, allows them to use passive sentences to identify the grammatical subcategory and meaning of an unknown verb.

Keywords: children, acquisition, passives, novel verbs

Young children learn words in their native language, but also learn how grammatical categories of words are meaningfully combined. A controversy regarding how they do so focuses on the relative contributions of unbiased learning from linguistic input, and of innate constraints that guide learning (e.g., Braine, 1963; Landau & Gleitman, 1985; Pinker, 1989; Tomasello, 2003). This controversy reflects two fundamental facts about languages.

First, languages the world over share striking grammatical similarities, hinting that these similarities may result from built-in linguistic and conceptual biases (e.g., Chomsky, 1986; Goldin-Meadow, So, Ozyurek, & Mylander, 2008; Pinker, 1989). For example, languages honor basic principles governing the linking of verbs with syntax. Verbs whose meanings imply two semantic roles readily occur in transitive sentences with two noun-phrase arguments as in (1a), and verbs whose meanings imply one semantic role occur in intransitive sentences as in (2) (e.g., Landau & Gleitman, 1985; Pinker, 1989). Languages provide some way to tell apart transitive subjects and objects (1a), and link agents rather than patients (or undergoers) with active transitive subjects. Many languages provide a means of promoting a patient into subject position, as in the passive in (1b) (e.g., Croft, 1990). The active and passive sentences in (1) describe the same event, but differ in how the same semantic roles are linked with syntactic functions. Alternations such as the active/passive have played a central role in linguistic theory and in the study of acquisition, in part because they make clear that meaning (semantic roles) and sentence form (syntactic functions) must be represented as separate levels of linguistic structure that can be flexibly aligned (e.g., Bresnan, Asudeh, Toivonen, & Wechsler, 2015; Chomsky, 1965; Pinker, 1989).

(1) a. Daddy is feeding the baby. b. The baby is being fed by Daddy.

(2) The baby is sleeping.

Second, despite these strong cross-linguistic similarities, the formal marking of syntax is language-specific. Children must learn to identify nouns and verbs, subjects and

objects, and agents and patients, by whatever morphosyntactic cues their language provides. This implies an enormous amount of learning about words and their combinations. Two broad classes of accounts of how this learning proceeds make different assumptions about how learners represent language experience, and whether innate biases guide learning.

According to *usage-based* accounts, early linguistic representations are concrete and lexically-based, and learning recruits only domain-general mechanisms of categorization and pattern detection (e.g., Abbot-Smith, Lieven, & Tomasello, 2008; Ambridge & Lieven, 2015; Tomasello, 2003, 2009). Abstract knowledge emerges gradually via detection of similarity in form and meaning across many memorized sentence-situation pairs. Proposed mechanisms vary, but shared assumptions are that lexical overlap and semantic or situational similarity guide comparison. As a result, early language processing is thought to be dominated by lexically-anchored schemata that permit limited extensions to new utterances. Schemata can be anchored by verbs (e.g., X *feeds* Y) or by common collocations of function words and morphemes (e.g., *She's* X-*ing it*.). To illustrate, by detecting similarities across a set of *feeding* sentences similar to (1a), children might come to represent the semantic roles in (1a) as 'feeder' and 'feedee' (rather than agent and patient) and the sentence positions of the relevant nouns as before and after *feeding* (rather than before and after a transitive verb). Next, by detecting similarities among a growing set of such schemata (perhaps anchored by *hugging*, *washing*, and so on), children gradually detect a more abstract pattern—that nouns specifying agents precede certain verbs, and nouns specifying patients follow them. This process culminates in a language-specific *construction* representing the form and meaning of English active transitive sentences, which can be applied to new sentences of this type. A similar process of abstraction would build knowledge of simple intransitive (2) and passive sentences (1b), and other constructions in the native language.

Early-abstraction accounts share the assumption that children learn syntactic and

semantic facts about particular words, but also assume that children are biased to represent the form and meaning of sentences in abstract terms, and to expect systematic mappings between sentence structure and meaning (e.g., Christophe, Millotte, Bernal, & Lidz, 2008; Gertner, Fisher, & Eisengart, 2006; Pinker, 1989; Trueswell & Gleitman, 2007; Valian, 1986). Proposals for the nature of these biases vary widely, but shared assumptions are that abstract notions such as agent and patient, or noun and verb, become available early in the learning process. If so, children might identify the feeder in (1a) as an agent and the feedee as a patient, and interpret the presence of two nouns in the sentence as evidence that *feeding* is a transitive verb (e.g., Fisher, Gertner, Scott, & Yuan, 2010). Representations couched in these abstract terms can directly guide processing of sentences containing different words. For example, analyzed in this way, sentence (1a) would serve as one data point in favor of the hypothesis that agents precede transitive verbs in English.

Both early-abstraction and usage-based accounts require learning from linguistic input, in order to work out the meanings and syntactic behavior of each word, and to identify the inventory of syntactic categories and structures in the native language. Accordingly, both predict that children's syntactic representations change over time, as children gather the relevant data (e.g., Gertner & Fisher, 2012; Pozzan & Trueswell, 2015). But they differ in their predictions about the extension of newly-learned syntactic knowledge to new words. On a usage-based account, each advance in syntactic learning should at first be tied to the child's knowledge of familiar words and word combinations. The identification of abstract syntactic constructions that can be freely generalized to new words is predicted to be slow relative to lexical learning, because it requires the child to identify useful form-meaning generalizations amid a host of irrelevant features. On an early abstraction account, in contrast, each such advance (partial or incomplete as it may be) should transfer nearly seamlessly across words, allowing the rapid generalization of syntactic learning to new words.

Testing the predictions of early-abstraction vs. usage-based accounts

To test these predictions, researchers have probed how readily children generalize linguistic knowledge to new lexical contexts. Extensions to new verbs have been central to this effort, because verbs are good predictors of syntactic structure (and thus likely lexical anchors for sentence comprehension and production on a usage-based account). As children gain a fledgling command of each syntactic structure, do they extend that knowledge across verbs, or do such extensions become possible only later, after a period of lexically-restricted knowledge? Attempts to address this question yield growing evidence for early-abstraction accounts, but often leave open alternative explanations; this is due in part to the difficulty of testing children's language comprehension and production at the moment in development when they first identify each structure.

For example, three findings show abstract knowledge of the dative alternation at age three. The dative alternation involves a pair of structures that permit different orderings of object and recipient in transfer events (*Give a book to her* vs. *Give her a book*). First, 3-year-olds who learned a new verb presented only in one dative structure (*You pilked Toby the key!*) spontaneously used that verb in the alternative structure (*I pilked the key to Toby!*; Conwell & Demuth, 2007). Second, 3-year-olds' production and comprehension of dative sentences show syntactic priming effects that span sentences with different familiar verbs (e.g., comprehension: Thothathiri & Snedeker, 2008; production: Rowland, Chang, Ambridge, Pine & Lieven, 2012). Third, in a pointing task, 3-year-olds comprehended dative sentences containing unknown verbs (*I'm glorping Rabbit (to) the duck*; Rowland & Noble, 2010). Taken together, these findings reveal abstract representations of the two dative structures by age three, and flexibility in linking semantic roles (object and recipient) to different sentence positions. But the trouble is, children produce dative sentences soon after age two (Campbell & Tomasello, 2001). Evidence for a robust abstract representation of the dative alternation at

age three, a year after many children first produce the relevant sentences, cannot address how children represented their initial knowledge of these structures.

Another approach has been to seek evidence of younger children's use of abstract syntactic knowledge to understand or produce simple sentences with novel verbs. For example, in a looking-preference comprehension task, 21-month-olds extended their knowledge of English word order to an unknown verb (*The girl is gorping the boy* vs. *The boy is gorping the girl*; Gertner et al., 2006). Similarly, 19-month-olds assigned two-participant relational meanings to invented verbs in simple transitive (*He's gorping him*) but not intransitive sentences (*He's gorping*; Yuan, Fisher & Snedeker, 2012). Kline and Demuth (2014) found evidence for abstract knowledge of two transitivity alternations in 2-year-olds' sentence production. After being trained with a novel verb in transitive sentences (e.g., *Joey pilked the sock*), children produced appropriate intransitive uses of the verb (*The sock pilked* or *Joey pilked*) in response to elicitation questions (for related comprehension data see Fernandes, Marcus, Di Nubila, & Vouloumanos, 2006; Naigles, 1996; Scott & Fisher, 2009).

These early successes with simple sentences strongly support an early-abstraction account. But again, children begin to understand multiword sentences with familiar words by 14 or 15 months (Hirsh-Pasek & Golinkoff, 1996; Seidl, Hollich, & Jusczyk, 2003). A usage-based account could explain the successes of 2-year-olds and even 19-month-olds by proposing that enough learning has taken place to permit the emergence of fragile, partially abstract representations of simple sentence structures from initially item-specific representations (e.g., Ambridge & Lieven, 2015; Kline and Demuth (2014) noted the same problem). This ambiguity of interpretation is partly due to the ubiquity of simple transitive and intransitive sentences in the input. The wealth of linguistic evidence makes it hard to tell whether children could acquire a fragile competence at an early age via item-based learning.

