Crying helps, but being sad doesn't:

Infants constrain nominal reference using known verbs, not known adjectives

Kristen Syrett[a*], Alexander LaTourrette[b], Brock Ferguson[b], Sandra R. Waxman[b]

[a]Rutgers, The State University of New Jersey – New Brunswick

[b]Northwestern University

***Corresponding author**

kristen.syrett@rutgers.edu

Abstract

Speakers can make inferences about the meaning of new words appearing in an utterance based on the lexical semantics of other words that co-occur with them. Previous work has revealed that infants at 19 and 24 months of age can recruit the semantic selectional restrictions of known verbs (e.g., *eating*) to deduce that a noun appearing in the subject position maps onto an animate referent. We asked how general this ability to capitalize on the semantics of familiar words to identify the referent of a novel noun in subject position is by extending this investigation to adjectives, which also denote properties, and which also have animacy constraints (e.g., *hungry*). We found that unlike in the previous studies with verbs, neither 24- nor 36-month-olds could successfully recruit known adjectival semantics – even for adjectives they produce and comprehend – to home in on an animate nominal referent, even in a more interactive task without time constraints. We discuss two possible non-mutually-exclusive hypotheses for the differences between verbs and adjectives in word learning, focusing on (a) the role of the morphosyntactic environment in which the known words occur and (b) the (lack of) stability of perceptual cues for the target property in context of the utterance and mental states. Both possibilities raise exciting and rich questions about the infant's developing lexicon and the mechanisms at play in the process of word learning.

1. Introduction

If in the course of a conversation at a crowded event, you overheard the fragments of another speaker's utterance as, *"__ is eating the __"*, you could reasonably make certain inferences about the missing subject and object arguments of the verb *to eat*. For example, you could deduce that the object is something edible, and the subject is something or someone who can consume food, and is most likely an animal or human (absent a metaphorical usage). Thus, without even being presented with a visual scene or hearing the complete utterance, you are able to constrain potential meaning for the words that fill those argument slots and their corresponding referents. This process works, because verbs such as the one featured here have semantic selectional restrictions on the arguments they take, and the semantics of verbs and the events they denote have consequences for the syntactic structure and other lexical items that appear in them (Chomsky, 1965; Grimshaw, 1979; Jackendoff, 1990, 1997; Pinker, 1994; Resnik, 1996; Van Valin, 1990). These inferences about permissible co-occurring meaning based on lexical semantics take many shapes. For example, only a liquid gets *sprayed* or *washes* something away, *wipe* requires one of the arguments to be a surface location, only a hard object *shatters*, only animate, sentient agents can *think* or *believe*, and so on (Levin & Rappaport Hovav, 1991; Rappaport Hovav & Levin, 2001).

However, the role of semantic content in constraining meaning goes beyond the selectional restrictions of verbs. For example, a word that co-occurs in the same utterance might also perform a similar function (Pinker, 1994). For example, a speaker who says, *Yum!* or *Mmm, delicious!* when offered a *dax* invites an inference from a listener that a dax is something edible (and comestibly desirable). Even a more general expression of surprise or one of clear positive or negative valence towards an object can help toddlers constrain the possible word meaning of a

novel word and its potential referent (for review, see Tomasello, 2001). Thus, the lexical semantic representation of words can help to narrow the meaning of other words occurring within the same utterance (with the caveat that other operators such as negation or ironic prosody will lead to the opposite inferences). As a result of these interpretational restrictions, sentences that are grammatical (i.e., generated by the grammar/syntax) may be further assessed as felicitous or infelicitous based on meaning. Recall for instance, Chomsky's famous example, *Colorless green ideas sleep furiously* from *Syntactic Structures* (Chomsky, 1957).

Semantic restrictions in development

This ability of speakers to use known words to constrain the hypothesis space for upcoming linguistic information and their corresponding object referents has been well documented, even in children as young as two years of age. In a seminal work that launched a series of eye gaze studies, Altmann and Kamide (1999) tested Altmann's (1999) hypothesis that a verb's semantic restrictions on its argument(s) are activated predictively and constrain the search for a discourse referent that satisfies those selectional restrictions. The showed adult participants a 'visual world' scene (Tanenhaus, 1995) with a boy, a ball, a cake, a toy car, and a toy train. Participants heard either *The boy will move the cake* or *The boy will eat the cake*. Anticipatory looks to the cake began after the onset of the verb *eat* (but not with *move*), indicating that participants rapidly integrated the lexical semantics of the verb and real world knowledge with the discourse context. Kamide, Altmann, & Haywood (2003) extended these findings to show that participants also rapidly integrate information about the agentive semantic role of the subject with the verb. (See Boland (2005) for findings related to the argument/adjunct distinction in prediction.)

A similar pattern of anticipatory looks reflecting integration of semantic constraints with

the discourse context has been shown in much younger participants. Borovsky, Elman, and Fernald (2012) showed that even children as young as 3-10 years of age can make inferences about a possible object given a forced choice between four candidates in a visual world, based on the combination of the agent in subject position and the verb. Participants were shown a pirate ship, a cat, a bone, and a box of treasure. Looks to the treasure increased upon hearing *The pirate hides*…, whereas looks to the ship increased upon hearing *The pirate chases*... Patterns changed when the subject was *The dog*, and looks to the bone and the cat increased instead (see also, Borovsky & Creel (2014).).

Even younger children still make use of lexical information predictively in a scaled-down task similar to that of Altmann & Kamide's. Mani and Huettig (2012) presented two year olds with a picture of a cake and a picture of a bird, and presented them with an auditory stimulus with either an informative verb (e.g., *The boy eats the big cake*) or a neutral verb (e.g., *The boy sees the big cake*). Toddlers fixated on the target (the cake) soon after the onset of the verb *eat*, but waited until the onset of the noun with *see*, indicating that they made use of the verb's semantic restrictions to select a thematically appropriate argument referent. While the anticipatory abilities of toddlers – especially those with elevated vocabulary – had previously been documented in their rapid selection of an object referent for a familiar noun (Fernald et al. 2008), this finding demonstrated that they could predict a referent based on known selectional restrictions. (See Valian, Prasada, & Scarpa (2006) on consequences of verbal selectional restrictions on ease of production in two-year-olds.)

This finding can be extended to cases in which the object (or the nominal label) is not a familiar one. Goodman, McDonough, & Brown (2008) have shown that at two to 2.5 years of age, children can identify the correct animate referent when told to *Show me the ferret* after

hearing a linguistic stimulus in which the selectional restrictions of the verb call for an argument that can consume food (*Mommy feeds the ferret*). However, this study does not tell us about the time course of their selection, and uses actual – albeit infrequent and potentially unfamiliar – nouns.

Remarkably, at the same age, two-year-olds can also use information about known nouns to make inferences about the selectional restrictions of novel verbs that take them as object arguments–even without a visual scene to support the inference. Yuan et al. (2011) presented children with a series of linguistic utterances during a listening phase in which one novel verb was paired with inanimate objects (e.g., *She nerked a fork*), while another was paired with animate arguments (e.g., *She wants to stipe the elephant*). During the test phase, participants were presented with a choice between an animate and an inanimate candidate (e.g., a cat and a spoon), and asked which one they would *nerk/stipe*. In both these 'unfamiliar' trials and in trials with familiar verbs (e.g., *eat, drive*), participants zeroed in on the correct referent after the onset of the verb.

Narrowing the space for subject arguments

If the selectional restrictions of a verb can be rapidly recruited to identify an intended referent for an object argument, then they may also be useful in narrowing down the potential meaning of a subject argument. Indeed, in a clear illustration of young children's capacities to recruit known word meanings to deduce the meaning of novel words, Ferguson, Graf, & Waxman (2014) (FGW14) have shown that by 19 months of age, infants can use the animacy restrictions of known verbs to constrain the meaning of novel nouns in subject position. FGW14 compared infants' eye gaze across two trial types: one in which objects seen were familiar and referred to

with known nouns (e.g., *dog, bottle*), and one in which the objects were unfamiliar and referred to with a novel nouns (e.g., *dax*). Within these critical 'unfamiliar' trials, there were two further conditions: a neutral condition in which the property made no reference to animacy (e.g., *The dax is right here.*) and an 'informative' condition in which the verb selects for an animate subject (e.g., *The dax is crying*). After a brief exposure to side-by-side images of an animate and an inanimate object , the key linguistic information was presented during a trial phase when there was no supporting visual scene. In the next phase, infants saw the same two images again and were asked where the dax was. FGW14 found that 19-month-old infants quickly and successfully identified the correct referents in the 'familiar'trials, and while infants had a slight overall preference for animate referents in the 'unfamiliar' trials, their looks were mediated by the type of predicate: novel nouns that were combined with animate-subject-selecting verbs yielded more looks to the animal than the artefact at test.

