English-learning preschoolers can correctly parse and interpret negative sentences to guide their interpretations of novel noun and verb meanings

Alex A de Carvalho, Victor Gomes, John Trueswell

▶ **To cite this version:**

Alex A de Carvalho, Victor Gomes, John Trueswell. English-learning preschoolers can correctly parse and interpret negative sentences to guide their interpretations of novel noun and verb meanings. Language Acquisition, In press. halshs-03814811

HAL Id: halshs-03814811
https://shs.hal.science/halshs-03814811

Submitted on 14 Oct 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

English-learning preschoolers can correctly parse and interpret negative sentences to guide their interpretations of novel noun and verb meanings.

Journal:	*Language Acquisition*
Manuscript ID	HLAC-2021-09-A-0070.R2
Manuscript Type:	Article
Keywords:	Negation, Word Learning, Processing, Syntax

SCHOLARONE™
Manuscripts

English-learning preschoolers can correctly parse and interpret negative sentences to guide their interpretations of novel noun and verb meanings.

Alex de Carvalho [a*], Victor Gomes [b] and John Trueswell [b]

alex.de-carvalho@u-paris.fr; vgomes@sas.upenn.edu; trueswel@psych.upenn.edu

a. Laboratoire de Psychologie du Développement et de l'Éducation de l'Enfant - LaPsyDÉ, La Sorbonne, Université Paris Cité, CNRS, Paris, France

b. Department of Psychology, University of Pennsylvania, PA, USA

* *Corresponding author*: correspondence concerning this article should be addressed to Alex de Carvalho, Email: alex.de-carvalho@u-paris.fr; Address: LaPsyDÉ - La Sorbonne, 46 rue Saint-Jacques (escalier A, 4ème étage), 75005 Paris, France.

Pre-print version. To appear in Language Acquisition

Funding information

This project has received financial support from the CNRS through the MITI interdisciplinary programs award to Alex de Carvalho. It was also supported by a Fyssen Foundation Research Grant award to Alex de Carvalho, (grant Eotp RH03J20AFO04_ EDENFCOGN°H03R8240) and by grants from the University of Pennsylvania Research Foundation (URF) award to Alex de Carvalho and John Trueswell and from the National Institute of Child Health and Human Development (grant R01HD37507) award to John Trueswell.

Acknowledgements

We thank all the bright "actors" who participated in the videos illustrating actions in Experiment 1 and specially Marianna Olave and Abigail Marcus for performing so well in the dialogue videos. Special thanks to Abigail Laver for acting so beautifully in the teaching videos of Experiment 2. We also would like to thank Yiyi (Yelina) Chen and Bosede Ajiboye who assisted us in the recording of these videos and with recruitment and testing of participants, and Abigail Marcus who also assisted us in programing Experiment 1. We are also extremely grateful to Cindy Fisher for sharing and allowing us to use the videos of actions used in the test trials of Experiment 1. We also thank Sandy Waxman and Alexander LaTourrette for sharing the stimuli of Havy and Waxman (2016) for Experiment 2. We also thank Isabelle Dautriche for her thoughtful comments and suggestions for Experiment 2.

Declaration of Conflicting Interests

The authors declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Abstract

We studied English-learning children's ability to learn the meanings of novel words from sentences containing truth-functional negation (Exp1) and to use the semantics of negation to inform word meaning (Exp2). In Exp1, 22-month-olds (n=21) heard dialogues introducing a novel verb in either negative-transitive ("*Mary didn't blick the baby*") or negative-intransitive ("*Mary didn't blick*") sentences. When then asked to "Find blicking!" while viewing two-participant vs. one-participant actions, children who heard negative-transitive sentences looked longer at the two-participant event than children who heard negative-intransitives. Thus, the mere presence of negation does not disrupt sentence processing and word learning in young children. Experiment 2 tested whether 2-to-4-year-olds (n=20) use the semantics of negation to restrict the meaning of novel nouns when categorizing objects varying along a perceptual continuum (from 10% to 90% exemplars). Children initially heard "*These are blickets*" paired with certain exemplars (e.g., yellowish creatures, exemplars 10% and 30%). They then saw additional exemplars (e.g., pinkish creatures, 70% and 90%) while hearing either "*These are not blickets*" (negative condition) or "*These are also blickets*" (affirmative condition). At test, when seeing two novel exemplars from the continuum (e.g., creatures 20% and 80%) and asked to find "a blicket," children in the negative condition selected the exemplar from the bottom of the continuum (i.e., the 20%) more often than children in the affirmative condition. Thus English-learning children as young as 22-months of age correctly parse negative sentences and 2-to-4-year-olds can use negation to understand the boundaries of a word's meaning.

Keywords: language acquisition, negation understanding, syntactic bootstrapping, word-learning, categorization, category learning, perceptual continua, lexical development, conceptual development.

English-learning preschoolers can correctly parse and interpret negative sentences to guide their interpretations of novel noun and verb meanings.

Introduction

Decades of research in language acquisition indicate that well before their second birthday, infants exploit the local linguistic context instantiated by syntactic and semantic evidence to infer the meaning of novel words, often in surprisingly sophisticated ways (see e.g., Fisher, 1996; Fisher, Jin, & Scott, 2020; Gillette, Gleitman, Gleitman, & Lederer, 1999; Gleitman, 1990; Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005; Landau & Gleitman, 1985; Naigles, 1990). Toddlers, ages one-and-a-half years and up, can use the syntax of a sentence to infer the meaning of a novel verb in that sentence (e.g., Arunachalam & Waxman, 2010; Dautriche et al., 2014; de Carvalho, Dautriche, Fiévet, & Christophe, 2021; Naigles, 1990; Yuan & Fisher, 2009) and can make inferences about novel word meanings based on the semantic information carried by words they already know (e.g., Ferguson, Graf, & Waxman, 2014, 2018; Syrett, LaTourrette, Ferguson, & Waxman, 2019). This application of sentence meaning to word meaning requires toddlers to correctly parse and interpret utterances, most likely in real-time (see e.g., de Carvalho, Babineau, Trueswell, Waxman, & Christophe, 2019; Lew-Williams & Fernald, 2010; Trueswell, Sekerina, Hill, & Logrip, 1999). It is thus surprising that children's understanding of a common combinatory element, the negation functor "not" has been found to be delayed, with English-learning 20-month-olds incorrectly interpreting negative sentences as affirmatives (Austin, Theakston, Lieven, & Tomasello, 2014; Feiman, Mody, Sanborn, & Carey, 2017) and even 2-to-5-year-olds showing difficulty understanding negative sentences in certain tasks (e.g., Austin et al., 2014; Doyle, Friesen, Reimer, & Pexman,

2019; Feiman et al., 2017; Grigoroglou, Chan, & Ganea, 2019; Kim, 1985; Nordmeyer & Frank, 2014, 2018; Pozzan et al., 2019; Reuter, Feiman, & Snedeker, 2018). This is surprising because parents commonly use negation in some labeling events ("That's not a stone!") presumably in an effort to restrict and/or correct semantic generalizations (see e.g., Cameron-Faulkner, Lieven, & Theakston, 2007; Jasbi, McDermott-Hinman, Davidson, & Carey, 2020). However, if children treat negative labeling as affirmative, parents' attempts would be thwarted because "That's not a stone" would convey that it is. Alternatively, if children are simply unable to process sentences containing negation, they should learn little or nothing about word meaning from negative sentences.