The present approach: Acquisition of the passive

One way to address these problems is to adapt novel-verb comprehension tasks for children at the start of multiword sentence comprehension (e.g., Jin & Fisher, 2014). In the present study we took a complementary approach, applying a novel-verb comprehension task to an alternative structure, the English passive. Our rationale for this approach is as follows: The passive is learned late in English, in part because of its rarity. Nonetheless, as children begin to show knowledge of the passive, the contrasting predictions of early-abstraction and usage-based accounts about the nature of this early knowledge still hold. If children's initial representation of each linguistic construction is concrete and item-specific, then children of an age to begin to comprehend and produce passives with familiar verbs should at first be unable to use this knowledge to understand a passive sentence with a novel verb. In contrast, if children's initial knowledge is represented in abstract terms, then they should understand novel-verb passives about as soon as they can understand passives with familiar verbs.

Passives, like active transitive sentences, describe events with two participant-roles, but differ from actives in how they link semantic roles to syntactic positions: A passive (3) links the patient argument of a transitive verb to subject position and demotes the agent argument to a post-verbal *by*-phrase. The *by*-phase is optional; thus one argument can be omitted in short passives (4). Full and short passives are marked by a complex of morphological cues, none of which is unique to the passive in English. For example, the auxiliary uses of *be* or *get* in (3-4) have the same forms as main-verb uses of *be* and *get* (*The girl was/got angry*)[1], and *by*-phrases can express locations as well as agents (*The girl was seated by the pool*). Children must therefore learn this complex of markers as a set, along with its implications for non-canonical role assignment and argument omission.

(3) The girl was/got tickled by the boy.

[1] Linguistic theoretical treatments differ in whether they consider *get*- and *be*-passives to be variants of the same passive structure, or different syntactic structures (e.g., Fox & Grodzinsky, 1998; Bresnan et al., 2015). The psycholinguistics literature has tended to treat them as variants of the same structure, but has found the choice of auxiliary to be related to genre (*get*-passives are colloquial, hence rare in written language), and to discourse structure and event semantics (e.g., Marchman, Bates, Burkhardt & Good, 1991; Thompson et al., 2013).

(4) The girl was/got tickled.

Because the passive is rare in English, children receive only sparse data to support this learning. For example, Gordon and Chafetz (1990) searched a corpus of nearly 87,000 child-directed utterances and found only 91 verbal passives, of which just 4 were full passives. The data scarcity problem is compounded by the preponderance of short passives. Short passives, lacking a *by*-phase, provide no linguistic evidence that an implicit agent is part of the sentence's meaning. Even worse, short passives in English are homophonous with adjectival passives (e.g., *This is torn*; *She's scared*); these refer to states rather than actions, and their meanings do not include an implicit agent.

Consistent with the rarity and ambiguity of the verbal passive, English-speaking children acquire it later than other structures (e.g., Fraser, Bellugi & Brown, 1963), and later than do children acquiring languages in which passives are more frequent and less ambiguously marked (e.g., Allen & Crago, 1996; Armon-Lotem et al., 2016; Demuth, 1989; Kline & Demuth, 2010). English-learning children begin to show knowledge of the passive at about their third birthday: They produce (a few) full and short passives with familiar English verbs before 3.5 years of age, for example (e.g., Budwig, 1990; Crain, Thornton & Murasugi, 2009), and at the same age can (sometimes) comprehend full passive sentences with familiar verbs (Bencini & Valian, 2008). The young 3-year-old's command of the passive is tentative. Children make many errors in producing and comprehending passives throughout the preschool years (e.g., Bever, 1970; Huang, Leech, & Rowe, 2017; Messenger, Branigan, & McLean, 2012), and school-aged children are less likely than are adults to produce a passive structure when it is appropriate to the discourse (Marchman et al., 1991).

One might take the late appearance of the passive as preliminary evidence for a usage-based account, because such accounts strongly predict effects of construction frequency on learning rate. However, the rarity of passives should affect learning rate on any account, for

at least two broad reasons. First, frequency affects the rate at which children could encounter passive sentences in informative referential contexts. The task of recovering the two-participant meanings of passives from the situation is unlikely to be trivial. For example, the preponderance of short passives (*This got broken*) should hamper learning, because the situations that elicit them are just those in which the agent's role is less relevant to the discourse. Second, low frequency should affect the child's ability to accurately represent the form of passive sentences when they encounter them. For example, word recognition depends on syntactic context; thus, toddlers and adults identify known words faster and more accurately when they occur in frequent syntactic surroundings (e.g., Christophe et al., 2008; Fernald & Hurtado, 2006; Gerken & McIntosh, 1993). Rare structures make bottom-up sentence processing more difficult. Both of these considerations predict slow learning for rare structures. Interestingly, both also hint that young 3-year-olds should vary in their initial grasp of the passive, due both to differences in the availability of data, and in children's ability to parse what data are available; we return to this point below. However, once children show an initial command of the passive, usage-based and early-abstraction accounts lead to different predictions about the nature of their initial representations. These predictions follow from core assumptions of each account.

On a usage-based account, children should learn about the passive as sketched above, by abstracting over memorized sentence-situation pairs to form lexically-anchored schemata. Comparison across lexicalized schemata, in turn, supports the gradual emergence of an abstract passive construction. Likely anchors for early schemata include the passive morphology itself, combined with particular verbs (Y *was hit* (*by* Z)) or with pronouns (*She was*/*got* X-*ed*). The variables or slots in early schemata and in emerging abstract sentence-level constructions are not adult-like categories such as 'transitive verb', freely re-combined in different constructions; instead, they reflect the form and meaning of the words children

abstracted over to learn about that slot (e.g., Ambridge & Lieven, 2015; Croft, 2001; Tomasello, 2009). If children's first tentative knowledge of the passive emerges in this manner, then this initial knowledge should depend largely on lexicalized schemata that permit only limited generalization to new words.

In contrast, on an early-abstraction account, as children encounter passives in the input, they should represent them as sequences of familiar syntactic parts (nouns, transitive verbs, auxiliaries, prepositions), used to communicate about abstract semantic roles (patients, agents). Therefore, even their initial representation of the passive should support broad generalization to new words.

Given the developmental timetable sketched above, we tested these contrasting predictions by asking whether young 3-year-olds can extend their emerging knowledge of the passive to new verbs. If they can, they should make two kinds of inferences about novel verbs in passive sentences. First, when encountering an unknown verb in a *short* passive (*She's getting snedded*), children should use morphological cues to the passive to identify the new word as a transitive verb, even though the short passive contains only one overt noun phrase; they should therefore infer that its meaning involves two participant-roles. Second, when encountering an unknown verb in a *full* passive (e.g., *The girl is getting snedded by the boy*), children should use morphological cues to the passive to compute non-canonical role assignments; they should therefore identify the subject referent as the patient of the action, not the agent.

These predicted inferences provide a route for children to use knowledge of the passive to infer the transitivity, and therefore the meaning, of a novel verb. Extensions to unknown verbs provide a strong test of our contrasting predictions, because they require a representation of the passive that can be identified without the aid of a known transitive verb, based only on the complex of morphosyntactic cues that marks the English passive.

Two sets of prior findings set the stage for these predictions. First, children just past their third birthday can be primed to produce passive uses of familiar transitive verbs. In a picture-description task, children who heard and repeated passive prime sentences produced more passive target sentences than did children who heard and repeated active primes (Bencini & Valian, 2008; Shimpi, Gámez, Huttenlocher, & Vasilyeva, 2007). Syntactic priming across sentences with different content words provides strong evidence that abstract representations of sentence structure, above the level of individual verbs, influence everyday acts of passive sentence production at age 3. However, these findings do not address whether children can identify a passive structure without the aid of a familiar transitive verb.

An earlier hint of syntactic priming of passives appeared in a novel-verb training study by Brooks and Tomasello (1999). Children just under 3 years old (mean age 2;10) received training in the use of two novel verbs; one verb was modeled only in passives, and the other only in active transitive sentences. Some of the children (40%) used the active-trained verb in passive sentences; moreover, they were more likely to do so than were children who heard both novel verbs only in active sentences. This difference can be interpreted as syntactic priming: Being trained to use one verb in the passive made children more likely to use a different transitive verb in the passive. Evidently some of the children had achieved a representation of the passive that was abstract enough to support generalization across verbs, at least when substantial training on the passive was provided within the experiment. Their success was fragile: Children's passives included many reversal errors (i.e., nouns in an agent-patient order in sentences with passive morphology), and only a minority of children (35%) used their *passive*-trained verb productively in active transitive sentences when prompted to do so, suggesting that the children (not quite 3 years old) often failed to understand the passive training sentences.

Second, a recent report provided the first evidence that children at the same age can

understand full passive sentences with novel verbs. Ibbotson, Theakston, Lieven and Tomasello (2011) tested 2- and 3-year-olds' use of word order in active transitive and passive sentences to compute agent-patient roles. Each new verb appeared repeatedly in both active and passive sentences; the active sentences were included to provide clear evidence that the new verbs were transitive. Under these circumstances older children (mean age 3;6) used word order to understand both active and full passive sentences, interpreting subjects as agents in active sentences, and as patients in passives. Younger children (mean age 2;10) correctly understood the active sentences, but also understood passive word order under some circumstances—in sentences with two case-marked pronouns (e.g., *He is getting tammed by her*), but not in those with one case-marked pronoun (e.g., *It is getting tammed by her*).