Ferguson, Graf, & Waxman (2018) (FGW18) extended this research to 24-month-olds, replicating the same pattern observed with the 19-month-olds. Both groups of infants successfully recruited the known verbal meanings to zero in on an animate referent in the 'unfamiliar noun' trials. The main difference FGW18 found was that the 24-month-olds were more efficient in their processing, and therefore settled in on the intended referent much sooner (approximately 2200 ms sooner). Thus by two years of age, infants not only recruit this semantic knowledge about animacy in the service of referent selection, but do so quickly, as the speech stream unfolds.

These combined findings illustrate the power of the developing lexicon to rapidly constrain the meaning of newly-encountered words, and in particular, highlight the potency of the selectional restrictions of verbs in narrowing the hypothesis space for the meaning of nouns

appearing in their argument positions. Given the potency of verbs in constraining the space of an intended object referent for a novel noun, a key question that arises is how general this process of recruiting known words to learn new ones is, and whether a lexical item from another category with similar animacy restrictions can perform the same function. Here, we turn to adjectives as a potential cue.

Why adjectives?

Why might we turn to adjectives in particular? We present four main reasons. First, verbs and adjectives share a similar semantic representation in that both verbs and adjectives denote *properties*. The difference is that while verbs describe properties of *events* (situations in which event participants are, e.g., crying, eating, or sleeping), adjectives denote properties of *entities* (individuals who are, e.g., sad, hungry, or tired).[1] With these particular lexical items, there is a shared conceptual and semantic interpretation regarding the truth conditions that must hold in order for the predicate (verb or adjective) to be true, and in each of these cases, outside of a metaphorical usage, the properties share a restriction on the agent expressed by the grammatical subject based on animacy (e.g., an agent who is *crying* or is *sad* must have a particular biological constitution and/or be able to experience emotion, an agent who is *eating* or is *hungry* is consuming or desires to consume food, etc.).

[1] Adjectives do not always have to denote a property of an individual; they can also describe sets of individuals (e.g., *the group was large, the committee was concerned, the problems were numerous*, etc.). Here, too, there is a parallel between adjectives and verbs, since some verbs can or must apply to a group or plurality (e.g., *the crowd dispersed, the committee disbanded, the children gathered around the teacher*). See Syrett (2015).

Second, verbs and adjectives have similar surface-level distribution (at least in English, the language under investigation in FGW and here). Both can appear in an utterance-final position after *is*. The verb can appear in a present progressive form (i.e., *X is eating*) while the adjective can appear in post-copular predicative position (i.e., *X is hungry*). Third, both verbs and adjectives appear around the same time in child-directed speech (Dale & Fenson, 1996), and are typically delayed in production relative to nouns.

Finally, much like verbs, adjectives can also help children to rapidly home in on an intended object referent in a visual scene (Eberhard et al., 1995; Sedivy et al., 1999; Tanenhaus et al, 1995). This ability to recruit adjectives incrementally in the service of narrowing down the hypothesis space surfaces in children as early as three years of age (Fernald, Thorpe, & Marchman, 2010; Thorpe and Fernald 2006). For example, when presented with a forced choice between a blue car and a blue house and asked, *Where's the blue car?*, 36-month-olds waited until soon after the onset of the noun to lock in on looking at a referent, but when shown a blue and a red car, and asked the same question, they did not wait, and instead made immediate use of the adjectival modifier. Children only six months younger were (rather counterintuitively) less efficient in this latter condition, and did not show signs of rapid integration of the adjectival meaning.

Under one hypothesis (Ninio 2004; Thorpe and Fernald 2006), integration of the prenominal adjective with the following noun with which it semantically composes and syntactically combines is challenging for children younger than age three. Their inferior processing capacity might mean that they cannot encode the linguistic information in light of the visual discourse scene, and also attend to the subsequent linguistic information that follows in the speech signal, which impacts the representation they are able to build incrementally. If this is

the case, then we might predict that removing these barriers paves the way to successful recruitment of adjectival information in children younger than 36 months of age. Specifically, we could take two measures.

First, we might remove the adjective from prenominal position and place it in salient predicative position, which also does not carry restrictions on which adjectives can occur in that position, as the prenominal position does (Prasada, 1992). Second, we might disentangle the linguistic and visual stimuli by presenting the relevant linguistic information in the absence of a visual scene – a strategy that has been successfully used in a number of word learning studies (Arunachalam & Waxman, 2010; Arunachalam, Syrett, & Chen, 2016; Yuan and Fisher, 2009). One might also hypothesize that the 30-month-olds struggled in Fernald et al's task, because they were confronted with color words, a subcategory of adjectives for which development is notoriously prolonged. (For discussion of the challenges of learning color words, see in particular Sandhofer & Smith (1999), Soja (1994), and Wagner, Jergens, & Barner (2018), a.o.). Thus, by appealing to adjectives that have animacy restrictions, we not only conduct a study that parallels previous work with animacy-selecting verbs, but also sidestep difficulties that may be associated with color words.

The hypothesis that children might recruit familiar adjectives to assign a meaning to novel nouns is bolstered by the fact that by 30 months of age, children are able to accomplish a task that seems equally hard if not harder: using a familiar adverb to deduce the meaning of other novel words. They recruit the presence of a highly frequent and familiar manner adverb (*slowly*) to assign a meaning to a novel word appearing earlier in the utterance (*He's gonna pilk it slowly*) as an event-denoting verb instead of referent-denoting noun (Syrett, Arunachalam, & Waxman, 2014). They also recruit the presence of a known adverb (*together*) to narrow the hypothesis

space of an unknown verb appearing with a coordinated subject (*My sister and the lady are going to biff together*) as referring to an event in which two agents are engaged in spatiotemporally contiguous subevents, rather than a causative event in which an agent acts on a patient (Arunachalam, Syrett, & Chen, 2016). Finally, children at this age are capable of using the selectional restrictions of known adverbs to constrain the meaning of novel adjectives in predicate position with which they compose (*These are both completely pelgy*), given a forced choice between objects two competing properties that correspond to different gradable adjective scales (Syrett, 2007; Syrett & Lidz, 2010).

Current research

We have reviewed evidence from previous work that by 19 to 24 months of age, children use the animacy restrictions of a known verb (even without a co-occurring supporting visual scene) to deduce the meaning of its subject argument and its corresponding real world referent. We also presented reasons to think that known adjectives with similar selectional restrictions and salient utterance position might be able to accomplish the same goal. Thus the question that we entertain here is whether adjectives possess the same power as verbs in word learning: can infants recruit the lexical-semantic representations of known adjectives to narrow the hypothesis space of a novel noun meaning, and zero in on the intended subject referent?

We begin with the oldest age at which FGW18 found that infants can use the animacy selectional restrictions of verbs to constrain the meaning of novel nouns: 24-month-olds (5 months older than the infants in FGW14's study). Based on these findings, we then move to an older age group, 36-month-olds, since children at this age not only produce a range of adjectives, but have been shown to display semantic knowledge of different adjectives (see Syrett (2007) for

a review) and can process known adjectives rapidly to identify a referent for the noun they modify (Fernald, Thorpe, & Marchman, 2009). Finally, given the findings with this older group, we test this same age range on a more interactive forced-choice pointing task exploring the same semantic constraints.

Previewing our findings, we find that neither 24- nor 36-month-old children homed in on the animacy-restricted meaning of the novel noun/referent based on the presence of a known adjective, whereas they had done so efficiently in previous studies with familiar verbs. These admittedly puzzling findings leads us to consider the possible reasons for the inability of adjectives to perform a role comparable to verbs in this paradigm, targeting linguistic, perceptual, and conceptual components as possible (not mutually exclusive) causes. As a consequence, these findings – while demonstrating a failure of one particular lexical cue relative to another to narrow the hypothesis space in word learning – raise intriguing and deep questions about the informational sources and deductive processes at play in early word learning.

2. Experiment 1 (Forced Choice looking)

2.1. Participants

45 24-month-olds were included in the final sample (M: 24.2 months, SD: .64, 23 females). An additional 14 infants were excluded due to failure to complete the task (7), severe track-loss (5), or technical issues (failure to calibrate, 1, equipment malfunction, 1). All infants were recruited from Evanston, IL, based on caregiver reports of less than 25% exposure to a language other than English. Upon entering the laboratory, caregivers completed the MacArthur Short Form Vocabulary Checklist: Level II (Form A) (Fenson et al., 1993), as well as a supplementary checklist that asked which of the familiar adjectives used in this design were known by their

child. Parental reports indicated that infants produced 59.4 words on the MCDI (SD = 23.2), including 34.8 (SD = 12.3) nouns and 5.8 (SD = 4.1) verbs, and on average 4.50 of the 6 target adjectives.[2] (In addition, the majority of children tested were reported to know each of the individual adjectives, with the exception of *friendly*.) The results of the MCDI scores strongly correlate with the results of the supplemental adjective checklist ($r(42) = .44$, $p = .003$.). All experiments and the norming study reported below were performed under IRB approval, and informed consent was obtained for experimentation with human subjects.