The goal of the present work is therefore to investigate whether young children can learn novel word meanings (i.e., verbs and nouns) uttered in negative sentences. In light of previous studies showing that children fail to understand negative sentences around age two, we hope to ascertain whether the presence of negation in a sentence disrupts the mechanism that children use to learn novel noun and verb meanings. Do children in this age range make any commitment to word learning when sentences are negated? Or rather, do they fail to learn word meanings (i.e., behaving at chance and showing confusion) when processing any kind of negative sentence simply because they don't know how to integrate the meaning of the negation functor "not" to compute the ultimate meaning of the sentence? In Experiment 1, we will investigate whether 2-year-olds can still learn aspects of novel verb meanings, namely subcategorization information (i.e., whether a novel verb refers to a causal action between two participants or to a single action performed solo), when they process negative sentences. In Experiment 2, we will go a step further and investigate whether 2-to-4-year-olds can directly use the semantic information provided by negative sentences to restrict the meaning of novel nouns in a categorization task.

Before we present our study details, we review the literature on the acquisition of negation and discuss the challenges negation may present to young language learners. We also review recent attempts to investigate whether young children can use negative sentences to learn word meanings.

The importance of negative sentences for language acquisition

Negation is a universal and abstract component of human reasoning and language and, as such, it is not only of great interest for understanding the relationship between cognitive and language development (e.g., Bloom, 1970; Déprez & Espinal, 2020) but also raises interesting questions for language acquisition research (see e.g., Feiman, 2015; Feiman et al., 2017; Hochmann, 2020; Thornton, 2020). As opposed to affirmative sentences such as "*This is a dog,*" from which infants could potentially associate the word "dog" to a given animal in their environment, the presence of a negative functor such as "not" in sentences like "*This is not a dog*" reverses the truth-value and makes the connections between words and their meanings much more complex to infer than in affirmative sentences. Note for instance that the sentence "This is not a dog" can refer to anything in the world, except a dog.

Understanding negative sentences, although challenging, could be crucial for language acquisition because it might provide infants a tool to constrain a word's meaning, by learning what a word does or does not refer to. For example, if, in the presence of a cat, children start incorrectly calling it "a dog" (perhaps because they believe if refers to small mammals or pets generally) and their caregivers say: "*That's not a dog! It's a cat*," children could use negation to narrow down their interpretation of what "dog" means. Thus, understanding negative sentences might be crucial for language development since it would allow infants in some cases to guide and refine word meanings. However, parsing strategies in young children might be challenged

when sentences contain a logical operator that can substantially change the meaning of sentences. In adults, for instance, negation can be challenging to process in some circumstances, with adults often interpreting negative sentences less accurately and more slowly than affirmatives (Carpenter & Just, 1975; Clark & Chase, 1972; Just & Carpenter, 1971; Kaup, Dudschig, Kaup, & Dudschig, 2020; Kaup, Lüdtke, & Zwaan, 2006; Kaup, Yaxley, Madden, Zwaan, & Lüdtke, 2007; Lüdtke, Friedrich, De Filippis, & Kaup, 2008; Noveck, Petit, Tian, & Turco, 2021; Staab, Urbach, & Kutas, 2009; but see also: Papeo, Hochmann, & Battelli, 2016; Papeo, de Vega, Papeo, & de Vega, 2020; Tian, Breheny, & Ferguson, 2010; Kronmüller, Noveck, Rivera, Jaume-Guazzini, & Barr, 2017).

The acquisition of negation

Previous developmental research has established that before their first birthday, infants are already capable of building negated nonlinguistic representations (Hochmann & Toro, 2021) and begin producing negation in their own speech around 13 months old (e.g., Bloom, 1970; Choi, 1988; Pea, 1980, 1982). However, recent research has found that the interpretation of negative sentences can be particularly difficult for children, as they fail to understand the meaning of negative sentences before the age of 27 months (Austin et al., 2014; Feiman et al., 2017; Loder, 2006; Nordmeyer & Frank, 2014) and that even 2-to-5-year-olds have difficulty understanding negative sentences in some tasks (Austin et al., 2014; Doyle et al., 2019; Feiman et al., 2017; Grigoroglou et al., 2019; Kim, 1985; Koring, Meroni, & Moscati, 2018; Moscati, 2020; Nordmeyer & Frank, 2018, 2014; Pozzan et al., 2019; *but see also*: Arvindam, Tulling, & Cournane, 2020; de Carvalho, Crimon, Barrault, Trueswell, & Christophe, 2021; Reuter et al., 2018).

In Austin et al., (2014) and in Feiman et al., (2017), for instance, children from three age groups (20-, 24- and 27-month-olds) had to find an object that was hidden either in a bucket or a toy house by a first experimenter. To help them, a second experimenter (or the participant's caregiver in Feiman et al., 2017) asked about the location of the object ("*Is it in this house?*" or "*Is it in this bucket?*") to the experimenter who had hidden the object. The first experimenter replied either with an affirmative, such as "*It is in this house*" or with a negative, "*It's not in this bucket.*" Participants were then asked to find the hidden object. While the 27-month-olds found the hidden object in the correct place after listening to either the affirmative or negative sentence in both studies, 24-month-olds did not: in Austin et al., 24-month-olds searched in the correct place only in response to negative sentences, while in Feiman et al., 24-month-olds succeeded with affirmatives but performed at chance with negatives. The 20-month-old group, performed around chance in Austin et al., (2014) and did not distinguish between affirmatives and negatives in Feiman et al., (2017).

These failures of the youngest groups suggest that before 27 months, infants are unable to understand negative sentences. However, little is known about the specific difficulties children faced when comprehending negative sentences in these experiments. On the one hand, it is possible that the presence of "not" entirely disrupted language processing because the children simply didn't know how to integrate the meaning of the logical operator "not" to reverse the truth-value of a sentence. This uncertainty/confusion therefore would result in children being at chance when interpreting negative sentences in certain tasks. On the other hand, it is possible that the children simply imposed a partial representation on something they didn't correctly parse (see e.g., Gagliardi, Mease, & Lidz, 2016; Gertner & Fisher, 2012; Perkins, Feldman, & Lidz, 2022; Perkins & Lidz, 2020), ignoring the presence of the negative functor and processing

negative sentences as affirmatives (e.g., "It's ~~not~~ in this bucket"), which would be consistent with the fact that children did not consistently distinguish between affirmative and negative sentences.

Factors affecting the comprehension of negative sentences in young children

Despite these previous 'negative' results, we find it unlikely that infants are unable to understand negation before 27 months, because parents commonly use negation when talking to young children (see e.g., Cameron-Faulkner, Lieven, & Theakston, 2007; Jasbi, McDermott-Hinman, Davidson, & Carey, 2020) and, crucially, children produce negation in their own speech from 13 months onwards under seemingly appropriate contexts (e.g., Bloom, 1970; Choi, 1988; Pea, 1980, 1982). A more plausible explanation for young children's difficulty with the comprehension of negative sentences may be that they lack the processing skills necessary to succeed in the tasks mentioned above, especially those skills that require executive function abilities. Note that when children heard negative sentences in the above-mentioned experiments, they had to inhibit their first action. For example, in order to successfully go search for the hidden object in the "non-named" container (e.g., *the house* when hearing "It's not in the bucket") children had to inhibit their attention to the "named" container (e.g. *the bucket*). Thus it is possible that the task used in these studies are too complex for younger children, who do not yet possess the inhibitory abilities required to succeed (see e.g., Cepeda & Munakata, 2007; Diamond, 2013; Lagattuta, Sayfan, & Monsour, 2011; Ramscar, Dye, Gustafson, & Klein, 2013; Wright, Waterman, Prescott, & Murdoch-Eaton, 2003; Zelazo et al., 2003).