Ibbotson et al. (2011) interpreted this finding as evidence that concrete pronoun frames (e.g., *he__her*) anchored children's knowledge of the two sentence structures, supporting the assignment of agent-patient roles. Usage-based accounts propose that children acquire such concrete pronoun frames because certain pronouns occur reliably in particular sentence positions, and carry similar agent-patient roles (e.g., Childers & Tomasello, 2001). Interestingly, however, children more accurately interpreted *both* active and passive sentences if they contained two case-marked pronouns rather than one. Given this finding, we would argue that the benefit of case-marked pronouns in this task, spanning active and passive sentences, implies the recruitment of an abstract notion of subject vs. non-subject. This is because English case-marked pronouns provide a good cue for identifying subjects vs. non-subjects (*he* is a subject, *her* is not), but cannot directly cue the conflicting agent-patient role assignments of both actives (*He tammed her*) and passives (*He got tammed by her*).

These two key findings are consistent with our hypothesis that children's initial representation of the passive supports generalization across verbs known transitive verbs. By about age three, children can access a representation of the passive that supports across-verb

syntactic priming (Bencini & Valian, 2008; Brooks & Tomasello, 1999; Shimpi et al., 2007), and guides interpretation of sentences with newly-learned verbs (Ibbotson et al., 2011). However, in both cases children generalized knowledge of the passive across verbs that they already knew were transitive—familiar transitive verbs such as *stir* or *slice* (Bencini & Valian, 2008; Shimpi et al., 2007), or novel verbs that appeared repeatedly in active transitive sentences within the experiment (Brooks & Tomasello, 1999; Ibbotson et al., 2011). This experience presumably played a part in children's comprehension and production of passives in these tasks, because children and adults recruit knowledge of the syntactic-semantic properties of verbs in sentence processing (Snedeker & Trueswell, 2004).

The Present Study

We built on these prior findings to test our predictions, asking whether young 3-year-olds can use knowledge of passive syntax to guide the interpretation of sentences containing an entirely unknown verb, and thus to infer the grammatical subcategory and meaning of the new verb from the syntactic context alone. In three experiments, we used a preferential-looking comprehension task to explore 3-year-olds' knowledge of passives, both full and short passive forms. Crucially, in the passive condition of all three experiments, children encountered the novel verb only in passive sentences. As a result, children could not rely on prior knowledge of the verb to parse the passive sentences. To succeed in our task, children had to draw on abstract knowledge of the passive construction, cued by recognition of the passive morphosyntax, and immediately extend it to a novel verb.

In Experiment 1 we tested young 3-year-olds' comprehension of novel-verb *short* passives. In critical test trials, children saw two novel events (Figure 1a). One was a causal action event in which one person acted on another; the other was a one-participant action event in which two people alternately performed different solo actions. Children heard a novel verb in one type of sentence: a short passive ("She's getting snedded!"), an active

transitive ("She's snedding her!"), or a simple intransitive sentence ("She's snedding!"). If 3-year-olds have formed an abstract representation of the passive, then those who hear the verb in short passives should use the passive morphology to identify the new verb as a transitive verb, and thus interpret the verb as referring to the causal-action rather than the one-participant action event. Children in both the passive and active conditions should therefore look longer at the causal-action event than do children in the intransitive condition. We predicted that children in the intransitive condition would look about equally at the two events: intransitive verbs can refer either to events involving one participant (such as either action in the one-participant action event) or to a one-participant construal of a two-participant event (e.g., Fernandes et al., 2006; Yuan et al., 2012).

In Experiments 2 and 3 we tested children's comprehension of novel-verb *full* passives, asking whether they used word order to infer the (non-canonical) roles assigned by a passive sentence. Children saw two causal events involving a male and a female participant, referred to in the experiment as a boy and a girl. In one event the girl was the agent, whereas in the other the boy was the agent (Figure 1b). If 3-year-olds have formed an abstract representation of the passive, they should correctly infer that the subject noun refers to the patient of a causal event, and thus look longer at the event in which the person being acted upon matches the subject of the sentence they hear.

[FIGURE 1 ABOUT HERE]

In line with previous novel-verb studies (Brooks & Tomasello, 1999; Ibbotson et al., 2011), all passive test sentences had a 'get' auxiliary (e.g., *She's getting snedded* (*by the boy*)). We chose get-passives in part because previous studies have found a preference for get-passives in young children (e.g., Harris & Flora, 1982; Marchman et al., 1991). Harris and Flora (1982) suggest that the semantics of 'get' may provide a cue that a passive sentence's subject is not an agent.

Finally, we examined the relationship between children's vocabulary and their success in our tasks, because we expected 3-year-olds' performance to vary (as it did in all the studies of early passive comprehension or production cited above), and reasoned that vocabulary levels might partly predict this variation. To preview our results, we found that vocabulary predicted children's success with novel-verb passives in Experiments 1 and 2. Like Huang et al. (2017; see also Fisher, Klingler & Song, 2006), we considered two related routes by which vocabulary might predict performance in our task. First, vocabulary might serve as a proxy for children's varying degrees of access to data for learning about the passive. Vocabulary growth is associated with the quantity and diversity of linguistic input (e.g., Cartmill et al., 2013; Fernald, Marchman, & Hurtado, 2008; Hurtado, Grueter, Marchman, & Fernald, 2014). Because group-level command of the passive is just emerging at age three, high-vocabulary 3-year-olds might have encountered more of the linguistic data they needed to learn about the English passive. Second, vocabulary might serve as an index of language-processing efficiency. High-vocabulary children are quicker and more accurate in word identification, and quicker to integrate the constraints of multiple words within a sentence (e.g., Borovsky, Elman, & Fernald, 2012; Fernald, Perfors, & Marchman, 2006; Fernald, et al., 2008; Huang et al., 2017). High-vocabulary children therefore may be more successful in identifying the morphosyntactic cues to the passive within our task. These two possibilities--differences in prior experience, or differences in language processing efficiency during the task itself--are not mutually exclusive; on the contrary, they are strongly related. Just as higher-vocabulary children might process our stimulus sentences more efficiently, giving them a better chance to apply their knowledge of the passive within our task, higher-vocabulary children should reap similar benefits in acts of language comprehension at home, speeding their intake of data about words and syntax. Despite the strong ties between these two ways of interpreting vocabulary effects, they can be disentangled at least in part.

Experiment 3 was designed to tease apart these two possibilities, by lessening the language-processing demands of the task.

EXPERIMENT 1

Method

Participants

Sixty 3-year-olds (30 girls; age 34.1-42.7 months, M = 37.6) participated. Thirteen additional children were excluded due to inattentiveness (7), parental interference (1), or experimenter error (5). Children's productive vocabulary scores, collected using the MacArthur-Bates Communicative Development Inventory, Level III (Fenson et al., 2000), ranged from 11 to 96 (M = 70.1; median = 77.5). In this and the following experiments, all children were healthy, typically-developing native speakers of American English (English accounted for more than 80% of their language input). They were predominantly from white and middle-class families who were recruited through a participant database based on purchased mailing lists and local recruitment events. Twenty children (10 girls, 10 boys) were randomly assigned to each of three between-subjects sentence conditions: active, short passive, or intransitive. Analyses of variance (ANOVAs) revealed no significant differences in age (Active $M = 37.7$, $SD = 2.5$; Intransitive $M = 37.4$, $SD = 2.3$; Passive $M = 37.8$, $SD = 2.2$) or vocabulary (Active $M = 74.4$, $SD = 17.6$; Intransitive $M = 65.7$, $SD = 23.5$; Passive $M = 70.2$, $SD = 19.6$) across sentence conditions (F's < 1).

Apparatus

Children sat on a parent's lap facing two 20-inch television screens placed about 30 inches away. The screens were 12 inches apart and at child's-eye level. Soundtracks played from a concealed central speaker. A camera hidden between the two screens recorded children's faces during the experiment. Parents wore opaque glasses.

Materials and Procedure

The materials were live-action videos involving six female actors performing simple actions; each actor appeared in only one stimulus video. Videos were shown in synchronized pairs, accompanied by a soundtrack recorded by a female native English speaker. The procedure involved two phases: practice and test.

In the practice phase, children heard sentences containing familiar words accompanied by familiar events. Children viewed two 7-s events, a ball event showing an actor seated on a large ball and a chair event showing a different actor seated on a stool (referred to as a chair because we judged this word more familiar to children); both actors moved slightly throughout the event (e.g., tilting from side to side) whilst keeping their seats. The ball and chair events appeared simultaneously, one on each screen, in four 7-s trials separated by 4-s blank-screen intervals. In the first two of these trials, the audio directed children to look at the ball event: "She's on the ball! See? She's on the ball!" In the second two trials, children heard audio directing them to look at the chair event: "She's on the chair! See? She's on the chair!" The practice phase was designed to teach children that one screen matched the soundtrack on each trial; we chose simple locative events and sentences to avoid priming children to expect transitive sentences (active or passive) later in the task.

In the test phase, children were presented with the novel verb *sned* accompanied by a pair of novel events (see Figure 1a). In the causal-action event, one actor lay on the floor whilst another actor repeatedly pushed and pulled on her feet so that her legs bent at the knees. In the one-participant action event, two actors standing side-by-side alternately performed different one-participant actions: One curtseyed; the other stood with her right hand on her hip, lifted her right foot across her left knee and tapped it with her left hand.