2.2. Apparatus

We used a Tobii T60XL corneal-reflection eyetracker for stimulus presentation and data collection in a laboratory setting. This eyetracker has a sampling rate of 60 Hz, and a display size of 57.3 × 45 cm. Participants were seated approximately 60 cm from the screen on their caregiver's lap.

2.3. Materials

2.3.1. Stimuli

There were 12 trials in each experimental session. Each trial had the same structure.

The trial consisted of three phases: a Preview phase, a Dialogue, and a Test phase, as depicted in Figure 1.

[2] In comparison, in FGW18, 19-month-old infants knew on average 4.9 of the 6 'known' target verbs, and at 24 months, they were reported to knew 5.96 of the 6 target verbs. Bothe age groups succeeded in this task with verbs.

Figure 1: Trial structure, with example of an 'unfamiliar' trial in both the 'informative' and 'neutral' conditions

	Preview phase (6 s)		Dialogue phase (9 s)	Test phase (6 s)	
Visual stimuli	 Image 1 (animate)	 Image 2 (inanimate)		 Image 1	 Image 2
'informative' condition	*Oh, wow! Look here!*		*The dax is sad!*	900 ms → *Where is the dax?*	
'neutral' condition			*The dax is right here!*		

2.3.1.1. Visual Stimuli

The visual stimuli were almost identical to those employed in Ferguson, Graf, & Waxman (2014, 2018)[3], allowing us to make the comparison between familiar verbs and familiar adjectives as tight as possible. Selection of familiar objects was evenly split between animate and inanimate objects and was based on names of objects understood by at least 72% of 15-month-olds (inanimate nouns: *bottle, spoon, car*; animate nouns: *bird, cow, dog*) (Dale & Fenson, 1996). Unfamiliar objects were those whose names infants would most likely not know (abstract sculptured artefacts and exotic animals).

2.3.1.2. Linguistic and Auditory Stimuli

[3] The one difference was the use of an image of a car in place of an image of a horse. We conservatively made this change in order to balance animacy targets in the familiar trials, since we had noticed an imbalance in the previous studies of FGW.

Auditory stimuli were modeled after the stimuli featured in Ferguson, Graf, & Waxman (2014, 2018). They were recorded in a sound-attenuated room by two native speakers of English (male, female) using a child-directed speech style.

Lexical items were selected based on a combination of factors in order to identify an optimal set of adjectives. First, we began with the animacy-selecting verbs from the previous studies by Ferguson, Graf, & Waxman (2014, 2018): *crying, dancing, drinking, eating, looking, sleeping*. We then identified corresponding adjectives for as many of these as possible: *sad* (*crying*), *hungry* (*drinking, eating*), *sleepy* (*sleeping*), and then supplemented the list with three more similar animacy-restricting adjectives: *angry, friendly, happy*. These adjectives are mono- or bisyllabic and are highly frequent. With the exception of *sad*, all had a salient and typical adjectival *–y* ending.

To confirm that these six adjectives had an animacy bias, we administered an independent norming task to 60 undergraduates (30 in each condition). We pseudo-randomized these six adjectives along with four other animate candidates (e.g., *mad, tired*), 11 inanimate candidates (e.g., *wooden, absorbent, plastic*), and 15 potentially neutral candidates (e.g., *nice, pretty, fuzzy, fake, wet*), and provided adults with a rating task with the instructions that follow in (1). Half of the participants received the 'animate' version, while half received the 'inanimate' version.

(1) Instructions in adult 'animacy' norming task

> Some things in the world are **animate**. These are things (like humans and animals) that can move on their own, can have emotions, and may be able to communicate. Some things in the world are **inanimate**. These are things that cannot move on their own, do not have emotions, and cannot communicate. Some of these things (like books, clothing,

> or toys) are manmade. Others (like trees, water, or stone) come from nature. Here, we want you to think about [animate/inanimate] things. Please rate each of the adjectives in the following list from 1 to 5 using the following scale:
>
> 1: cannot be used to describe [animate/inanimate] things
>
> 3: can maybe be used to describe [animate/inanimate] things
>
> 5: is ok being used to describe [animate/inanimate] things

The six target animate adjectives received an average of 4.97 to 5 for the animate version of the rating task and an average of 1.27 to 1.63 for the inanimate version, indicating that participants viewed them as selecting for 'animate things' and *not* 'inanimate things'. The target inanimate controls displayed the opposite pattern across the two rating tasks, averaging an overall 2.16 in the animate version and 4.63 in the inanimate version, indicating that participants viewed them as selecting for 'inanimate things' and not 'animate things'. We were therefore confident about our six target adjectives being robust cues for animacy.

The predicates in the 'neutral informative' condition were the same as in Ferguson, Graf, & Waxman (2014, 2018): *right here, very clean, nearby, so close, so nice, so little*. None of these is a strong signal for animacy or inanimacy. The novel nouns were also the same as those in these previous studies. They were all monosyllabic and were CVC or CVCC words that are phonotactically licensed in English.

2.4. Procedure

There were 6 'familiar' trials and 6 'unfamiliar' trials. In the 'familiar' trials, the animal was a common animal (e.g., dog), and the object was a known, familiar object (e.g., bottle). In the 'unfamiliar' trials, the animal was an uncommon, unfamiliar animal and the object was a novel artefact. The position of the two images was counterbalanced across trials.

Each trial type had three phases. In the Preview phase (6 s), infants saw images of two objects (one animal and one novel object) presented side-by-side on the screen. In the Dialogue phase (9s), an abstract screensaver appeared and infants heard a dialogue. In the Test phase (6s), the same two images from the Preview phase then reappeared in the same positions on the screen.

During the Preview phase, infants heard, "*Oh, wow! Look here!*" to direct their attention to the screen. The animal and object were displayed for one second, then disappeared. The trial then proceeded to the Dialogue phase. During this phase, as infants viewed a colorful, abstract scene, a dialogue between two people played. In the 'familiar' trials, the speakers made reference to one of the two objects by making a statement about it with a full definite DP in subject position and a locative phrase in predicative position (e.g., *The bottle is right here.*). In the 'unfamiliar' trials, the speakers instead used novel object names (e.g., *The dax*). The unfamiliar trials were the locus of the experimental manipulation.

Infants were randomly assigned to one of two between-subject conditions ('informative' and 'neutral'), depending on the adjective they heard within the 'unfamiliar' trials during this phase. In the 'informative' condition, the novel noun was accompanied by a familiar, highly frequent adjective, which seeks out an animate subject (e.g., *The dax is sad.*). In the 'neutral' condition, the novel noun was accompanied by a locative phrase that had no animacy restrictions, as in the 'familiar' trials (e.g., *The dax is right here.*). In the next phase, the Test phase, the two candidate images from the Preview phase reappeared in their original locations, and infants were asked about the location of the object that had been mentioned during the preceding dialogue (e.g., *Where is the dog/bottle/dax?*). The onset of the target noun occurred approximately 900 ms into this phase.

To be clear, across both conditions, infants saw the same images and heard the same linguistic stimuli during the Preview and Test phases. The only difference between the conditions was in the linguistic information provided during 'unfamiliar' trials of the Dialogue phase, as infants viewed the abstract screen saver. Thus, the question was whether this minimal linguistic information in the absence of any potential co-occurring object referents or event, could constrain infants' selection of a previously seen object referent in the Test phase.

2.5. Predictions

As with the previous studies with verbs, we generated two main sets of predictions. First, we predicted that in the 'familiar' trials, infants would have no difficulty using the known images and familiar nouns (e.g., *bottle*, *dog*) to zero in on looking at the correct referent during the Test phase. Second, we predicted that in the 'unfamiliar' trials, where a novel noun was mentioned during the Dialogue phase, infants in the 'neutral' condition would demonstrate 'at chance' looking between the two candidates, since the linguistic stimulus was uninformative about the choice of referent. There was nothing in the Dialogue phase that could be used to direct infants' gaze towards one image or another at Test. By contrast, in the 'informative' condition, infants who recognize the animacy-based selectional restrictions of the target adjectives (e.g., *sad*, *hungry*) should zero in on the animate nominal referent, despite it not being a familiar animal. Thus, while we predicted that although infants might perhaps demonstrate an overall preference for the animals over the artefacts, this preference (both in terms of what was preferred at Test and how quickly infants locked in on this image) would be modulated by the linguistic information presented during the Dialogue phase.