Consistent with this hypothesis, Nordmeyer and Frank (2014) showed that even 2- to 5-year-olds experience difficulties correctly processing negative sentences, in contexts that seem to require inhibitory abilities. Children were asked to "*Look at the boy who has no apples*"

(negative condition) or "Look at the boy who has apples" (affirmative condition) while seeing a boy with two apples on one side of the screen, and another boy with two boxes on the other side of the screen. When processing negative sentences, 3- to 5-year-olds were able to correctly look toward the image of the boy without apples whereas 2-to-3-year-olds interpreted negative sentences as if they were affirmative, preferring the boy with apples regardless of condition. It was argued that young children struggled because the negative sentences required them to refrain from looking at the boy who has apples, while entertaining a proposition with the concept *apple* in their working-memory. Additionally, children had to deal with the ability to switch between the strategy that they used in response to an affirmative sentence (i.e., looking at the named object) and the strategy they had to apply in response to negative sentences (i.e., refrain from looking at the named object). Note that switching responses introduces conflict demands that are difficult for young children in general, even in non-linguistic tasks (e.g., Cepeda & Munakata, 2007; Diamond, 2013; Lagattuta, Sayfan, & Monsour, 2011; Ramscar, Dye, Gustafson, & Klein, 2013; Wright, Waterman, Prescott, & Murdoch-Eaton, 2003; Zelazo et al., 2003).

Moreover, Nordmeyer and Frank (2014, 2018) argued that fine-grained pragmatic computations might also interfere with the processing of negative sentences in their experiment: in a naturalistic context, if a speaker wanted to ask someone to "*look at the boy with boxes,*" she would probably say "*Look at the boy who has boxes*" rather than "*Look at the boy who has no apples.*" Thus, the negative utterances were pragmatically infelicitous in this context: Speakers are expected to produce affirmative rather than negative sentences – unless there is a special reason for producing a negative sentence, for instance to mark a contrast with a proposition that has been uttered previously or to negate an expectation that is supposed to be entertained by the listener (Nordmeyer & Frank, 2014, 2015, 2018; see also: Horn, 2001; Déprez & Espinal, 2020;

Kaup et al., 2020; Reuter et al., 2018). Indeed, Reuter et al., (2018) found that 3-to-4-year-olds could understand negative sentences better in a pragmatically felicitous context, especially when the task had reduced switching demands.

These limitations raised above might explain why previous studies with English-learning children have found no understanding of negative sentences before 27 months and some difficulty in young children between ages two to four. It remains unclear however whether infants are really lacking any understanding of negation before 27 months and whether it is really the case that they struggle with negation until age 5. Given that many studies have attested that infants can represent and express negative concepts in their own speech well before 27 months (e.g., Bloom, 1970; Choi, 1988; Hochmann & Toro, 2021), it might be the case that what requires time to develop is not the comprehension of negation *per se*, but rather the sophisticated cognitive abilities that were required to interpret negative sentences appropriately within previous tasks, such as understanding the pragmatic structure of the experiment and dealing with inhibitory/switching skills. As a consequence, it is possible that a simpler task, reducing pragmatic and cognitive control demands, may uncover an ability to understand negation during the second and third year of life.

A recent study in French showed that under pragmatically felicitous contexts and in situations that do not seem to tax infants' inhibitory/switching skills, infants as early as 18 months seem to be able to understand the meaning of negative sentences (de Carvalho, Crimon, Barrault, Trueswell, & Christophe, 2021). A simple habituation-switch paradigm was used in which infants were first taught the meaning of two novel words in French (e.g., "bamoule" and "pirdaling"). They learned that "bamoule" meant "penguin" while they listened to sentences such as "*Look! It's a bamoule!*" and watched a video showing a penguin spinning. They learned that

"pirdaling" meant "cartwheeling", while they listened to sentences such as "*Look! It is pirdaling!*" and watched a video showing a penguin cartwheeling. At test, the associations between the sentences and the videos were switched, and negative sentences were presented: one negating the verb meaning learned during the habituation phase and the other one negating the noun meaning. Infants were surprised when they listened to negative sentences rendered false by their visual context ("*Look! It is not a bamoule!*" while they watched a video showing a penguin cartwheeling); in contrast, they were not surprised when listening to negative sentences rendered true by their context ("*Look! She is not pirdaling!*" while they watched a penguin spinning). This study provided the first evidence for the understanding of negative sentences during the second year of life, at least to the extent that 18-month-olds do not seem to process negative sentences as affirmative sentences, under pragmatically felicitous contexts and in situations that do not tax their inhibitory/switching skills.

Under the right circumstances, can children use negative sentences to learn word meanings?

A second experiment in de Carvalho et al. (2021) investigated how well 24-month-olds could exploit affirmative and negative sentences to constrain the meaning of a novel noun. In a preferential looking paradigm, French 24-month-olds were first exposed to a teaching phase in which they saw two videos showing a woman talking about a novel object/cartoon (a bamoule). In the first video (common to all children in the study), the woman "accidentally" sat in front of the television so they couldn't see the cartoon while listening to the sentences: "*Look! It's a bamoule!*" For the second video, children could see a referent being labeled by the experimenter (e.g., a blue monster). Children either heard "*It's a bamoule!*" (affirmative condition) or "*It's not a bamoule!*" (negative condition). At test, children were asked to find the bamoule while viewing

two images: the familiar object seen during the second video of the teaching phase (e.g., the blue monster) versus a novel object never seen before (e.g., a red monster). Children in the affirmative condition preferred the familiar character (i.e., they learned the familiar character was a bamoule) more than those in the negative condition (who showed no preference for either monster). Although this experiment showed that 24-month-olds do not process negative sentences as affirmatives, it does not allow us to draw strong conclusions about the use of negative sentences to constrain the acquisition of word meanings. Although we could imagine that the difference between children in the affirmative vs. negative condition suggests that toddlers in this age range successfully understood negation (i.e., they did not learn that the monster in front of them was a bamoule when hearing "*This is not a bamoule!*"), the lack of preference for the novel object during the test phase could also indicate that 24-month-olds might simply have been confused and not yet know how to process negative sentences appropriately, as was observed in the studies in English with children in this same age range. Thus, more studies are needed to investigate how children can use the semantic information provided by negative sentences not only to wipe out a potential label-referent association (as tested in de Carvalho et al., 2021) but also to find alternative referents for the meaning of the novel word. If an object is described as "not a blicket" can children find alternative referents for the meaning of that novel word?

The current study

In order to investigate how negative sentences impact the acquisition of word meanings, we selected tasks in which young children were attested to successfully learn word meanings with affirmative sentences but modified them here to include negative sentences. We examined children ages 2 to 4 years because there is evidence, as described above, that English-learning

children fail to understand negative sentences before 27 months, and that even 2-to-5-year-olds show difficulty understanding negation in certain tasks. Experiment 1 employed a common verb-learning task to test whether 2-year-olds can learn novel verb meanings when they process negative sentences. This is a straightforward test of whether negation disrupts parsing and interpretation in young children and whether this could affect their ability to learn novel word meanings. Experiment 2 employed a common noun-learning/categorization task to test the semantic application of negation and to evaluate whether 2-to-4-year-olds can use the semantic information provided by negative sentences to restrict the meaning of novel nouns that labeled novel objects.

If children can parse and interpret negative sentences as well as they do affirmative sentences, then they should be able to learn the meaning of novel words appearing within these sentences. However, if negation disrupts the sentence processing mechanisms that children use to learn novel noun and verb meanings, they would behave at chance in our tasks (as they did in previous studies). Success in our tasks would indicate that negation *per se* does not disrupt the word learning process; hence, children's at-chance behavior in previous experiments with negation might not have been caused by confusion when encountering negation, but rather by executive function/pragmatic demands imposed by these tasks, as we discussed above.