The sequence of events in the test phase is shown in Figure 2, with test sentences taken from the short passive condition. First, children were introduced to the events in two

preview trials. In the first preview trial, children saw the one-participant action event on one screen (8s) accompanied by neutral audio ("Look here! See this?") whilst the other screen remained blank. After a 4s blank-screen interval, the causal-action event was previewed in the same manner on the other screen. Next, during a 7-s blank screen interval, children heard the novel verb in the sentence structure appropriate for their condition (passive: "Hey watch! She's gonna get snedded!"; active: "Hey watch! She's gonna sned her!"; intransitive: "Hey watch! She's gonna sned!"). This was followed by two 8-s test trials in which children saw both events and heard the novel verb used in sentences with the appropriate structure for their condition (active, passive, or intransitive). Test trials were separated by a 7-s blank-screen interval in which children heard another novel-verb test sentence in the past tense. In total, children heard the novel verb in the appropriate sentence context for their condition 6 times.

The screen on which the target event appeared in the test phase was counterbalanced with sentence condition and with the left-right side of the agent in the causal action test event (this was done using a "flip" operation in the video-editing software).

[FIGURE 2 ABOUT HERE]

Coding

We coded where children looked (left-screen, right-screen, away) frame by frame from silent video. A second coder re-coded 15 children's data to assess reliability; the two coders agreed on 97.7% of coded video frames.

Looking times to each test event and away from the events were averaged across the two test trials. Time spent looking away in the test trials (in seconds) was analysed by means of a univariate ANOVA with sentence condition (active vs. passive vs. intransitive) as a between-subjects factor. This analysis revealed no effect of condition, $F < 1$, suggesting that children looked away about equally in the three sentence conditions (active $M = 0.56$ s, $SD = 0.56$; passive $M = 0.46$ s, $SD = 0.54$; intransitive $M = 0.47$ s, $SD = 0.45$). We therefore

conducted our main analyses on a single measure, looking time to the causal-action event as a proportion of total looking time to either test event. Preliminary analyses of test-trial performance revealed no significant effects of participant gender, agent side in the causal-action event, or target side; we collapsed across these factors in subsequent analyses. Vocabulary scores were bimodally distributed in our sample; therefore in the analyses presented below we treated vocabulary as a dichotomous variable, via a median split. For comparability across measures and experiments, we report analyses that dichotomize vocabulary and age in the same way; however, as we note below, similar patterns emerged when vocabulary and age were treated as continuous variables.

Results

Figure 3 shows the proportion of looking time to the causal-action event by condition, and by vocabulary group; Table 1 shows group means and standard deviations. An ANOVA with sentence condition as a between-subjects factor showed a significant effect of sentence condition on looking time to the causal-action event ($F(2,57)= 5.10$, $p= .009$). Planned comparisons showed a significant difference between looking times in the active and intransitive conditions ($t= 2.93$, $p= .005$) but not between the passive and intransitive conditions, ($t= -0.36$, $p= .72$).

Because we expected to find emerging command of the passive in our young 3-year-olds, we asked whether there was any relationship between the children's age or vocabulary scores and their performance in the test trials. Age and vocabulary were modestly positively correlated in our data ($r = .298$, n = 60, $p = .021$, 2-tailed). However, preliminary analyses revealed that vocabulary, but not age[2], was systematically related to test-trial performance.

[2] An ANOVA with sentence condition (active vs. passive vs. intransitive) and median age split (above vs. at or below the median age) as between-subjects factors revealed no main effect of age or interaction of age with sentence condition (F's <1, p's > .5). The same result emerged when we treated age as a continuous predictor: A linear regression revealed no effect of age or interaction of age with sentence condition (F's < 1.2, p's > .30).

An ANOVA with sentence condition and median vocabulary split (above vs. at or below the median) as between-subjects factors revealed a main effect of sentence condition, $F(2,54) = 6.58$, $p = .003$, no main effect of vocabulary split, $F < 1$, $p = .46$, but a significant interaction of sentence condition and vocabulary split, $F(2,54) = 5.87$, $p = .005$[3]. Thus, vocabulary level predicted children's test-trial performance differently in different sentence conditions.

Inspection of Figure 3 reveals two main patterns that explain the interaction between vocabulary and test-trial performance. First, the active and intransitive conditions differed from each other, independent of children's vocabulary levels. Most children in the active condition spent more than half of their time looking at the causal-action event, whereas children in the intransitive condition distributed their attention about equally between the causal-action and the one-participant action events. Second, children in the short passive condition varied widely in their looking preferences, and this variability appears to be related to vocabulary. Most of the high-vocabulary children in the short passive condition looked longer at the causal-action event, whereas the low-vocabulary children distributed their attention about equally between the two videos.

[FIGURE 3 ABOUT HERE]

[3] Similar results emerged when we treated vocabulary as a continuous predictor. A linear regression revealed a significant effect of sentence condition, $F(2,54) = 5.32$, $p = .008$, no main effect of vocabulary ($F < 1$), and a marginal interaction of sentence condition and vocabulary, $F(2,54) = 2.59$, $p = .08$.

Table 1. *Mean (SD) proportion looking-time to the causal-action event, by sentence condition and vocabulary group (based on a median split), Experiment 1.*

	Sentence Condition		
	Active	Short Passive	Intransitive
High-vocabulary children (*N* = 30)	0.65 (0.12)	0.67 (0.17)	0.41 (0.21)
[vocabulary M = 87, range 78-96]	*(n=12)*	*(n=10)*	*(n=8)*
Low-vocabulary children (*N* = 30)	0.68 (0.20)	0.43 (0.21)	0.52 (0.12)
[vocabulary M = 53, range 11-77]	*(n=8)*	*(n=10)*	*(n=12)*
All children	0.66 (0.15)	0.55 (0.23)	0.47 (0.17)

Separate analyses of the high- and low-vocabulary groups showed that the looking preferences of both the high- and the low-vocabulary children varied significantly across sentence conditions (high-vocabulary $F(2,27) = 7.04$, $p = .003$; low-vocabulary $F(2,27) = 4.39$, $p = .022$). As shown in Table 1, the high-vocabulary children in both the active and passive conditions looked longer at the causal-action event than did their peers in the intransitive condition (active vs. intransitive, $t(18) = 3.32$, $p = .004$; passive vs. intransitive, $t(16) = 2.99$, $p = .009$). The looking preferences of high-vocabulary children in the active and passive conditions did not differ ($t < 1$). Table 1 shows a different pattern for the low-vocabulary children: those in the active condition looked longer at the causal-action event than did those in either the intransitive ($t(18) = 3.32$, $p=.004$) or the passive condition ($t(16) = 2.52$, $p =.023$), while the looking preferences of low-vocabulary children in the passive and intransitive conditions did not differ ($t(20) = 1.29$, $p = .212$).

Discussion

Experiment 1 yielded the first evidence of emerging abstract knowledge of the short passive in young 3-year-olds. First, as expected based on many previous findings, children

who heard a novel verb in active transitive ("She's snedding her!") and simple intransitive sentences ("She's snedding!") arrived at appropriately different interpretations. The active transitive sentence guided children's attention to an event in which one participant acted on another (the causal-action event), relative to an intransitive sentence. Vocabulary did not predict responses to these two sentence types, suggesting they posed no challenge for 3-year-olds.

When 3-year-olds heard the novel verb in short passive sentences ("She's getting snedded!"), their vocabulary level predicted their looking preferences. High-vocabulary children correctly identified the novel verb in a short passive as transitive, despite its single overt noun-phrase: they looked longer at the causal-action event than did those who heard intransitive sentences, and showed as strong a preference for the causal-action event as did those who heard active transitive sentences. To do so, they must have already identified the available morphosyntactic cues to the short passive, along with their consequences for argument omission; this representation of the passive structure was abstract enough to be applied to an entirely unknown verb. The lower-vocabulary children, in contrast, did not succeed in identifying a novel verb in short passives as transitive: they looked less at the causal-action event than did their peers who heard active transitive sentences, and their looking preferences did not differ from those who heard simple intransitives.

This vocabulary effect suggests that short passives presented a challenge for children at this age. This challenge may reflect either of the two possibilities laid out in the Introduction: Vocabulary might predict differences in prior experience with the passive, differences in language processing efficiency during the task itself, or both. That is, it may be that only the high-vocabulary children had taken in enough input to acquire an abstract representation of the passive syntax by age three; or it may be that only high-vocabulary children had the processing abilities to promptly identify the sentence as a short passive, and

not an intransitive or adjectival form. Given their ambiguity, short passives with a novel verb might well present a processing challenge for children. Within the time limit of the test-trial, children must detect the morphology that marks a short passive, including the participle form of a novel verb (*She's getting snedded*), and use this to infer that the sentence refers to a two-participant event even though it contains only one noun. This requires them to distinguish the short passive from a simple intransitive sentence or an adjectival form (*She's getting silly*). As we shall see, Experiment 2 also revealed a vocabulary effect; we further explore this effect in Experiment 3.

EXPERIMENT 2

In Experiment 2 we tested 3-year-old children's comprehension of novel verbs in full passive sentences, asking whether children would correctly use word order to infer the (non-canonical) semantic roles that a passive sentence assigns to each noun phrase. Children saw two causal events (Figure 1b) involving actors referred to as a boy and girl. In the boy-agent event, the boy acted on the girl; in the girl-agent event, the girl acted on the boy. Children heard full passives containing a novel verb, with either the girl or boy as sentence subject. If 3-year-olds have formed an abstract representation of the full passive structure that they can apply to a new verb, they should look longer at the target event—the one in which the patient in the causal-action event matches the subject of the sentence.

Method

Participants

Thirty-two 3-year-olds (16 girls; age 34.2–42.2 months, M= 38.4) participated. Two additional children were excluded due to inattentiveness (1) and an outlying vocabulary score (more than 2.5 standard deviations below the mean vocabulary; 1). Children's productive vocabulary scores ranged from 36 to 100, (M = 76.5, median = 78).