2.6. Results

2.6.1. Data Preparation and Analysis

We analyzed participants' looking during a time window in the Test phase of each trial from 500ms prior to noun onset until 4000ms after noun onset. We chose this window to perform a comparable analysis with the previous research, which suggests the effects should emerge within this window (FGW 2014, 2018). During this window, during the familiar trials, infants can rely on the presentation of images in the Preview phase and the familiar noun mentioned in the Dialogue phase to anticipate the referent being highlighted in the Test phase. Our dependent variable was the proportion of looking time devoted to the animate referent out of the total time spent looking at both the animal and artefact combined during this target window of the Test phase.

To assess children's looking behavior, we created areas of interest (AOIs), measuring 810 x 710 pixels, around each of the test images. Any looking outside of the AOIs was excluded from the analysis. We also excluded any trial during which the child attended to the images for less than 25% of the relevant window at test. For inclusion in the analysis, children were required to contribute a minimum of 3 trials in both familiar and unfamiliar blocks. On average, children contributed an average of 5.80 trials (SD = .59) during the familiar trials and 5.51 trials (SD = .84) during the unfamiliar trials. Critically, the number of unfamiliar trials contributed did not vary by condition ($M_{informative}$ = 5.50, $M_{neutral}$ = 5.52, $t(43)$ = .09, $p > .9$).

All data preparation and analyses were performed with the eyetrackingR package (Dink & Ferguson 2015), and followed the method employed in FGW18.To analyze children's looking behavior during the target window, we conducted two kinds of analyses: an aggregate analysis and a time-course analysis. In the *aggregate* analysis, we averaged participants' looking across the full test window, finding the proportion of looking to the animate referent during each trial for each subject. To correct for the association between means and variances in proportional

data, we submitted these proportions to an empirical logit transformation. We then created a linear mixed-effects model including random effects of participant and trial and random slopes as specified by the design; transformed proportions remained the dependent variable. Significance values were obtained using the Satterthwaite method for estimating degrees of freedom in the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017), an appropriate method of significance evaluation for smaller samples (Luke, 2017). In all studies, traditional ANOVA methods yielded the same results.

For the *time-course* analyses, we separated the data into 100ms bins and conducted a cluster-based permutation analysis across these bins, again using logit-transformed proportions as the dependent variable. For this analysis, we first selected a t-threshold, based on a desired alpha of .05. Next, we conducted t-tests within each time-bin and identified the time-bins whose t-statistic exceeded our threshold. Finally, we summed together the t-statistics of any consecutive time-bins, creating a measure of the size of this divergence between groups. To test the likelihood of such a divergence, we conducted 10000 simulations of the data with randomly shuffled condition labels and performed the same analysis on each simulated dataset. To obtain a significance value, we then compare the observed divergence to this distribution of chance-based divergences.

2.6.2. Experimental Results

The results for the aggregate analysis are presented in Figures 2 and 3. The results for the time-course analysis are presented in Figures 4 and 5. Figures 2 and 4 present the looks to the animate referent for the animate and inanimate targets in the ‘familiar’ trials. Figures 3 and 5 presents the looks to the animate referent for the ‘informative’ and ‘neutral’ conditions of the ‘unfamiliar’ trials.

Familiar trials

As predicted, children's looking during the 'familiar' trials varied as a function of the known words they heard. Children looked significantly more to the animate object when hearing words referring to the animate object (M = .79, SD = .12) than when hearing words referring to the inanimate object (M = .34, SD = .16), $\beta = 3.24$, SE = .34, $p < .0001$. Moreover, this difference between animate-referring and inanimate-referring words emerged quickly: a cluster-based permutations analysis identifies a *significant and prolonged divergence* between the trial types beginning 200ms before noun onset and extending 2900ms after onset, cumulative t-statistic = 303.9, $p < .0001$. A second, marginal divergence also occurred between 3400 and 3900ms, $t_{summed} = 13.7$, $p = .079$. The early onset of the first divergence is likely due to the nature of the Dialogue phrase (which across trials predictably labels one referent) and the transition into the Test phase (which then immediately directs participants to locate it). This should be a facile task for familiar nouns and objects.

Unfamiliar trials

In contrast to the familiar trials, children in both the 'informative' (M = .47, SD = .12) and 'neutral' (M = .51, SD = .10) conditions did not significantly differ in their aggregate looking to the animate referent ($\beta = -.22$, SE = .27, p = .43). In fact, children in the 'neutral' condition looked numerically more to the animate referent. Additionally, a cluster-based permutation analysis found no significant divergences between the two conditions: no time-bin even exceeded the initial t-threshold. This striking similarity between these two conditions suggests that 24-month-old children were unable to use animacy restrictions on familiar adjectives to

learn the meaning of novel nouns, in contrast to the previous performance with verbs.

Figure 2. Proportion of looking time to the animate referent for the animate and inanimate target across the 'familiar' trials of Experiment 1 (24-month-olds)

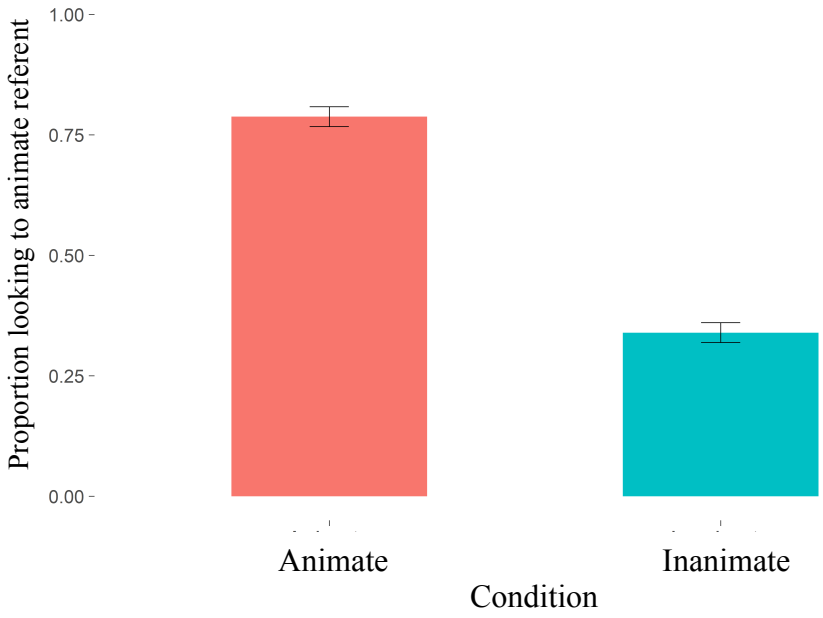


Figure 3. Proportion of looking time to the animate referent in the two conditions of the 'unfamiliar' trials of Experiment 1 (24-month-olds)

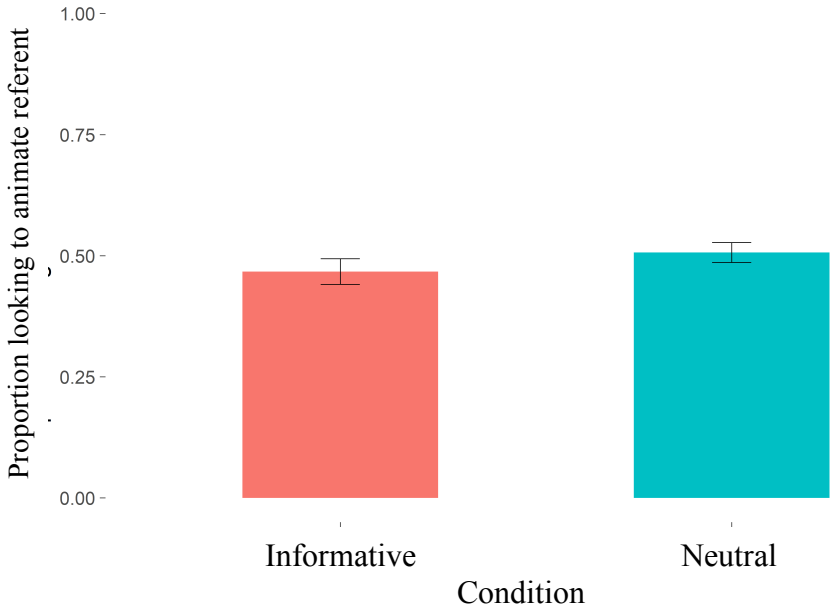


Figure 4. Time-course of looking to the animate referent for the animate and inanimate target across the 'familiar' trials of Experiment 1 (24-month-olds)