Experiment 1

To test young children's ability to learn novel verbs uttered in negative sentences, we used the dialogue preferential-looking paradigm developed by Yuan and Fisher (2009). This study showed that infants can make inferences about the meaning of novel verbs based on the type of syntactic structures in which these verbs occur. In their study, children were first exposed

to a situation in which they watched a video showing two women having a conversation and uttering a novel verb (e.g., "blicking") in either affirmative transitive frames (e.g., A: "Guess what? She blicked the baby!" B: "Really? She blicked the baby?"…) or in affirmative intransitive frames (e.g., A: "Guess what? She blicked!" B: "Really? She blicked?"…). At test, toddlers saw two videos illustrating novel actions side-by-side: one video showing a causal action between two participants and the other video showing a single participant doing a self-generated action. All participants were asked to "find blicking!" The results showed that participants who listened to the novel verb in affirmative transitive frames looked reliably more at the two-participant event than participants who listened to the affirmative intransitive sentences. The fact that children as young as 15-months can use syntax to guide verb learning in this paradigm has been replicated in many other studies, even in different languages (in *French*: Dautriche et al., 2014; de Carvalho, Dautriche, et al., 2021; in *Japanese*: Matsuo, Kita, Shinya, Wood, & Naigles, 2012; Suzuki & Kobayashi, 2017; in *Mandarin*: Arunachalam, Syrett, & Chen, 2016; and in many other studies in *English*: Arunachalam et al., 2013; Arunachalam, Escovar, Hansen, & Waxman, 2011; Arunachalam & Waxman, 2010; Gertner & Fisher, 2012; Messenger et al., 2015; Scott & Fisher, 2012; Yuan et al., 2012).

In the current study we used the same paradigm and tested whether infants from 15- to 28-months can still make inferences about a novel verb (i.e., whether "blicking" refers to a two-participant action or to a one-participant action) when they listen to negative versions of the transitive and intransitive sentences used in previous studies. For instance, the negative transitive dialogue contained sentences like: "A: "Guess what? She did not blick the baby!" B: "Really? She did not blick the baby?"…); and the negative intransitive dialogue contained sentences like "A: "Guess what? She did not blick!" B: "Really? She did not blick?"…).

We had three conditions in a between-subject design: 1) negative transitive, 2) negative intransitive, and 3) affirmative transitive (used as a control to replicate the findings observed in previous studies and allow us to directly compare performance in affirmative vs. negative sentences). We compared participants' behavior in the negative transitive sentences with their behavior in the negative intransitive sentences to investigate whether children could still learn the novel verb's transitivity (i.e., whether it refers to a causative action involving two participants or not) despite the fact that the sentences were negatives. This study will help us to rule out the explanation of the previous studies outlined in our introduction in which it was claimed that negation "confused" young children. If children can learn the meaning of novel words even when the sentences are negatives, they would not behave at chance when processing negative sentences as observed in previous studies. Rather, infants should be able to extract information about the argument structure of the verb as well as they do when the sentences are affirmatives. This would indicate that negation *per se* does not disrupt the word learning process; hence, children's at-chance behavior in previous experiments might not have been caused by confusion when encountering negation. However, on the other hand, if children fail to learn verb meaning from the syntactic contexts (i.e., transitive vs intransitive) when the sentences are negatives, this would suggest that negative sentences might disrupt the mechanism that children use to learn novel verb meanings.

Method

This study, including the method, analysis and criteria for exclusion of participants, was pre-registered on the Open Science Framework (OSF) database before running the experiment. This preregistration can be accessed with the following link: https://osf.io/9hxyp. The stimuli used,

collected data, and data analysis, are freely available to readers through the following link: https://osf.io/35j9f/?view_only=192e991b4a864710bddcec5aa82c4f0a

Participants. Twenty-one American 22-month-olds participated in the study (mean age = 21.9 months, range = 15.8 to 28.9 months; *SD* = 3.1; 11 girls), with 8 in the negative transitive condition, 6 in the negative intransitive condition and 7 in the affirmative transitive condition. They were all monolingual native English-learning speakers with less than 20% exposure to another language. An additional three infants were tested, but were not included in the final sample because of fussiness not allowing them to finish the experiment (n = 2) or because of a technical problem with the calibration procedure of the eye-tracker (n = 1). In addition, fifty-four adults (18 per condition), participated in the same test to provide us with a baseline of how children should behave in this task if they have adult-like comprehension of the experimental sentences. This research was approved by the Institutional Review Board (IRB) of the University of Pennsylvania. Adult participants were tested in the lab. Children were tested either in the lab or in daycares and preschools in the Philadelphia area. Prior to participation, written parental/adult consent was obtained using procedures approved by the University of Pennsylvania's IRB.

The number of participants to be tested was chosen on the basis of a power analysis conducted on the effect size found in previous studies using the same verb-learning paradigm (i.e., Yuan & Fisher, 2009; Yuan et al., 2012). In Yuan and Fisher (2009) Exp2-same-day with 2-year-olds (age ranged from 26 to 30 months), they tested 16 participants in the transitive condition and 16 in the intransitive condition. The effect size observed in this study was of d=1.66. We conducted a power analysis based on this effect and the result suggested that we had

to test at least 6 participants in each condition (negative transitive, negative intransitive, and affirmative transitive) in order to have an effect power of 80% and reach a significant level < 0.05. In Yuan et al. (2012) Experiment 3 with 19-month-olds (age ranged from 18 to 20 months), 12 participants were tested in the transitive condition and 12 in the intransitive condition. The effect size observed was of d=0.96. A power analysis based on this effect suggested that we should test at least 18 participants in each condition. So, in our pre-registration, we initially planned to test 18 participants in each condition, however, because of the COVID-19 pandemic we had to stop data collection before planned. We have therefore changed our plans and accepted that the study should end with the number of participants recommended by the effect size of Yuan and Fisher (2009).

Apparatus. Participants were tested individually in a sound-attenuated booth in the lab or in a quiet room in daycares/preschools. They sat facing a 23-in computer screen positioned about 70cm away from them. Participants' eye movements were recorded by an eye-tracker (Tobii TX300) placed below the screen, and operating in a remote mode with a sample collected every 8ms. When tested in the lab, infants sat on their parents' lap. The caregiver wore opaque glasses and the experimenter stayed outside the testing room (or behind participants in the preschool) during the test.

Materials and Procedure. The stimuli were videos of two women conversing (for the dialogue phases) and videos of people performing actions (for the practice or test phases). The videos of actions were accompanied by sound tracks recorded by a female native speaker of English.

The procedure was similar to that of Yuan and Fisher (2009) and was composed of three phases: practice, dialogue and test. The practice block was comprised of two practice items

involving familiar verbs to familiarize children with the task, one intransitive (i.e., to walk) and one transitive (i.e., to push). These practice items consisted of two 8s test trials in which a synchronized pair of videos was presented side-by-side on the screen along with audio tracks that encouraged infants to look at one of the videos (e.g., "*Find Walking!*" or "*Find Pushing!*", see Figure 1). Each video was first presented alone for 5 seconds on the left or the right side of the screen during an inspection period to provide participants with enough time to inspect each individually before hearing the test sentence . Right after the presentation of each video, they both disappeared and the screen remained blank for 5s while participants heard one exemplar of the test sentence (e.g., "*Hey, Watch! Walking! Can you find walking?*"). Next, the two videos reappeared side-by-side on the screen for 8s, and at the same time participants heard the test sentences repeating the target word three times (e.g., "*Find walking! Where is walking? See? Where is walking?*"; see e.g., Figure 1).