Apparatus, Materials and Procedure

The apparatus was as described in Experiment 1. The materials were live-action videos involving male and female actors (referred to as boys and girls) performing simple actions; videos were shown in synchronized pairs accompanied by a soundtrack recorded by a female native English speaker. The procedure involved two phases: practice and test. Each phase involved a different pair of actors (a boy and a girl), and began with an actor-identification item followed by a sentence-comprehension item that involved familiar words in the practice phase but a novel verb in the test phase.

In the actor-identification item of the practice phase, two actors (a boy and a girl) were first introduced in two preview trials. In the first preview trial, the girl appeared, waving, on one screen (5s) and was labelled twice (e.g., "There's a girl!") whilst the other screen remained blank. After a 2-s blank-screen interval, the boy was labelled in the same manner on the other screen. Next, in two 5-s trials separated by a 3-s interval, the girl and boy video-clips appeared simultaneously; children were instructed to look at the boy in the first trial (e.g., "Find the boy!") and the girl in the second ("Find the girl!").

Next, in the sentence-comprehension item of the practice phase, children viewed a chair and a ball event similar to those used in the practice phase of Experiment 1. In the chair event the boy sat on a stool (again referred to as a chair); in the ball event the girl sat on a large ball; both moved slightly while keeping their seat. The chair and ball events appeared simultaneously, one on each screen, in four 8-s trials. In the first two trials children were told to look at the ball event (e.g., "The girl is on the ball! See?"); in the next two trials they were told to look at the chair event (e.g., "The boy is on the chair! See?").

The test phase began with an actor-identification item in which a new pair of actors (a boy and girl) was first introduced and labelled one at a time in two 4-s preview trials. The girl and boy video-clips then appeared simultaneously in two 4-s trials, and children were exhorted in the first trial to find the girl, and in the second to find the boy.

Finally, in the sentence-comprehension item of the test phase, children were presented with the invented verb *sned* accompanied by a pair of novel events (Figure 1b). In the boy-agent event, the boy turned the girl back and forth in a tall chair by pulling on a band around her waist; in the girl-agent event the girl tipped the boy back and forth in a rocking chair. The sequence of events in the novel-verb sentence-comprehension item is shown in Figure 4. The events were first introduced in two preview trials. In the first preview trial, the boy-agent event appeared on one screen (8s) accompanied by neutral audio ("Look here! See this?") whilst the other screen remained blank. After a 4-s interval the girl-agent event was previewed in the same manner on the other screen. Next, during an 8-s blank-screen interval, children heard the novel verb in a full passive. Half of the children heard "Hey watch! The girl is gonna get snedded by the boy!" and half heard "Hey watch! The boy is gonna get snedded by the girl!" Both test events then played simultaneously in two 8-s test trials, each accompanied by the novel verb in a passive sentence with the appropriate sentence subject, followed by a prompt to "Find snedding!"; these trials were separated by an 8-s blank-screen interval during which children heard another novel-verb sentence in the past tense (e.g., "The girl got snedded by the boy!"). In total, children heard the novel verb presented in a full passive structure four times.

The screen on which each test event appeared was counterbalanced with test sentence subject (*girl* or *boy*), the left-right position of the agent within the test events, and with the screen on which the girl vs. the boy appeared in the actor-identification item of the test phase.

[FIGURE 4 ABOUT HERE]

Coding

We coded where children looked as described above. A second coder re-coded 8 children's data to assess reliability: the two coders agreed on 97.5% of coded video frames.

Looking times to each test event and away from the events were averaged across the

two test trials. Inspection of means revealed that time spent looking away in the test trials (in seconds) did not differ depending on whether children heard girl- or boy-subject sentences (boy-subject M= 0.25 s, SD = 0.15; girl-subject M = 0.32 s, SD = 0.29). Therefore we conducted our analyses on a single measure, looking time to the target event as a proportion of total looking time to the two events, averaged across the two test trials. The target event was defined as the event in which the patient of the action matched the subject of the test sentence.

Preliminary analyses of test-trial performance revealed no significant effects of test sentence subject (boy vs. girl), participant gender, agent side, or target-event side, t's$\leq$ 1.5, p's $\geq$ .14, or whether children's average match proportion in the sentence comprehension item of the practice phase (chair vs. ball events) was above or below the median, $t(30)$= 1.86, p=.07. The data were therefore collapsed across these factors in subsequent analyses.

Results

Table 2 (left panel) shows mean proportion looking-time to the target event by vocabulary group, and for the entire group, averaged across the two test trials. Because all participants heard the same sentence structure (full passives differing only in choice of sentence subject), we compared these target proportions to the proportion expected by chance (.50). As Table 2 shows, the children looked at the target event—in which the patient of the action matched the test sentence subject—longer than expected by chance, $t(31)$ = 2.27, p = .03.

As in Experiment 1, we explored whether there was any relationship between the children's age or vocabulary score and their performance in the test trials. We found no significant correlation between test-trial performance and age (Pearson's r= .26, n= 32, p= .16, 2-tailed), but a significant positive correlation between vocabulary and target proportion in the test trials (Pearson's r= .43, n= 32, p= .014, 2-tailed; see Figure 5). For comparability

with Experiment 1, we also examined vocabulary as a dichotomous variable. As shown in Table 2, children with high vocabulary scores performed differently to children with low vocabulary scores. In separate analyses for each group, children in the high-vocabulary group looked reliably longer at the target event than predicted by chance, $t(16) = 4.46$, $p < .001$, but those in the low-vocabulary group did not ($p > .5$).

Table 2. *Mean (SD) proportion looking-time to the target event by vocabulary group (based on a median split), Experiments 2 and 3.*

	Experiment 2		Experiment 3	
	Vocabulary Scores	Target Proportion	Vocabulary Scores	Target Proportion
High-vocabulary children	*M = 90.5* *range 78-100*	0.67 (0.16) *n* = 17	*M = 87.9* *range 76-98*	0.59 (0.23) *n* = 16
Low-vocabulary children	*M = 60.5* *range 36-74*	0.47 (0.18) *n* = 15	*M = 49.6* *range 23-72*	0.56 (0.17) *n* = 16
All children		0.58 (0.20)		0.57 (0.20)

[FIGURE 5 ABOUT HERE]

Figure 6a shows fixations to the target event as a proportion of fixations to either event, in 33-ms time intervals from trial onset, by vocabulary group. The time-course data cannot be interpreted as a measure of online sentence processing, because children heard the test sentence four times across the two test trials, including once before the test trials began (e.g., “The girl is gonna get snedded by the boy!”). However, examining looking-patterns across the trial gives us another view of the differing performance of children in the high and low vocabulary groups. As Figure 6a shows, the high vocabulary children showed a preference for the target event that began early in the trial and was sustained throughout. In contrast, the low vocabulary children showed a preference for the target event early in the

trial, but abandoned it in favour of the non-target event in the second half of the trial. This suggests that the lower-vocabulary children were typically unable to interpret passive word order appropriately in our task.

[FIGURE 6 ABOUT HERE]

Discussion

Experiment 2 yielded evidence of emerging comprehension of word order in novel-verb passives. Considered as a group, the 3-year-olds looked longer at the target event, correctly inferring the semantic roles of the boy and girl based on word order in a passive sentence. To do so, they must have identified the morphosyntactic cues to the full passive and learned their implications for role assignment. Furthermore, they must have had access to a representation of the passive abstract enough to be extended to a novel verb. This result with novel verbs is strikingly similar to the performance of children at the same age with familiar-verb passives (Bencini & Valian, 2008).

Individual children's accuracies varied quite a bit, and we found that some of this variation was related to vocabulary, as in Experiment 1. Based on prior findings, we expected children's performance in our task to vary widely. The previous report showing 3-year-olds' comprehension of full passives with familiar verbs showed similar variability among children (Bencini & Valian, 2008; although vocabulary data were not reported): In a picture-choice comprehension task, accuracies ranged as widely as did the present data in Figure 5.

As noted previously, we can envision at least two explanations for the vocabulary effects in Experiments 1 and 2. On the one hand, vocabulary may provide an index of children's access to relevant input: those with higher vocabularies may have experienced more of the data they need to learn about the passive. On the other hand, vocabulary may predict children's language processing efficiency within our task: those with higher vocabularies may have been more able than children with lower vocabularies to identify cues

to the passive structure, and retrieve the appropriate syntactic and semantic representations. In Experiment 3 we explore the relative contributions of prior learning about the passive vs. language processing skill within the task to our vocabulary effect by reducing the language-processing demands of the task, giving children more time to process the passive sentences.

EXPERIMENT 3

In Experiment 3 we sought to replicate the main result of Experiment 2, confirming 3-year-olds' emerging comprehension of word order in novel-verb passives, and also began to explore the vocabulary effects uncovered in Experiments 1 and 2. To do so, we made several changes to the materials of Experiment 2 to lessen the language-processing demands of the task: We lengthened the test trials, giving children more time to process the events and sentences, and gave children two additional repetitions of the novel-verb test sentence. We chose to probe the vocabulary effect using the word-order design of Experiment 2 because this experiment tested comprehension of one sentence structure (the full passive, with subject counterbalanced), whereas Experiment 1 compared three between-participants sentence conditions. This simpler design should offer greater power to explore vocabulary differences between participants.