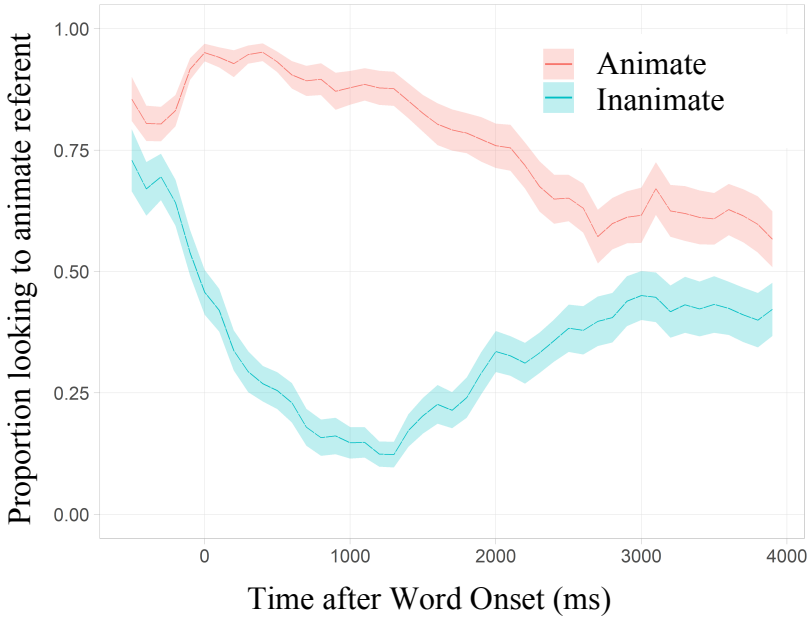
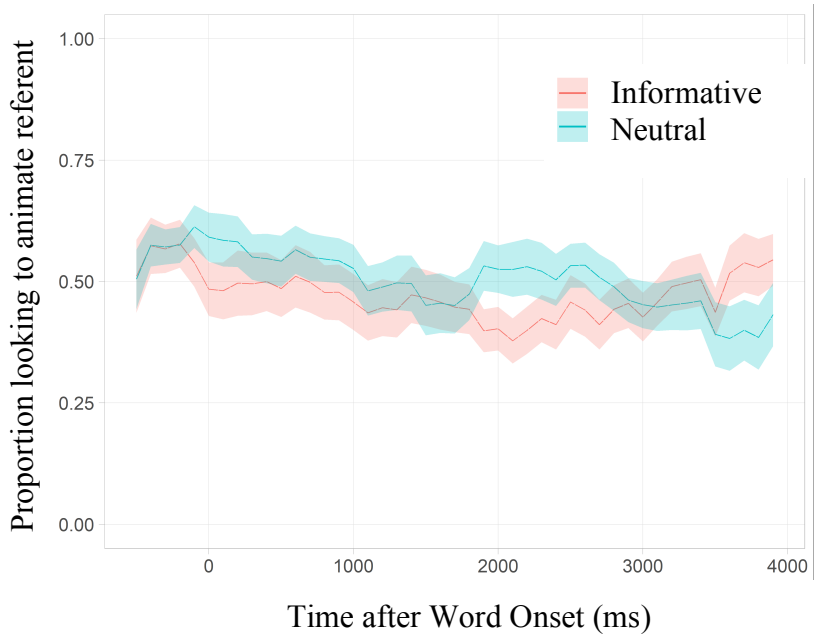


Figure 5. Time-course of looking to the animate referent in the two conditions of the 'unfamiliar' trials of Experiment 1 (24-month-olds)



2.7. Discussion

In Experiment 1, we investigated whether infants at 24 months of age could recruit the meaning of familiar adjectives to constrain the meaning of a novel subject argument and identify the intended referent. Previous research by FGW18 had documented that infants at the very same age with the very same paradigm were able to successfully use familiar verbs to perform this function. Unlike the previous research, the present experiment revealed that 24-month-olds do not meet with success when presented with familiar adjectives. Given that this experiment gives us a minimal age at which infants cannot recruit adjectives for this purpose, we decided to conservatively target a much older group – 36-month-olds – in the next experiment. This age was selected based on the findings discussed earlier related to the processing capacity and semantic knowledge of adjectives possessed by children at this very age.

3. Experiment 2 (Forced Choice looking): Methods

3.1. Participants

Forty-eight 36-month-olds were included in the final sample (M: 35.6, SD: 1.2, 24 females). An additional 26 children were excluded due to failure to complete the task (5), severe trackloss (14), parental interference (1), or technical issues (failure to calibrate, 3, or equipment malfunction, 3). Parental vocabulary reports indicated children produced 83.7 words (SD = 18.9) on the MCDI (Level II, Form A), including 45.6 nouns (SD = 7.43) and 12.0 verbs (SD = 3.1), and on average 5.66 of the 6 target adjectives. (In addition, the majority of children tested were reported to know each of the individual adjectives.)

3.2. Stimuli and Procedure

The stimuli and procedure were the same as in Experiment 1. 36-month-olds were seated either

in their caregiver's lap or alone in the chair, according to their preference.

3.3. Predictions

Given the performance of the 24-month-olds in Experiment 1, and the previous performance of infants through 24 months of age reported by Ferguson, Graf, & Waxman (2014, 2018), as well as the productive and processing capacity of children by age three reviewed earlier, we predicted that the 36-month-olds would successfully home in on an animate referent, given the selectional restrictions of the known adjectives in this experiment.

3.4. Results

As in Experiment 1, we present the proportion of looking time in the two trial types first (Figures 6 and 7), followed by the time-course of looking within the two conditions of the two trial types (Figures 8 and 9). Data preparation was identical to Experiment 1. Children contributed an average of 5.44 trials (*SD* = .92) in the familiar trials and 5.48 trials (*SD* = .82) in the unfamiliar trials. Again, the number of unfamiliar trials contributed did not differ in the informative (*M* = 5.63, *SD* = .65) and neutral (*M* = 5.33, *SD* = .96) conditions (t(46) = 1.23, p = .22).

Familiar trials

Performance on the familiar trials suggested the paradigm was viable for the new age group: 36-month-old children reliably directed their looking toward the named referent. On trials for which the word referred to an animate object, children looked significantly more to the animate referent (*M* = .80, *SD* = .12) than on trials for which the word referred to the inanimate object (*M* = .35, *SD* = .17), $\beta = 3.42$, *SE* = .43, $p < .001$. Again, we also observed a significant divergence between the two types of trials over time, $t_{summed} = 289.4$, $p < .0001$, lasting from 500ms before word onset to 3100ms after word onset.

Unfamiliar trials

In the informative condition, children did look slightly more to the animate referent (M = .47, SD = .12) than their counterparts in the neutral condition (M = .43, SD = .11); however, this difference did not reach significance (β = .40, SE = .24, p = .10). A cluster-based permutation analysis revealed a marginal divergence between the two conditions: the informative condition showed greater attention to the animate referent between 0ms and 500ms after noun onset, t_{summed} = 12.23, p = .059. Thus, immediately after 36-month-olds in the informative condition heard the novel noun, they tended to increase their looking to the animate referent. However, this tendency is neither as robust nor as prolonged as for the familiar words, nor was it as robust or prolonged as with verbs in the younger, 24-month-old group.

Figure 6. Proportion of looking time to the animate referent for the animate and inanimate target across the 'familiar' trials of Experiment 2 (36-month-olds)

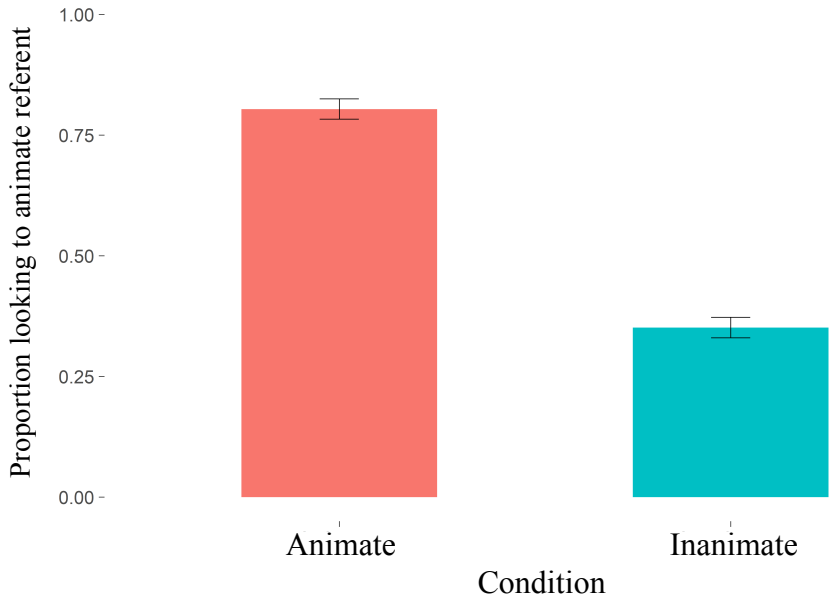


Figure 7. Proportion of looking time to animate referent in the two conditions of the 'unfamiliar' trials of Experiment 2 (36-month-olds)