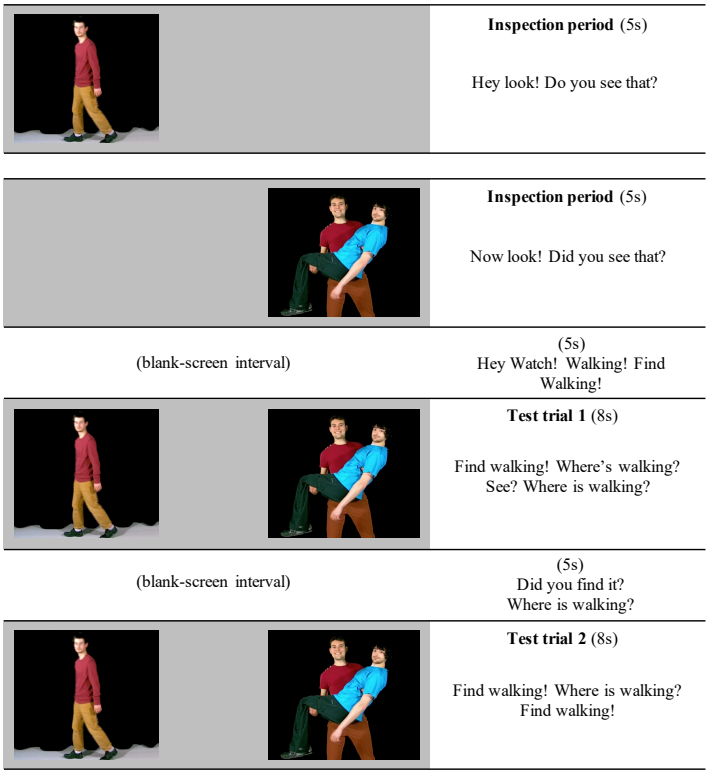

Figure 1: Time-course of one of the two practice trials of Experiment 1.

The order of items and side of presentation of the target videos were counterbalanced across participants, such that half of participants had an intransitive target verb first (i.e., to walk) and a transitive target verb second (i.e., to push) and the other half had the reverse. Within each trial, half of the participants saw the target video on the left side and the other half on the right side. After two practice trials, the dialogue phase started. Participants watched the videos of a dialogue showing two women having a conversation in child-friendly speech in which they used a novel verb (i.e., "blicking") in one of the three experimental conditions (i.e., negative transitive, negative intransitive, or affirmative transitive; see Figure 2).

Dialogue phase (3 conditions)

Negative Transitive

A: Hey! You know what? Michael is **not** gonna blick the cat!
B: Really? He's **not** gonna blick the cat?
A: And you know what else? Mary was **not** blicking the man.
B: Wow, she was **not** blicking the man.
A & B: laughing
--
A: Hey! Guess what? Sarah did **not** blick the baby!
B: Oh, she did **not** blick the baby?
A: And you know what else? Brian was **not** blicking the boy.
B: Wow, he was **not** blicking the boy.
A & B laughing

Negative Intransitive

A: Hey! You know what? Michael is **not** gonna blick!
B: Really? He's **not** gonna blick?
A: And you know what else? Mary was **not** blicking.
B: Wow, she was **not** blicking.
A & B: laughing
--
A: Hey! Guess what? Sarah did **not** blick!
B: Oh, she did **not** blick?
A: And you know what else? Brian was **not** blicking.
B: Wow, he was **not** blicking.
A & B laughing

Affirmative Transitive

A: Hey! You know what? Michael is gonna blick the cat!
B: Really? He's gonna blick the cat?
A: And you know what else? Mary was blicking the man.
B: Wow, she was blicking the man.
A & B: laughing
--
A: Hey! Guess what? Sarah blicked the baby!
B: Oh, she blicked the baby?
A: And you know what else? Brian was blicking the boy.
B: Wow, he was blicking the boy.
A & B laughing

Figure 2: Sample of dialogues in Experiment 1 for the three conditions: negative transitive, negative intransitive and affirmative transitive. The dialogues were split in two 24-s videos containing four sentences each separated by a 3-s blank screen. Negative Transitive and Affirmative Transitive conditions were composed exactly of the same words, but differed only with regards to the presence of the negative functor "not." Negative Transitive and Negative Intransitive sentences differed only with regards to the presence of a second noun phrase (i.e., the patient of the action) in the transitive sentences, but not in the intransitive sentences, reflecting therefore their different syntactic structures (i.e., transitive vs intransitive).

In the dialogue phase two four-sentence dialogue video clips of 24s separated by a 3s interval were presented in the middle of the screen. Thus, each participant was exposed to eight sentences containing the novel verb (four sentences in each video, see Figure 2, for the entire list of sentences in each condition).

Three seconds after the end of the dialogue phase, participants started the test phase presenting them with two videos illustrating two novel actions (the same test videos were used in Yuan and Fisher, 2009). One video showed an action executed by one single participant (a girl making circles with her arm) and the other video showed a causative action between two participants (a girl swinging another girl's leg, see Figure 3).

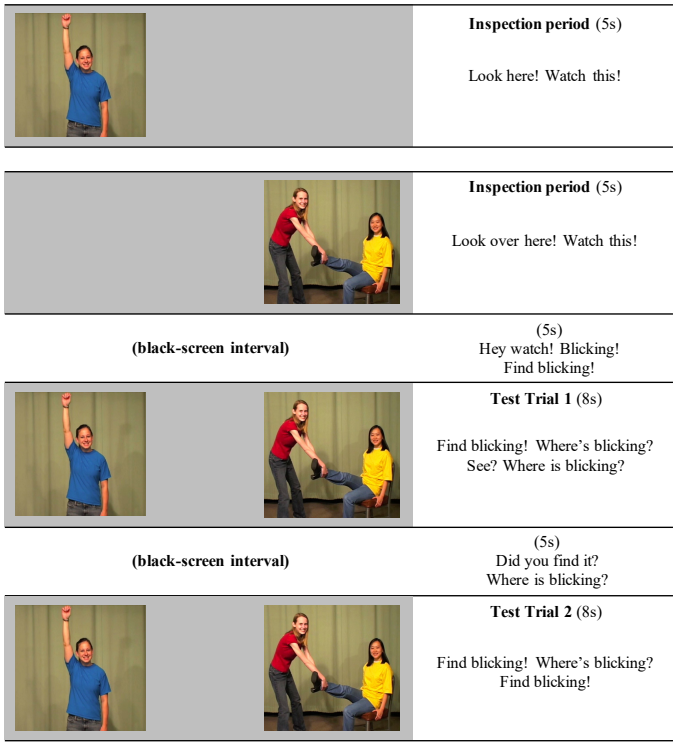

Figure 3*:* Time-course of the test phase of Experiment 1. After watching the dialogue videos, participants were presented with two novel action videos that were first individually presented in a different side of the screen for 5 seconds. Then the two videos were presented simultaneously side-by-side on the screen for 8 seconds (in each of the two test trials) and participants were asked to "Find blicking!". Figure adapted from Yuan and Fisher (2009).

During each test trial, participants heard three sentences featuring the novel verb in a neutral syntactic frame: "*Find blicking! Where is blicking? See? Where is blicking?*", while they

watched the two videos. Participants' eye-gaze towards the videos were recorded during the entire experiment. Note that the auditory stimuli in the test trials were identical for all participants.

Predicted results. If children can process the negative sentences and learn information about the novel verb, we expected the same findings as those obtained by Yuan and Fisher (2009) and Yuan, Fisher and Snedeker (2012). Children in the negative transitive condition would look significantly more to the two-participant event than children in the negative intransitive condition. This result would suggest that although the sentences were negatives, children were still able to exploit the argument structure of a novel verb to make inferences about its meaning. These results would indicate that children's failure to interpret negative sentences in previous studies cannot be explained by the hypothesis that children were confused with negation or that they stop interpreting linguistic input altogether when they encounter the negative functor "not".