If 3-year-olds can access an abstract representation of the full passive without the aid of a known transitive verb, they should again look longer at the target event—the one in which the patient matches the subject of the sentence. In addition, the results of a less demanding version of the task may constrain our interpretation of the vocabulary effects of Experiments 1 and 2. If vocabulary size primarily indexed children's prior progress in learning about the passive, then our task modifications should not eliminate the effect of vocabulary. In contrast, if vocabulary size primarily indexed language processing skill within our task, these modifications should diminish the effect of vocabulary by making it easier for children to process the stimulus sentences.

Method

Participants

Thirty-two 3-year-olds (16 girls; age 34.1–42.1 months, *M* = 37.1) participated. Two additional children were excluded due to inattentiveness (1) or experimenter error (1). Children's productive vocabulary scores ranged from 23 to 98 (*M* = 68.7, median = 74).

Apparatus, Materials and Procedure

The apparatus, materials, and procedure were similar to those of Experiment 2. The procedure again involved two phases: practice and test. The practice phase was identical to that of Experiment 2. The test phase was similar to that of Experiment 2 except for the following three changes: (1) The girl-agent event of Experiment 2 was replaced by a different causal-action event involving the same boy and girl: the girl bent the boy forward and back by pushing and pulling on his shoulder. This replacement event was chosen because a 10-s clip of this action was available. (2) During the two novel-verb test trials, the boy- and girl-agent events played simultaneously for 10s rather than 8s, and (3) during each 10-s test trial, children heard one additional repetition of their test sentence (e.g., "He's getting snedded by the girl! See? The boy is getting snedded by the girl!"). Thus in total, children heard the novel-verb full passive six times (as opposed to four times in Experiment 2). The video presentation was counterbalanced as in Experiment 2.

Coding

We coded where children looked as described above. To assess reliability, a second coder re-coded 7 children's data. The two coders agreed on 98.5% of coded video frames.

Looking times to each event and away from the events were averaged across the two test trials. Inspection of means showed that time spent looking away (in seconds) did not differ depending on whether children heard girl- or boy-subject sentences (boy-subject *M* = 0.35s, *SD* = 0.44; girl-subject *M* = 0.32s, *SD* = 0.32). Therefore we analysed looking time to

the target event as a proportion of total looking time to the two events, averaged across the two test trials.

Preliminary analyses of test-trial performance revealed no significant effects of participant gender, agent side, target-event side (left or right screen), or whether children's performance in the sentence comprehension item of the practice phase (chair vs. ball events) was above or below the median, t's ≤ 1.5, p's $> .13$, or girl- vs. boy-subject, $t(30) = -1.86$, $p = .07$. The data were collapsed across these factors in subsequent analyses.

Results

Table 2 (right panel) shows mean proportion looking-time to the target event by vocabulary group, and for the entire group, averaged across the two test trials. Children looked longer at the target event—the event in which the patient matched the subject of the sentence—than predicted by chance (0.50), $t(31) = 2.15$, $p = .04$.

As in Experiment 2, we found no significant correlation between target proportions and age ($r = 0.29$, $n = 32$, $p = .11$, 2-tailed). We next examined whether children's vocabulary scores predicted their test trial performance (see Figure 5). A bivariate correlation showed no signification relationship between vocabulary and target proportion in the test trials ($r = .11$, $n = 32$, $p = .54$, 2-tailed). Accordingly, as Table 2 shows, the high vocabulary children did not look reliably longer at the target event than did the low vocabulary children, $t < 1$, $p = .73$.

A cross-experiment comparison provides some additional support for the claim that the role of vocabulary was weaker in Experiment 3 than in Experiment 2. An ANOVA with experiment (2 vs. 3) and vocabulary group as between-subjects factors revealed no main effect of experiment, $F(1,60) < 1$, a significant effect of vocabulary group, $F(1,60) = 5.863$, $p = .019$, and a marginal interaction of experiment by vocabulary group, $F(1,60) = 3.606$, $p = .062$. Note that vocabulary scores did not differ across experiments (Experiment 2: $M = 76.5$,

median = 78; Experiment 3: *M*= 68.7, median = 74; *t*(62)= 1.51, *p*= .14, 2-tailed), though the mean age was slightly lower in Experiment 3 (M= 37.1) than in Experiment 2 (M=38.4; *t*(62)= 2.08, *p*= .04, 2-tailed).

Figure 6b shows the time-course of fixations to the target event, averaged across the two 10-s test trials, by vocabulary group. As noted in Experiment 2, the time-course data do not reflect online parsing, because children heard the test sentence six times across the two test trials, including once before the test trials began; however, the time-course data can yield insight into how the high and low vocabulary children approached the task. Children tended to look longer at the target event, and to do so throughout the trial. High and low vocabulary children showed very similar patterns in this task, unlike the distinct patterns shown by high and low vocabulary children in Experiment 2. Additionally, the looking patterns show that both groups returned to the target video at the end of the trial after a brief look at the alternative video. This could be due simply to the extra time at the end of the trial or to the additional stimulus sentence cueing them to redirect their attention to the target; nonetheless, in comparison to Experiment 2, this pattern suggests that these task modifications enabled both groups of children to identify the target video across the lengthened trial.

Discussion

Experiment 3 replicated the main finding of Experiment 2: upon hearing a novel-verb full passive, young 3-year-olds looked longer at the event that matched the sentence. This suggests that they used abstract knowledge of English passive morphology to identify the test sentences as passives, and inferred the requisite non-canonical role assignments, without the aid of a known transitive verb.

Again, we expected individual accuracies to vary widely, and they did (Figure 5). However, Experiment 3 did not reproduce the strong relationship between passive comprehension and vocabulary scores found in Experiment 2. We failed to find a systematic

relationship even though the range of both measures was similar in Experiments 2 and 3 (see Figure 5). This negative finding should be pursued in further studies of early comprehension of both familiar- and novel-word passives. At present, however, the absence of a vocabulary effect in Experiment 3 suggests that our modifications succeeded in lessening the demands of the task. More time and additional repetitions of the sentence permitted children with relatively low vocabulary scores to identify the structure of the passive sentences. This, in turn, suggests that the previously observed vocabulary effects were due at least in part to differences in language-processing skill that are correlated with vocabulary, and that affected children's intake of the stimulus sentences themselves. By age three, children with either high or low vocabulary scores could access an abstract representation of the passive and extend it to novel verbs—at least if given enough time to do so.

Interestingly, inspection of Figure 5 suggests that higher vocabulary children varied more in their overall attention to the target in Experiment 3 than did their peers in Experiment 2. This pattern, if replicated, might also be interpreted as consistent with a speed-of-processing account of the relationship between vocabulary and task performance. In longer trials, children who were quicker to process the sentences may have located the target video early in the trial, and therefore used their time to investigate the other video.

GENERAL DISCUSSION

This study provided a new test of the contrasting predictions of early-abstraction vs. usage-based accounts of language acquisition, by asking whether young 3-year-olds could extend their knowledge of a newly-learned syntactic pattern, the passive, to new verbs. We reviewed evidence in the Introduction that children begin to produce and understand passives around their third birthday; early-abstraction accounts predict that children would promptly extend this new knowledge to new verbs, whereas usage-based accounts predict that such extensions should follow a period of lexically-restricted usage. Passives are useful to us

because their rarity in the input makes it easier to tease apart these predictions. On both accounts, it should take a relatively long time to discover the workings of a rare structure; however, the two accounts make different predictions about the nature of the representations that permit the 3-year-olds' initial command of the passive. Given the sparse data from which children must learn the passive, the creation of an abstract passive construction via item-based mechanisms should take a particularly long time; therefore it should be easy to see any lag between children's first tentative grasp on the passive with familiar words (by about the third birthday), and children's eventual extensions to entirely unknown words.

In three experiments, young 3-year-olds showed an emerging command of the passive that they used to interpret both short and full passives with novel verbs. This required them to identify the morphosyntactic cues in the novel-verb passives, and understand their consequences for non-canonical word order and argument omission. In interpreting short passives (*She's getting snedded!*), this knowledge enabled children to identify an unknown verb as transitive (despite its single overt argument), and thus to infer that it should receive a two-participant interpretation. In interpreting full passives (*She's getting snedded by the boy!*), this knowledge enabled them to compute the appropriate role assignments, and thus to map the subject of the sentence onto a patient's role.

The present case seems particularly impressive to us because certain features of our task made it a demanding test. Children heard few examples of passives (4 or 6 in all), and none with familiar verbs. Thus they had no opportunity to learn about the passive within the task, or to be prompted by familiar-verb passive trials to adopt a patient-focused view of events that would aid comprehension of the test sentences (e.g., Brooks & Tomasello, 1999; Budwig, 1990). Most centrally, we gave children no information about the novel verb's syntactic or semantic properties other than the passive test sentence. Because children in the passive conditions of our experiments heard the new verb only in passive sentences, they had

to identify the passive without the support of prior knowledge of the meaning or syntactic privileges of the verb.

These findings add to the previous evidence of early abstract representations reviewed in the Introduction. Across ages, as each structure emerges we see swift generalization—from toddlers' use of simple transitive and intransitive syntax to learn new verbs (e.g., Gertner et al., 2006; Yuan et al., 2012) through the present case of the passive. At the earliest age at which children have been observed to produce and comprehend passives with familiar verbs in English (3 years; e.g., Bencini & Valian, 2008; Budwig, 1990), they generalized this new knowledge to newly-encountered verbs. Because the passive involves a non-canonical mapping of semantic roles onto sentence positions, this swift generalization requires independent abstract representation of semantic roles (agent, patient) and syntax (subject, object, oblique) that can be flexibly aligned in response to language experience.