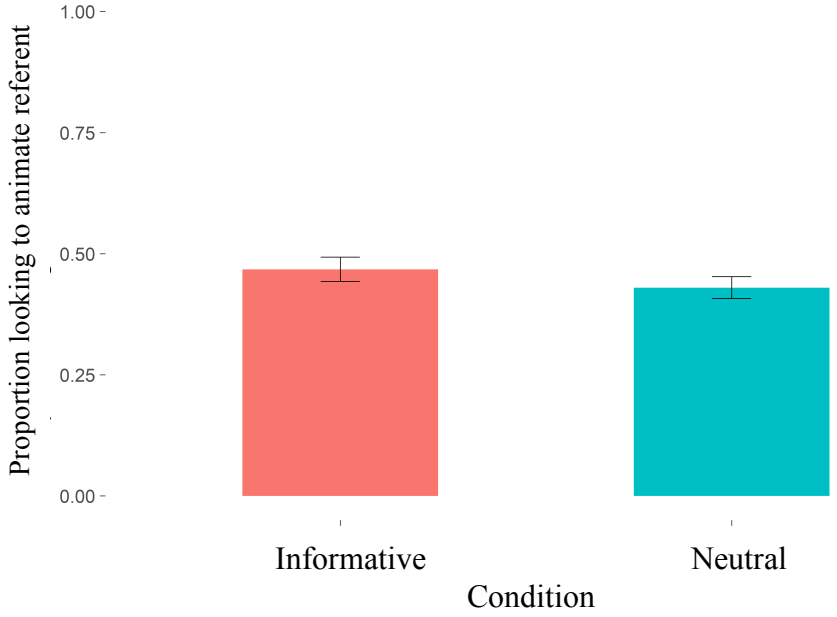


Figure 8. Time-course of looking to the animate referent for the animate and inanimate target across the 'familiar' trials of Experiment 2 (36-month-olds)

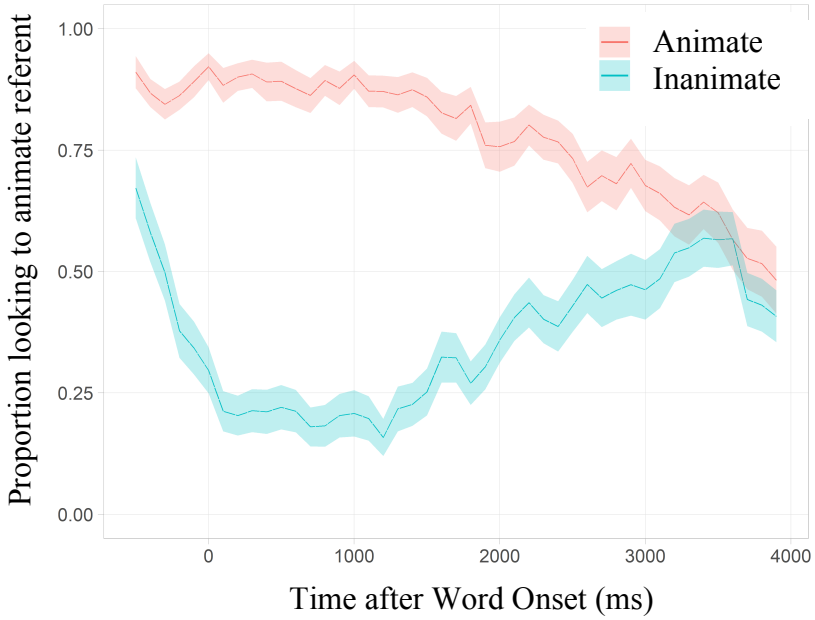
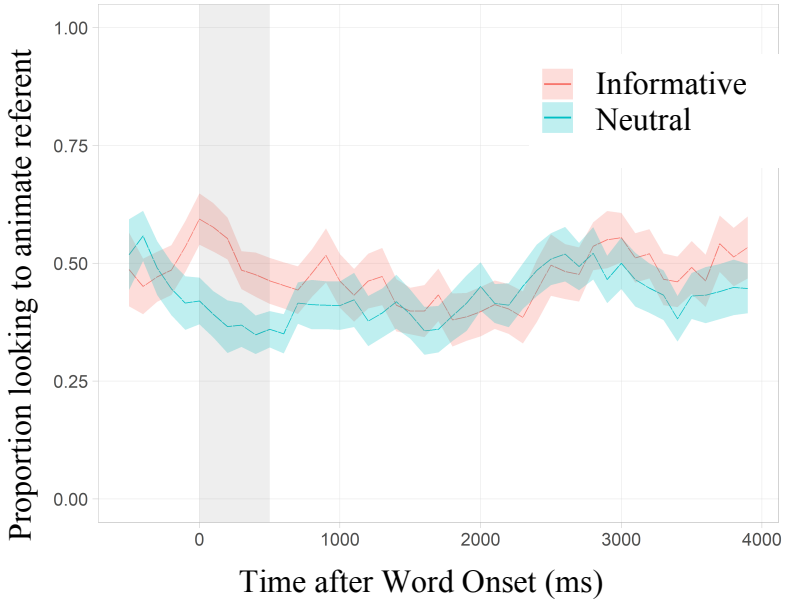


Figure 9. Time-course of looking to the animate referent in the two conditions of the 'unfamiliar' trials of Experiment 2 (36-month-olds)



3.5. Discussion

The results of Experiment 2 indicated that 36-month-olds were able to rapidly home in on the object referent in the familiar trials, demonstrating that they performed successfully in the paradigm when not called upon to learn the meaning of a novel word. However, in the unfamiliar trials, there was only a fleeting but marginally significant window in which children homed in on the animate referent. Thus, in contrast to the infants in the previous research, who were able at 19 to 24 months of age to recruit familiar verbs to identify an intended object referent, the children in the current study were unable to do so with familiar adjectives as late as 36 months of age. And at neither 24 or 36 months did overall vocabulary knowledge or specific knowledge of the adjectives significantly predict success on the task.

Why should these older children, who have superior lexical knowledge, productive capacity, and processing efficiency, not exhibit similar success? We might entertain two possibilities. One is that the time pressure of the timed looking task impeded stable selection of

the referent. The other is that the children had made a selection early in the test phase but then rapidly lost attention. In either case, we reasoned that correct selection of the animate referent might be facilitated and detected in a more interactive task where the time limit was removed. We therefore adapted our paradigm as an offline forced-choice study, which we report in Experiment 3.

4. Experiment 3 (Forced Choice pointing): Methods

4.1. Participants

10 children (M: 36.5, SD: 1.23, range, 3 females) participated.

4.2. Stimuli

We adapted the stimuli from the two previous experiments to create a forced-choice pointing task administered via Powerpoint slides on a 17″ Macbook Pro screen. The two images shown during the test phase were placed side by side on the screen, with a blank screen separating each set of images. The session began with two training items pitting an animate being (an animal) against an inanimate object. In one trial, children were asked to point to the animate referent, and on the other, they were asked to point to the inanimate referent, with sides counterbalanced, thereby establishing the premise that either referent and either side of the screen was viable. The prompt made use of the neutral predicates from the 'neutral' condition of the 'unfamiliar' trials. Children experienced no difficulty in the training trials.

4.3. Procedure

Children were introduced to the task as a game. They were told the experimenter was going to ask them to 'find some things,' and they would have to listen carefully to see if they could find what the experimenter was talking about. After the two training trials with the familiar words

(*horse*, *spoon*), the experimenter transitioned to the test session with the six target trials. The experimenter told the child that this time, they might not recognize some of the words, but they could still try their best to figure out what the experimenter was talking about.

Each trial had the same structure. During the blank screen preceding the two images, the experimenter repeated two assertions about the target image (e.g., *Look! The mot is friendly. The mot is friendly.*). The trial then preceded to the two images, and the experimenter directed the child to make a choice (e.g., *Can you find the mot? Point to the mot!*). The experimenter recorded the child's choice as it was made by circling L or R on a response sheet.

4.4. Results

Children averaged 55% correct, which was no different than chance ($t(59) = .77$, $p = .44$, $SD = .5$). The distribution of children's responses is presented in Table 1.