To investigate whether children's efficiency in learning the novel verb through exposure to negative sentences would be comparable to their efficiency with affirmative sentences (i.e., testing whether negation does not interfere in the same sort of learning that would happen in the case of affirmation), we planned to compare participant's performance specifically in the negative transitive condition versus the affirmative transitive condition[1]. We did not necessarily

[1] We did not include an additional comparison between performance in the negative intransitive condition versus an affirmative version of these intransitive sentences, because this comparison wouldn't be very informative. According to previous studies using the same verb-learning paradigm (e.g., Arunachalam & Dennis, 2018; Arunachalam et al., 2016; Arunachalam & Waxman, 2010; Dautriche et al., 2014; de Carvalho, Dautriche, et al., 2021; Messenger et al., 2015; Yuan & Fisher, 2009; Yuan et al., 2012), when children interpret the novel verb as intransitive and therefore infer that the verb's meaning involves one participant role, they tend to show no preference for any of the events at test because the intransitive verb could refer either to the one-participant event or to a subcomponent of the two-participant event (Fernandes, Marcus, Di Nubila, & Vouloumanos, 2006; Fisher, 2002; Yuan & Fisher, 2009). So, the negative intransitive and the affirmative intransitive conditions could give rise to exactly the same pattern of results (i.e., performance around chance) but not for the same reasons. In this case, it would be unclear if children performed around chance (i.e., showing no preference for the two-participant event) because they were confused by negation or if they correctly understood the sentence but were unable to decide whether the verb referred specifically to the one-

expect to observe a significant difference between these two conditions because in both cases the sentences are transitives and they both contain two noun phrases (which seems to be the crucial cue that children use to decide whether the novel verb is more likely to refer to a one or two participant action). Thus, no difference between the affirmative transitive and negative transitive conditions would suggest that, at least for the purpose of learning argument structure of novel verbs, children learn as well from transitive affirmative sentences as they do from negative transitive sentences. However, if the presence of negation makes word learning more difficult for young children (or even disrupts it), it is possible that we would observe better performance (i.e., more looks to the two participant action at test) in the affirmative transitive condition than in the negative transitive condition. In other words, if children are better at mapping the novel verb in the affirmative transitive condition to the two-participant action than in the negative transitive condition, this would suggest that the negative sentences might be harder for young children to learn subcategorization information than affirmatives.

Another pattern of results that we could observe in the current experiment is that no significant difference will be found between the negative transitive and the negative intransitive conditions, which would indicate that we fail to replicate the pattern observed in the previous studies with affirmative sentences. For instance, maybe because the novel verb has been negated "*She did not blick the baby*" or "*She did not blick*", participants could be less sure about whether or not these verbs are really transitive or intransitive. That is, in the presence of uncertainty arising from a linguistic element they do not understand, the most reasonable thing could be to not assume anything about the meaning of the verb in these contexts. If this is the case and we

participant event or to a subcomponent of the two-participant event. We therefore preferred to focus our comparison between affirmative and negative sentences specifically on the transitive sentences because these are the conditions in which the effect of learning (i.e., preference for the two participants event) should be clearly observed.

observe a significant difference between the negative conditions and our control condition (i.e., the affirmative transitive condition), it would suggest that with negative sentences, children failed to learn the subcategorization information that they were demonstrated to be able to learn in affirmative frames. This result would buttress the interpretation that negation can disrupt the mechanisms that children use to learn word meanings and that before twenty-seven months of age, children simply do not yet know how to interpret negative sentences to infer the meaning of novel words.

Criteria for trial exclusion. Trials in which a given participant did not provide at least 65% of exploitable eye-tracking data were excluded from the analysis. This happened only one time with adults. Each participant in the 22-month-old group had two trials with exploited eye-tracking data and contributed in average with .96% of exploitable data in each trial (SD = .03). Each participant in the adult group contributed in average with .96% of exploitable data in each trial (SD=.03).

Measurement and statistical analysis. During the test trials all participants listened to the same sound files (asking them "to find blicking!"). Our prediction was that the dialogues they heard before the test would impact their looking preference towards the two-participant action at test. Given that the looking times toward the two-participant action and toward the one-participant action are almost complementary (except for the away looking time, which was not reliably different between conditions), the dependent variable was the proportion of looking times towards the two-participant action, computed for each time bin of 50ms (obtained by averaging from an initial sampling frequency of 8 ms).

To analyze this data, we compared proportions of looking time to the two-participant event across conditions. We modeled the proportion of looking times towards the two-participant

event for each test trial in a mixed logit model with a fixed predictor Condition (3 modalities: negative transitive; negative intransitive; affirmative transitive) and a random Subject effect. The model was specified as: Prop_to_2P ~ Condition + (1 | Participant) and was used on data averaged at the trial level on the whole trial duration (such that each participant had 1 to 2 data points). Because the dependent variable is a continuous variable in the [0; 1] interval and is a mean of non-independent samples, we used the glmmTMB package (Magnuson et al., 2021) in R (R Core Team, 2015) to model it with a beta distribution.

Results

Figure 4 shows that the proportion of looking times towards the two-participant action in the test trials were affected by dialogue conditions in toddlers ($\chi^2(2) = 7.47$; $p < 0.03$) and in adults ($\chi_2(2) = 17.51$; $p < 0.001$).

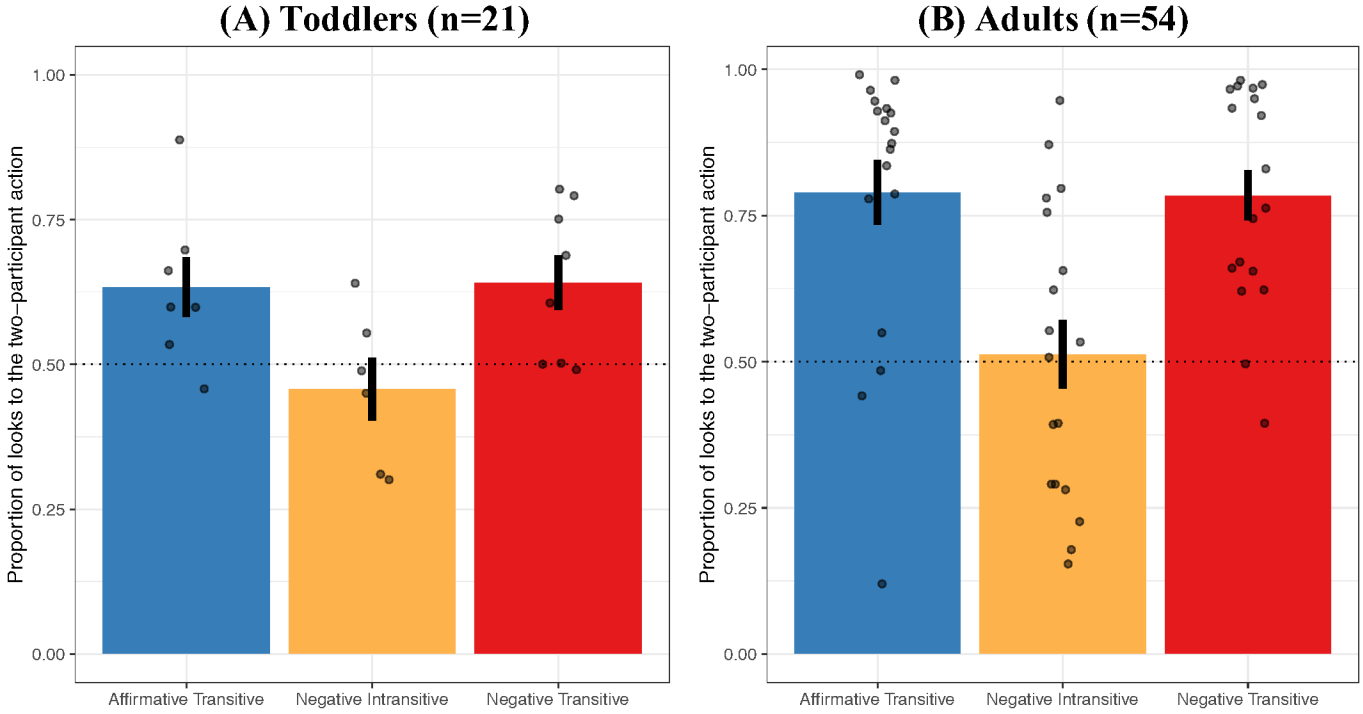

Figure 4: Proportion of looks towards the two-participant action averaged across the entire duration of test trials (8000ms) for (A) Toddlers, on the left, and (B) Adults, on the right, for participants in the affirmative transitive condition (blue), in the negative intransitive condition (orange), and in the negative transitive condition (red). Error bars represent the standard error of the mean. Grey dots represent data points for each participant.