One limitation to this conclusion is that, like the previous studies on which we built, we tested passives with a get-auxiliary; we have not tested three-year-olds' comprehension of novel verb be-passives. There is evidence to suggest that get-passives are easier for young children to comprehend and produce (Harris & Flora, 1982), thus it remains to be seen whether young three-year-olds also comprehend novel-verb be-passives.

This consistent evidence for immediate generalization has consequences for syntactic bootstrapping, the proposal that young children use even preliminary syntactic knowledge to learn the meanings of unknown words (e.g., Fisher et al., 2010; Landau & Gleitman, 1985). This procedure requires abstract representations of syntactic structures. The present findings support the hypothesis that throughout the early years in which children learn their basic vocabulary, they promptly use newly-learned syntactic knowledge to interpret novel verbs.

Vocabulary as an indicator of processing efficiency

Individual children varied in their accuracy in understanding novel-verb passives, just

as they do in understanding familiar-verb passives (Bencini & Valian, 2008; Huang et al., 2017). In Experiments 1 and 2, this variability was related to children's vocabularies. In Experiment 3 we gave children more time and more chances to hear the test sentence; in this context we detected no clear relationship between vocabulary and passive comprehension accuracy.

We interpreted the disappearance of the vocabulary effect in Experiment 3 as evidence that the association between vocabulary and language-processing skill within our task (as opposed to the association between vocabulary and the data-providing value of the input) accounted for the vocabulary effects in our task (see also Huang et al., 2017). When given additional repetitions of the test sentences, combined with more time to process them, lower-vocabulary children were more likely to understand the passive test sentences.

Our pattern of data suggests that despite the rarity of passives, both low- and high-vocabulary 3-year-olds have typically encountered enough relevant input to form an abstract representation of the passive structure. Note that the availability of this abstract representation does not imply that passives will be easy. Given their complexity, passives might be particularly susceptible to the aforementioned interactions between processing skill and task features (Messenger, Branigan, Mclean & Sorace, 2012). As noted in the Introduction, children struggle with them for years, and even adults make errors with passives (e.g., Ferreira, 2003). Likely contributors to this persistent difficulty with passives include their low input frequency (e.g., Allen & Crago, 1996; Demuth, 1989), the difficulty of revising an initial commitment to a canonical agent-first interpretation in online comprehension (Abbot-Smith, Chang, Rowland, Ferguson, & Pine, 2017; Huang et al., 2017; Huang, Zheng, Meng, & Snedeker, 2013; Pozzan and Trueswell, 2015), and the assessment of passives without appropriate discourse context. The typical function of the passive is to talk about the role of a discourse-prominent patient; both children and adults produce and

understand passives more readily when the patient's role is in focus (e.g., Brooks & Tomasello, 1999; Crain et al., 2009; Lempert, 1990). Despite this persistent difficulty, the 3-year-old's fledgling knowledge of the passive can be applied to new verbs.

Future research will continue to investigate the relationship between vocabulary and early comprehension of passive sentences. For example, would the vocabulary effect disappear from children's interpretation of short passives as in Experiment 1, with similar modifications to the procedure? Short passives may pose additional challenges relative to full passives (Armon-Lotem et al, 2016) because part of the complex of morphosyntactic cues that identifies the passive, the by-phrase, is not present to confirm the child's identification of the construction (see e.g., Maratsos & Abramovitch, 1975).

Children's acquisition of the passive: Learning when to generalize

We argued that the rapid extension of the passive to new verbs requires abstract representations of meaning (agent, patient) and sentence form (subject, object, oblique). Early abstraction accounts propose that children learn the meanings and syntactic properties of individual words, but also are innately biased to represent this learning in abstract terms. The key challenge for such accounts is therefore to explain the nature of the constraints that promote abstract representations, and to explain how children balance learning about words with learning about abstract syntactic patterns. Some early abstraction accounts propose an innate universal grammar richly supplied with elements such as subject, object, agent, and patient, and detailed links between them (e.g., Pinker, 1989); others argue that similar notions can be derived from simpler primitives in a suitably-constrained learning architecture (e.g., Chang, Dell & Bock, 2006; Newport, 2000; Saffran, 2002).

An example of the latter approach is the structure-mapping account, which proposes that abstract semantic representations such as agent and patient result from early conceptual development (Fisher & Song, 2006), and that abstract syntactic representations emerge from

constrained distributional learning (Connor, Fisher & Roth, 2013; Gertner et al., 2006); these claims build on strong evidence for structured conceptual knowledge in infancy, and infants' and toddlers' prowess in distributional learning. These two levels of structure are linked by simple but substantive innate constraints on relationships between syntax and semantics: via structure-mapping, the child links each noun in a sentence with a core participant-role in the sentence's meaning. On this view, the toddler who works out English word order in active transitive sentences, and the 3-year-old who acquires the rare passive, learn the argument-linking properties of each structure in the same way—through experience linking sentences with conceptual representations of scenes, facilitated by the structure-mapping constraint.

Given the strong discourse constraints of the passive, this account needs to be enriched with a notion of discourse prominence (e.g., Chang et al., 2006; Ibbotson, Lieven, & Tomasello, 2013). Fisher and Song (2006) argued that children link multiple independent semantic dimensions—including agent vs. patient and discourse-given vs. new—with syntax. The linking of a discourse-prominent element with sentence subject in passives may aid learners in disentangling the distinct role-mappings of active and passive (Chang et al., 2006). Consistent with this hypothesis, a recent artificial-language learning experiment showed effects of discourse function on linguistic generalization. Perek and Goldberg (2015) taught adults two contrasting word-order constructions in a made-up language. When one of the alternative word orders had a clear discourse function, adults generalized each structure to new verbs; when the two constructions were synonymous, adults tended to link each with particular verbs.

This finding, and seminal work by Wonnacott, Newport, and Tanenhaus (2008), reminds us that the availability of abstract representations does not force learners to generalize all learning broadly. Instead, learners use linguistic evidence to determine which patterns are conditioned on particular words, and which apply broadly across contexts (e.g.,

Reeder, Newport & Aslin, 2013). Accordingly, children and adults learn facts about each verb, including its syntactic subcategory and semantic selection restrictions (e.g., Scott & Fisher, 2009; Yuan, Fisher, Kandhadai & Fernald, 2011), but also learn general syntactic patterns, and appear to choose rationally whether to link new learning to a word, or to extend it to all words of a broad category such as transitive verbs (Thothathiri & Rattinger, 2016; Wonnacott et al., 2008; Wonnacott, 2011; Wonnacott, Boyd, Thomson & Goldberg, 2012). This data-driven rational choice between word-specific and abstract options requires that both options be available to learners.

Conclusion

Our evidence of a generalizable representation of the passive at age three, the earliest age at which children comprehend familiar-verb passives, supports the early availability of abstract representational options. Three-year-olds first learning the passive may be in the same position as the children and adults in the artificial language-learning studies just discussed. They represent passive sentences as sequences of familiar syntactic parts signalling abstract semantic roles; therefore, despite its rarity, it may take surprisingly few examples for children to learn the passive as a general pattern, rather than a quirk of a particular verb.

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Figure(s)

Figure 1. *Event-pairs and critical sentence contexts for the novel-verb test trials in Experiment 1 (a) and Experiment 2 (b).*

a.

Causal-action event

One-participant action event

Passive: "She's getting snedded!
Active: "She's snedding her!"
Intransitive: "She's snedding!"

b.

Boy-agent event

Girl-agent event

Girl-subject sentences: e.g., "The girl is getting snedded by the boy!
Boy-subject sentences: e.g., "The boy is getting snedded by the girl!"