Table 1. Distribution of children's responses in Experiment 3

proportion animate referent selection	number of children
<.5	3
=.5	2
>.5	5

4.5. Discussion

The results of Experiment 2 had raised the possibility that 36-month-olds did not succeed in the task either because of the time pressures of the task or that the looking time data masked their abilities, because their selection was fleeting and did not persist beyond a brief look to the animate referent. To test these hypotheses, we adapted the task to remove the time pressure and allowed children to indicate their selection by ostension. However, these manipulations revealed no greater success, as children patterned at chance in the forced-choice pointing task. Thus, while children can recruit the animacy selectional restrictions of familiar verbs to select a

referent for a novel noun even before two years of age, they ostensibly cannot do so with familiar adjectives, even at three years. In the next section, we discuss possible reasons for this disparity and the consequences for word learning.

5. General Discussion

A central question in language acquisition concerns the informational resources that are available for mapping an interpretation onto a novel phonological form. Simply put, how does a child learn the meaning of words? A prime source of information is the semantic representation of co-occurring words, and in particular, words that carry selectional restrictions on the other lexical items with which they compose. Previous work by Ferguson, Graf, & Waxman (2014, 2018) has shown that infants as young as 19 months of age can recruit the animacy restrictions of a known verb to identify an animate referent for a novel noun that occupies its subject argument (e.g., *The dax is eating*). Equipped with these findings, we conducted a set of experiments with children at the oldest age they tested (24 months) to determine whether a parallel process holds for adjectives that carry similar selectional constraints and that are presented in the same utterance-final position (e.g., *The dax is hungry*). What we found, however, was even at 36 months of age, young children do not successfully recruit the lexical semantic information encoded in adjectives, as they do with verbs. Thus, where children are called upon to recruit known words to learn a new noun, verbs are privileged over adjectives.

Why do we observe such a stark difference in the potency of verbs and adjectives in this aspect of language acquisition? What exactly is it about the linguistic stimuli with verbs that successfully constrains the search for the intended nominal referent? Here, we entertain two hypotheses.

The first hypothesis focuses on surface-level morphosyntactic cues that provide information about semantic meaning. In our linguistic stimuli, the verb and the adjective both appear in the same utterance-final position following *is*, but the syntactic representation is not the same. In the verb version, *The dax is eating*, the child is presented with an auxiliary verb heading a VP with inflectional morphology indicating present progressive aspect. By contrast, in the adjective version, *The dax is hungry*, the child is presented with a copular verb followed by a predicate. This difference may carry an important consequence. The verbal version signals that a durative event is currently unfolding. Thus, the morphosyntactic information in the verb condition, presented first in the Dialogue phase, may be a call to attention to inspect the visual stimuli in the Test phase for an event participant (the dax) who could be the agent of this ongoing event (see Syrett, Arunachalam, & Waxman (2014) and Arunachalam, Syrett, & Chen (2016) for related discussion concerning the role of adverbial VP modifiers). In contrast, a verb presented without present progressive aspect (e.g., *The dax [ate/will eat] a carrot.*) might yield weaker inferences about the meaning of the novel noun. In this way, the surface-level morphosyntactic cues are actually a bootstrap into semantic meaning – a finding consistent with a wide range of syntactic bootstrapping since Brown (1957) (see also, Fisher (1996), Gleitman (1990), Landau & Gleitman (1985), Lukynenko & Fisher (2014); Naigles (1990), a.m.o.). Thus, in English, verbs may be inherently privileged over adjectives, which do not host informative morphology.

Now, while adjectives may not host aspectual morphology as verbs do, in languages outside of English, they can host other morphological information such as grammatical gender and number marking. One might hypothesize that if one moves away from a language such as English to one like French or Spanish, in which adjectives host such morphological information, children could perhaps successfully use this kind of morphological information to identify the

referent of a novel noun. Given independent evidence that children at 36 months of age can rapidly recruit such morphosyntactic information, exploring this possibility seems like a promising line of future research. (See e.g., van Heugten & Christophe (2015); Kouider et al. (2006); Lew-Williams & Fernald (2007); Wood, Kouider, & Carey (2009), a.o.). However, if they continue to fail in these languages, this would be consistent with the hypothesis that there is indeed something special about the kind of event-relevant (aspectual) information verbs denote.

The second hypothesis concerns the truth conditions of the proposition expressed by the utterance and how they align with the visual scene (i.e., the discourse context). When one hears a speaker say, *The dax is eating*, the listener is faced with resolving the question as to whether this assertion is true and should enter the common ground. The way in which to make this determination is to inspect the context at hand: is the dax (or something agentive that could serve as the dax) eating? In our paradigm, this inspection followed presentation of the linguistic stimuli, which requires holding the representation in working memory. This would not seem to be the issue in and of itself, but the listener's expectations and subsequent search upon hearing either the verbal or adjectival form of the stimulus is quite different. In the verb version, the child must be prepared to inspect the scene for perceptible attributes of an agent engaged in an eating event. In the adjective version, there is not necessarily a perceptual cue that could be a reliable indicator about the mental or psychological state of the agent. One can be hungry, sad, or tired without a stable visible manifestation of this state, and whatever manifestations there are could vary across kinds. This difference gives rise to the hypothesis that if instead of verbs like *eat* or *cry*, children at 24 or 36 months of age were presented with propositional attitude verbs like *think*, *want*, or *believe*, they would struggle in a similar way as they did with adjectives (Hacquard & Lidz, 2018; Harrigan Hacquard, & Lidz, 2018; Papafragou, Cassidy, & Gleitman,

2007), especially given the challenges faced by children at this age in tasks that tap into theory of mind (see e.g., de Villiers (2005) and Wimmer & Perner (1983), a.o.). Exploring the range of known verbs for which this paradigm works or does not has the potential to uncover exciting details about the representation of lexical semantic knowledge in the child's developing lexicon and the influence of this knowledge as the child acquires new words.

A goal of future work will be to examine these two hypotheses experimentally. But whichever best accounts for the contrast between verbs and adjectives in this task (and they are not necessarily mutually exclusive), the current research has two even broader impacts. First, it raises the question of the nature of the semantic representation children have assigned to words that they already comprehend and produce, and the expectations about language and the world that arise as a result of these representations. And second, this new work opens the door for a richer discussion about the consequences of building up a lexicon with distinct grammatical categories, and how the semantic representations within and across these categories influence and interact with other semantic, structural, and conceptual information to guide the child's word learning process, beginning with the words that co-occur with them in the same utterance.

References

Altmann, Gerry T.M., & Kamide, Yuki. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition*, *73*(3), 247-264.

Arunachalam, Sudha, Syrett, Kristen, & Chen, Yonxiang. (2016). Lexical disambiguation in verb learning: Evidence from the intransitive frame in English and Mandarin Chinese. *Frontiers in Psychology (Language Sciences)*, *7,* 1-14.

Arunachalam, Sudha, & Waxman, Sandra R. (2010). Meaning from syntax: Evidence from 2-

year-olds. Cognition, *114*(3), 442-446.

Boland, Julie E. (2005). Visual arguments. *Cognition*, *95*, 237-274.

Borovsky, Arielle, & Creel, Sarah C. (2014). Children and adults integrate talker and verb information in online processing. *Developmental Psychology*, *50*(5), 1600-1613.

Borovsky, Arielle, Elman, Jeffrey L., & Fernald, Anne. (2012). Knowing a lot for one's age: Vocabulary skill and not age is associated with anticipatory incremental sentence interpretation in children and adults. *Journal of Experimental Child Psychology*, *112*(4), 417-436.

Brown, Roger W. (1957). Linguistic determinism and the part of speech. *The Journal of Abnormal and Social Psychology*, *55*(1), 1-5.

Chomsky, Noam. (1957). *Syntactic structures*. Berlin: Mouton & Co.

Chomsky, Noam. (1965). *Aspects of the theory of syntax*. Cambridge: MIT Press.

Dale, Philip S., & Fenson, Larry. (1996). Lexical development norms for young children. *Behavioral Research Methods, Instruments, & Computers*, *28*(1), 125-127.

de Villiers, Jill G. (2005). Can language acquisition give children a point of view? In J. Astington and J. Baird (Eds.), *Why language matters for theory of mind* (pp. 186-219). New York, NY: Oxford University Press.

Dink, Jacob W., & Ferguson, Brock. (2015). eyetrackingR: An R package for eye-tracking data analysis. Retrieved from http://www.eyetracking-r.com

Eberhard, Kathleen, Spivey-Knowlton, Michael J., Sedivy, Julie C., Tanenhaus, & Michael K. (1995). Eye movements as a window into spoken language comprehension in natural contexts. *Journal of Psycholinguistic Research*, *24*(6), 409-436.

Fenson, Larry, Marchman, Virginia A., Thal, Donna J., Dale, Philip S., & Reznick, J. Steven.