Toddlers in the Negative Transitive condition looked more toward the two-participant action (*M*= .64, *SD*=.04) than toddlers in the Negative Intransitive condition (*M*=.45, *SD*=.05; *β*=-0.74; *z* = -2.69; *p* < 0.01). In addition, toddlers in the Affirmative transitive condition looked reliably more toward the two-participant action (*M*= .63, *SD*=.05) than did toddlers in the Negative Intransitive condition (β = -0.72; z = -2.54; p < 0.02). No other difference between conditions was significant in toddlers (*p* > 0.1).

The same pattern of results was observed with adults. Adults in the Negative Transitive condition looked more toward the two-participant action (*M*= .78, *SD*=.04) than those in the Negative Intransitive condition (*M*= .51, *SD*=.06; *β*=-1.41; *z* = -3.86; *p* < 0.001). Adults in the Affirmative transitive condition looked reliably more toward the two-participant action (*M*= .79, *SD*=.06) than did adults in the Negative Intransitive condition (*β*=-1.42; *z*=-3.87; *p*<0.001). No other difference between conditions was significant in adults (*p* > 0.1).

Discussion

Experiment 1 shows that 22-month-old English-learning toddlers can learn combinatorial facts about a novel verb (i.e., whether it refers to an event involving two participants or not) even when the sentences were negative. Children (and adults) who heard transitive dialogues looked reliably longer at the two-participant event at test than did those who heard intransitive dialogues. The difference between the negative transitive and the negative intransitive conditions in the current study replicate prior results with affirmative sentences in English-learning infants (e.g., Yuan & Fisher, 2009; Yuan et al., 2012), demonstrating once again that before age 2, infants can readily exploit the syntactic context in which a novel verb occurs to make inferences about its possible meaning. We however extend these findings for the first time to negative sentences.

Our results show that negation *per se* does not disrupt children's word-learning mechanisms. Children were still paying attention to sentences containing negation and to what comes after "not," which, in our case, was the verb subcategorization information. If instead, the presence of the negation functor "not" immediately disrupted language processing in young children because they don't know yet how to integrate it in the sentence structure, we would only have observed a difference between the control condition (Affirmative Transitive) and the two negative conditions respectively, but not between the two negative conditions.

Note that the crucial comparison in our study was between the negative transitive and negative intransitive conditions. Both sentences contained the negative functor "not" and children successfully distinguished them and used the information conveyed by these sentences to constrain their interpretation of the novel verb meaning. Children's success in our task suggests that they are able to make inferences about novel word meanings even when the sentences are negatives, as did 18-month-olds in de Carvalho et al., (2021) in French.

Furthermore, the lack of the significant difference between the Affirmative Transitive and the Negative Transitive conditions suggests that negative sentences were not more difficult to process than affirmative sentences in the current experiment, at least for the purpose of using syntactic context to guide novel verb learning. Children and adults behaved just as well in both affirmative and negative transitive conditions.

It is important to notice that in our study, children were able to extract the syntactic structure of negative sentences and encode the information presented in these sentences to learn the novel verb and to notice in which syntactic contexts it could appear. At test, they retrieved that information to make a guess about the possible meaning of that novel verb. In other words, children linked what they heard during the dialogues to the novel verb without any referential

context. At test, the presentation of the novel verb at the same time that children saw two events side-by-side cued children to retrieve what they had learned about the verb in the dialogues and associate it with one of the possible events on the screen.

Our current findings showing that 22-month-olds seem able to learn novel verbs even when the sentences are negatives suggests that from the second year of life, young children might be able to use the information carried by negative sentences to support their acquisition of other word meanings. To investigate this question and better understand the role played by the semantics of negative sentences in lexical acquisition until age four, in Experiment 2 we directly tested whether English-learning preschoolers can exploit the semantic content of negative sentences to restrict and refine the meanings they associate to novel nouns. We also tested whether they could retain in memory the restrictive information provided by negative sentences as a cue to guide their interpretations and to find alternative referents.

Experiment 2

Experiment 2 tested whether the semantic information provided by negative sentences can be used by young children to refine their interpretation of word meanings in a categorization task involving novel nouns that could be used either to label a larger category of novel objects/creatures (in the affirmative condition) or a small category (in the negative condition). Many studies in the literature have shown that naming distinct objects with the same word promotes object categorization in young children, and that infants can use linguistic input to form object categories from their first months of life (Althaus & Westermann, 2016; Ferry & Guellai, 2021; Gliga, Mareschal, & Johnson, 2008; Havy & Waxman, 2016; Landau & Shipley, 2001; LaTourrette & Waxman, 2020b, 2020a, 2019; Mandler, 2000, 2004; Pauen, 2002;

Plunkett, Hu, & Cohen, 2008; Pomiechowska & Gliga, 2019; Quinn, 2006; Quinn, Schyns, & Goldstone, 2006; Quinn & Bhatt, 2009; Rakison & Oakes, 2008; Rakison & Yermolayeva, 2010; Westermann & Mareschal, 2014). Here we used an adaptation of one of the experimental designs used in these studies (Havy & Waxman, 2016). In Havy and Waxman, it was found that 9-month-olds can use affirmative labelling sentences to guide the identification of object categories (i.e., whether it refers to one vs two categories) along a perceptual continuum.

We investigated how affirmative and negative labeling influence children's categorization of objects that vary along a perceptual continuum (varying from 0 to 100%, e.g., from yellowish croissant-shaped creatures to pinkish bowl-shaped creatures, see Figure 5 and 6). 2-to-4-year-olds were presented with a continuum of novel creatures embedded into two videos labeled with a novel word (e.g., *blickets*). Each video was played on one of two different 'televisions' within a single video and introduced by a speaker (see Figure 5-B). In the first television (common to all participants), participants saw two objects from one end of the continuum (e.g., yellowish croissant-shaped creatures – exemplars 10% and 30% of the continuum) labeled several times in affirmative sentences: "*Oh look! These are blickets!*" Then, in the second television, participants saw two other creatures from the other end of the same continuum (e.g., pinkish bowl-shaped creatures – exemplars 70% and 90%) and were assigned to either the negative or the affirmative condition. Participants in the negative condition heard sentences like "*Oh look! These are not blickets,*" (from which they should then think that blicket can only apply to the yellowish croissant creatures in the first television, not the pinkish bowl creatures in the second television. In this case, they should form a small category for the novel word "blickets" that will only accept examplars from the bottom of the continuum - e.g., only the yellowish croissant-shaped creatures). Participants in the affirmative condition heard sentences

like "*Oh look! These are also*[2] *blickets!*" (from which they should think that blicket applies to all creatures in the two televisions. In this case, they should form a larger category for the novel word "blickets" that will accept all examplars of the continuum - e.g., going from the yellow croissant-shaped creatures in the first television to the pinkish bowl-shaped creatures in the second television). In other words, participants were either told that both ends of the continuum were "*blickets*" (i.e., in the affirmative condition) or that one end was blickets and the other end was not (i.e., in the negative condition).

Participants were then tested in a picture selection task (see Figure 5-C) with images side-by-side in two different trials. In Test trial 1, they saw a new creature from the bottom of the continuum – exemplar 20% of the continuum (e.g. a new yellowish croissant creature), versus a new creature from the top of the continuum – exemplar 80% (e.g., a new pinkish bowl creature), and were asked to find a blicket (e.g., "Where's the blicket? Show me the blicket!"). After responding and performing on two subsequent filler trials with known animals (e.g., "*Where's the cow/dog? Show me the cow/dog!*"), participants were tested in an additional test trial (i.e., Test trial 2) in which they were asked to find another exemplar of the novel word (e.g., "Where's the blicket? Show me the blicket!") while seeing a new exemplar from the top of the continuum – a 85% exemplar (e.g., a new pinkish bowl creature which was similar to a creature labeled as "not a blicket" in the teaching phase of the negative condition or "also a blicket" in the teachinhg phase of the affirmative condition), vs. a completely unrelated creature never seen before (see Figure 5-C).