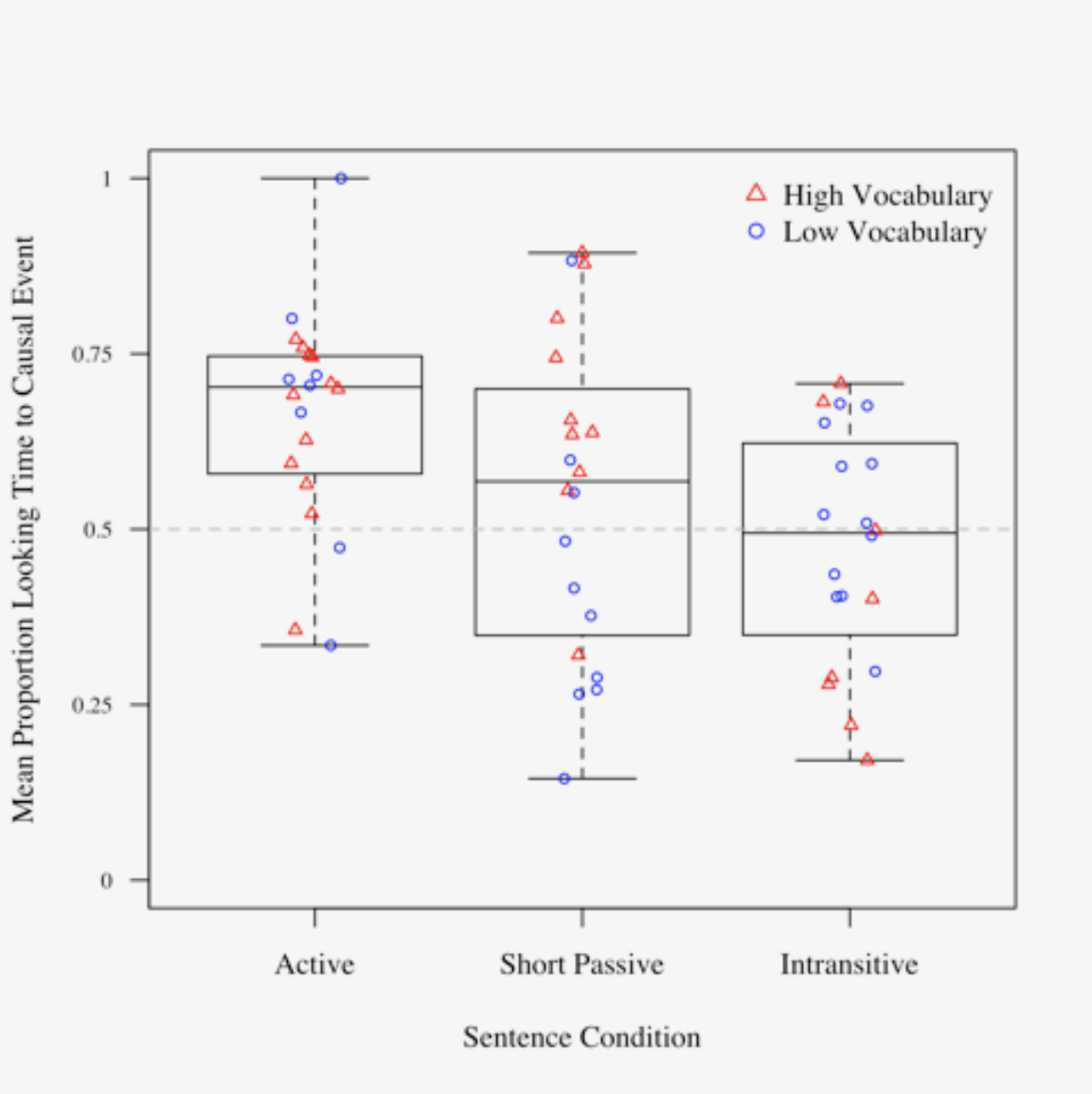
Figure(s)

Figure 2. *Sequence of events in the novel-verb test phase of Experiment 1. The test sentences shown are taken from the passive condition.*

(blank-screen interval)	"Now watch!" (3s)
	"Look here. See this?" (8s)
(blank-screen interval)	"Oh, look!" (4s)
	"Look over here. Watch this!" (8s)
(blank-screen interval)	"Hey, watch! She's gonna get snedded!" (7s)
	"Look! She's getting snedded! See? She's getting snedded!" (8s)
(blank-screen interval)	"She got snedded. Did you see it? Find snedding!" (7s)
	"Look, she's getting snedded. See? She's getting snedded!" (8s)

Figure(s)

Figure 3. *Box plots showing mean proportion looking-time to the causal-action event (as opposed to the one-participant action event) averaged across the two test trials, by sentence condition and vocabulary group, Experiment 1. Overlaid symbols show each child's score; plot symbols indicate whether the child's vocabulary was above or below the median. Note: The central line in each box is the median, the upper and lower portions of the box represent the first and third quartiles, and whiskers indicate minimum and maximum.*



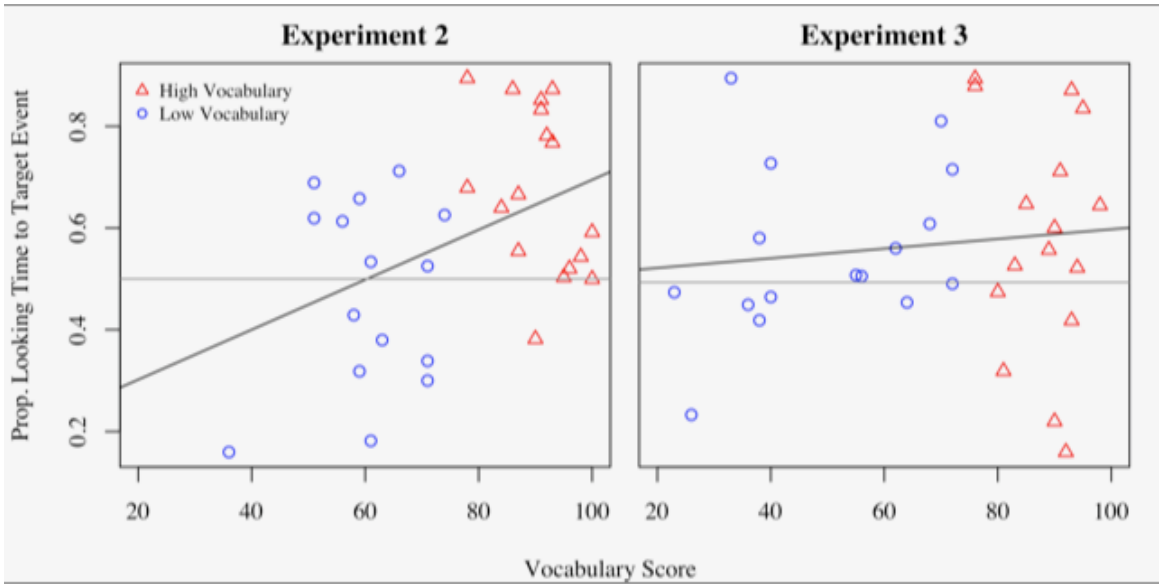
Figure(s)

Figure 4. *Sequence of events in the novel-verb test phase of Experiment 2. The test sentences shown are taken from the girl-subject condition.*

(blank-screen interval)	"Now watch!" (3s)
	"Look here. See this?" (8s)
(blank-screen interval)	"Oh, look!" (4s)
	"Look over here. Watch this!" (8s)
(blank-screen interval)	"Hey, watch! The girl is gonna get snedded by the boy!" (8s)
	"She's getting snedded by the boy! See? Find snedding" (8s)
(blank-screen interval)	"The girl got snedded by the boy! Did you see it?" (8s)
	"See? She's getting snedded by the boy! Find snedding!" (8s)

Figure(s)

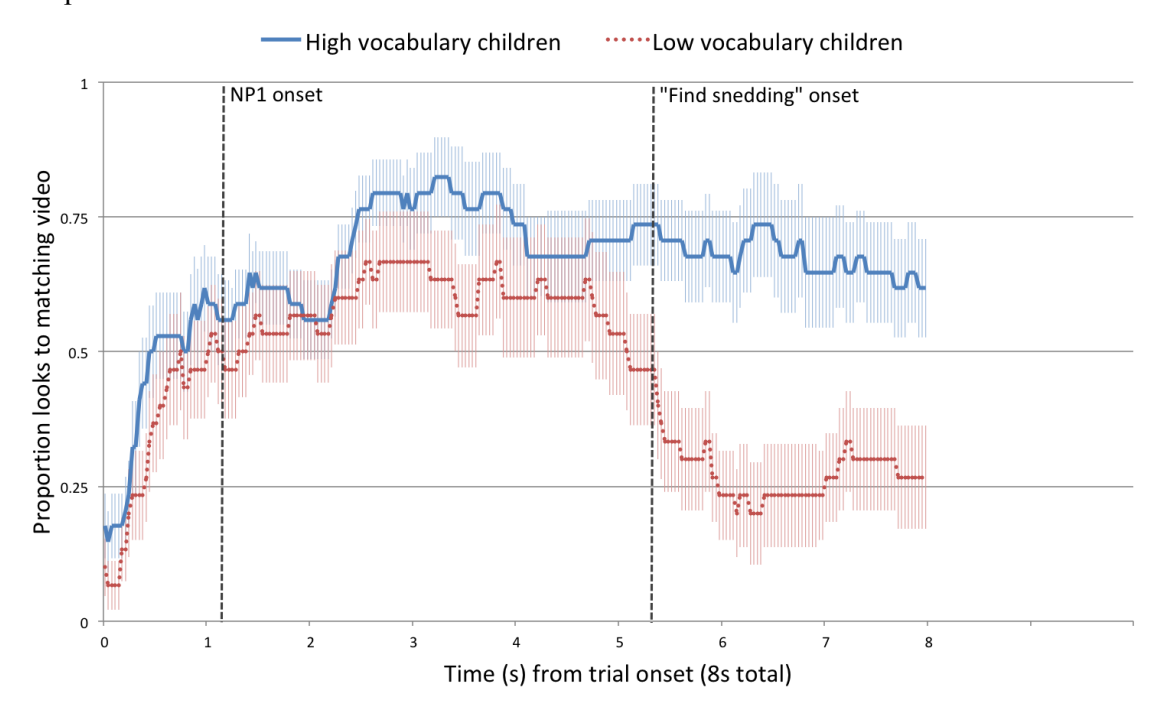
Figure 5. *Mean proportion looking time to the target event averaged across the two test trials by vocabulary score, Experiments 2 and 3. Plot symbols indicate whether each child's vocabulary was above or below the median.*



Figure(s)

Figure 6. *Mean (se) proportion fixations to the target event averaged across the two test trials, by vocabulary group, Experiments 2 (a) and 3 (b). The x-axis shows time from trial onset. Vertical lines indicate the average onset of stimulus sentences; note that the first NP in the passive test sentences was always the pronoun 'he' or 'she'.*

a. Experiment 2



b. Experiment 3