(2007). *The MacArthur Communicative Development Inventories: User's guide and technical manual*. Baltimore, MD: Brookes.

Ferguson, Brock, Graf, Eileen, & Waxman, Sandra R. (2014). Infants use known verbs to learn novel nouns: Evidence from 15- and 19-month-olds. *Cognition*, *131*(1), 139-146.

Ferguson, Brock, Graf, Eileen, & Waxman, Sandra R. (2018). When veps cry: Two-year-olds efficiently learn novel words from linguistic contexts alone. Language Learning and Development, *14*(1), 1-12.

Fernald, Anne, Thorpe, Kirsten, & Marchman, Virginia A. (2010). Blue car, red car: Developing efficiency in online interpretation of adjective–noun phrases. *Cognitive psychology*, *60*(3), 190-217.

Fernald, Anne, Zangl, Renate, Portillo, Ana L., & Marchman, Virginia A. (2008). Looking while listening: Using eye movements to monitor spoken language. In Irena A. Sekerina, Eva M. Fernández, & Harald Clahsen (Eds.), *Developmental psycholinguistics: On-line methods in children's language processing* (pp. 97-135). Amsterdam: John Benjamins.

Fisher, Cynthia. (1996). Structural limits on verb mapping: The role of analogy in children's interpretations of sentences. *Cognitive Psychology*, *31*(12), 41-81.

Gleitman, Lila R. (1990). The structural sources of verb meaning. *Language acquisition*, *1*(1), 3-55.

Goodman, Judith C., McDonough, Laraine, & Brown, Natasha B. (2008). The role of semantic context and memory in the acquisition of novel nouns. *Child Development*, *69*(5), 1330-1344.

Grimshaw, Jane. (1979). Complement selection and the lexicon. *Linguistic Inquiry*, *10*(2), 279-326.

Hacquard, Valentine, & Jeffrey Lidz. (2018). Children's Attitude Problems: Bootstrapping verb meaning from syntax and pragmatics. *Mind and Language*, *33*(3), 1-18.

Harrigan, Kaitlyn, Valentine Hacquard, & Jeffrey Lidz. (2018). Three-year-olds' understanding of desire reports is robust to conflict. *Frontiers in Psychology*, *9*, 119.

van Heugten, Marieke, & Christophe, Anne. (2015). Infants' acquisition of grammatical gender dependencies. *Infancy*, *20*(6), 675-683.

Jackendoff, Ray S. (1990). *Semantic structures*. Cambridge: MIT Press.

Jackendoff, Ray S. (1997). Twistin' the night away. *Language*, *73*(3), 534-559.

Kamide, Yuki, Altmann, Gerry T., & Haywood, Sarah L. (2003). The time-course of prediction in incremental sentence processing: Evidence from anticipatory eye movements. *Journal of Memory and Language*, *49*(1), 133-156.

Kouider, Sid, Halberda, Justin, Wood, Justin, & Carey, Susan. (2006). Acquisition of English number marking: The singular-plural distinction. *Language Learning and Development, 2(1),* 1-25.

Kuznetsova, Alexandra, Brockhoff, Per B., & Christensen, Rune Haubo Bojesan. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13), 1-26.

Landau, Barbara, & Gleitman, Lila R. (1985). *Language and experience: Evidence from the blind child*. Cambridge: Harvard University Press.

Levin, Beth, & Rappaport Hovav, Malka. (1991). Wiping the slate clean: A lexical semantic exploration. *Cognition*, *41*(1-3), 123-151.

Lew-Williams, Casey, & Fernald, Anne. (2007). Young children learning Spanish make rapid use of grammatical gender in spoken word recognition. *Psychological Science*, *18*(3),

193-198.

Lukynenko, Cynthia, & Fisher, Cynthia. (2014). 30-month-olds use verb agreement features in online sentence processing. In W. Orman & M.J. Valleau (Eds.), *Proceedings of the 38th annual Boston University Conference on Language Development* (pp. 292-305). Somerville, MA: Cascadilla Press.

Mani, Nivedita, & Huettig, Falk. (2012). Prediction during language processing is a piece of cake—But only for skilled producers. *Journal of Experimental Psychology: Human Perception and Performance*, *38*(4), 843-847.

Naigles, Letitia. (1990). Children use syntax to learn verb meaning. *Journal of Child Language*, *17*(2). 357-374.

Papafragou, Anna, Kimberly Cassidy, and Lila Gleitman. (2007). When we think about thinking: The acquisition of belief verbs. *Cognition*, *105*(1), 125-165.

Pinker, Steven. (1989). *Learnability and cognition: The acquisition of argument structure*. Cambridge: MIT Press.

Pinker, Steven. (1994). How could a child use verb syntax to learn verb semantics? *Lingua*, *92*(1), 377-410.

Prasada, Sandeep. (1992). *Acquisition of adjective meanings: A lexical semantic approach*. Doctoral dissertation, MIT.

R Development Core Team. (2012). R: A language and environment for statistical computing. Vienna, AU: R Foundation for Statistical Computing. Retrieved from http://www.r-project.org

Rappaport Hovav, Malka, & Levin, Beth. (2001). An event structure account of English resultatives. *Language*, *77*(4), 766-797.

Resnik, Philip. (1996). Selectional constraints: An information-theoretic model and its computational realization. *Cognition*, *61*(1), 127-159.

Sandhofer, Catherine M., & Smith, Linda B. (1999). Learning color words involves learning a system of mappings. *Developmental Psychology*, *35*(3), 668-679.

Sedivy, Julie C., Tanenhaus, Michael K., Chambers, Craig G., & Carlson, Gregory N. (1999). Achieving incremental semantic interpretation through contextual representation. *Cognition*, *71*, 109-147.

Soja, Nancy N. (1994). Young children's concept of color and its relation to the acquisition of color words. *Child Development*, *65*(3), 918-937.

Syrett, Kristen. (2007). *Learning about the structure of scales: Adverbial modification and the acquisition of the semantics of gradable adjectives*. Doctoral dissertation, Northwestern University.

Syrett, Kristen. (2015). Mapping properties to individuals in language acquisition. In Elizabeth Grillo and Kyle Jepson (Eds.), *Proceedings of the 39th Annual Boston University Conference on Language Development* (pp. 398-410). Somerville, MA: Cascadilla Press.

Syrett, Kristen, Arunachalam, Sudha, & Waxman, Sandra R. (2014). Slowly but surely: Adverbs support verb learning in 2-year-olds. *Language Learning and Development*, *10*(3), 263-278.

Syrett, Kristen, & Lidz, Jeffrey. (2010). 30-month-olds use the distribution and meaning of adverbs to interpret novel adjectives. *Language Learning and Development*, *6*(4), 258-282.

Tanenhaus, Michael K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, Julie C. (1995). Integration of visual and linguistic information in spoken language comprehension.

Science, *268*(5217), 1632-1634.

Thorpe, Kirsten, Baumgartner, Heidi, & Fernald, Anne. (2006). Children's developing ability to interpret adjective-noun combinations. In David Bamman, Tatiana Magnitskaia, and Colleen Zaller (Eds.), *Proceedings of the 30th Annual Boston-University Conference on Language Development* (pp. 631-642). Somerville, MA: Cascadilla Press.

Tomasello, Michael. (2001). Perceiving intentions and learning words in the second year of life. *Language acquisition and conceptual development*, (3), 132-158.

Valian, Virginia, Prasada, Sandeep, & Scarpa, Jodi. (2006). Direct object predictability: effects on young children's imitation of sentences. *Journal of Child Language*, *33*, 247-269.

Van Valin Jr., Robert D. (1990). Semantic parameters of split intransitivity. *Language*, *66*(2), 221-260.

Wagner, Katie, Jergens, Jill, & Barner, David. (2018). Partial color word comprehension precedes production. *Language Learning and Development*, *14*(4), 241-261.

Wimmer, Heinz, & Josef Perner. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, *13*, 103-128.

Wood, Justin, Kouider, Sid, & Carey, Susan. (2009). Acquisition of singular-plural morphology. *Developmental Psychology, 45*(1), 202-206.

Yuan, Sylvia, & Fisher, Cynthia. (2009). "Really? He blicked the cat?": Two-year-olds learn distributional facts about verbs in the absence of a referential context. *Psychological Science*, *20*(5), 619-626.

Yuan, Sylvia, Fisher, Cynthia, Kandhadai, Padmapriya, & Fernald, Anne. (2011). You can stipe the pig and nerk the fork: Learning to use verbs to predict nouns. In Nick Danis, Kate

Mesh, and Hyunsuk Sung (Eds.), *Proceedings of the 35th Annual Boston University conference on language development* (pp. 665-677). Somerville, MA: Cascadilla Press.