[2] Note that there is evidence in the literature suggesting that children in the age range we tested (i.e., 1-to-4-year-olds) might be capable to understand "also" in our sentences, beucase they spontaneously produce "also" in their own speech and they were shown to understand it in different tasks and in different languages (see e.g., Berger & Höhle, 2012; Bergsma, 2006; Höhle, Berger, Müller, Schmitz, & Weissenborn, 2009; Kurokami, Lidz, Valentine, & Goodhue, 2021).

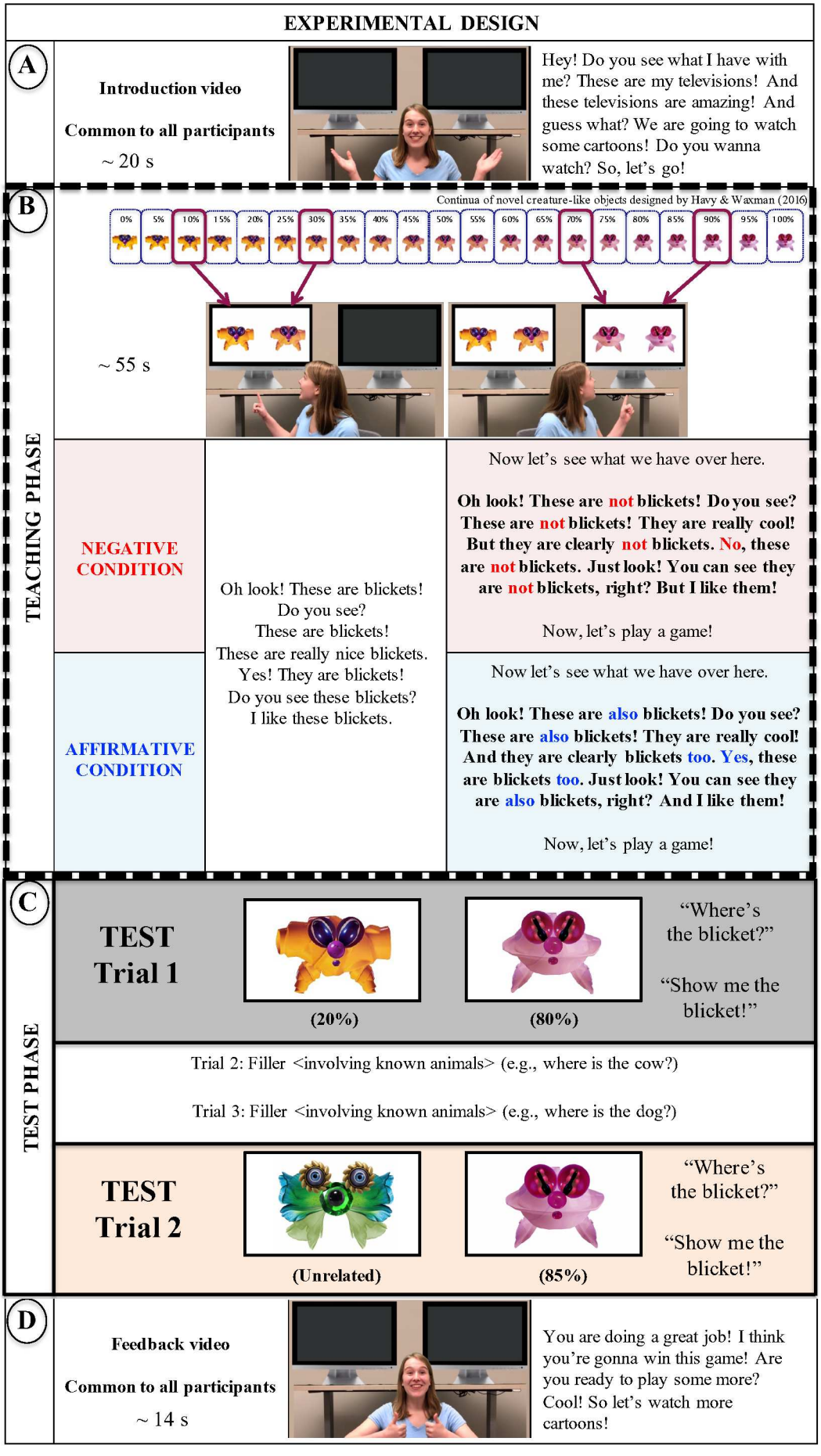
EXPERIMENTAL DESIGN
A
Introduction video
Common to all participants
~ 20 s
Hey! Do you see what I have with me? These are my televisions! And these televisions are amazing! And guess what? We are going to watch some cartoons! Do you wanna watch? So, let's go!
B
TEACHING PHASE
Continua of novel creature-like objects designed by Havy & Waxman (2016)
0% 5% 10% 15% 20% 25% 30% 35% 40% 45% 50% 55% 60% 65% 70% 75% 80% 85% 90% 95% 100%
~ 55 s
NEGATIVE CONDITION
Oh look! These are blickets!
Do you see?
These are blickets!
These are really nice blickets.
Yes! They are blickets!
Do you see these blickets?
I like these blickets.
Now let's see what we have over here.
Oh look! These are not blickets! Do you see? These are not blickets! They are really cool! But they are clearly not blickets. No, these are not blickets. Just look! You can see they are not blickets, right? But I like them!
Now, let's play a game!
AFFIRMATIVE CONDITION
Now let's see what we have over here.
Oh look! These are also blickets! Do you see? These are also blickets! They are really cool! And they are clearly blickets too. Yes, these are blickets too. Just look! You can see they are also blickets, right? And I like them!
Now, let's play a game!
C
TEST PHASE
TEST Trial 1
(20%)
(80%)
"Where's the blicket?"
"Show me the blicket!"
Trial 2: Filler <involving known animals> (e.g., where is the cow?)
Trial 3: Filler <involving known animals> (e.g., where is the dog?)
TEST Trial 2
(Unrelated)
(85%)
"Where's the blicket?"
"Show me the blicket!"
D
Feedback video
Common to all participants
~ 14 s
You are doing a great job! I think you're gonna win this game! Are you ready to play some more? Cool! So let's watch more cartoons!

Figure 5 (A-D): Experimental design of Experiment 2 - All participants watched the same introductory video first (A). Then they started the teaching phase (B) in which the speaker showed them novel creatures in Television 1 and 2. The objects in Television 1 and the sentences uttered to describe them were the same for all participants. Then depending on their condition, while seeing the creatures in television 2, participants heard either negative or affirmative sentences. Finally, they all went through the same test phase (C) with novel exemplars of the continua of novel creatures (e.g., exemplars 20% vs 80% in Test trial 1 or exemplar 85% vs an unrelated object in Test trial 2) and were asked to find the novel word referent (e.g., "*Where's the blicket?*"). Right after the end of Test trial 2 all participants watched a short feedback video (D) congratulating them and encouraging them to keep doing the task. The experiment contained four novel words in total (with two test trials, Test trial 1 vs Test trial 2, for each novel word). Participants were taught and tested on 4 novel words in this manner, using 4 different perceptual continuums of novel creatures.

Method

Experiment 2 was not pre-registered. The stimuli, data and analyses of this experiment are nevertheless freely accessible to readers on the OSF (Open Science Framework) database through the following link:

https://osf.io/5f2tw/?view_only=fabb8e37a1d34cacbae4225c4c4e824e

Participants. Twenty 2-to-4-year-olds participated in this study (M*age*=39.5mo, range from 26 to 46.7months; *SD* = 6.4; 7 girls). Participants were all monolingual with less than 20% exposure to another language. Participants were randomly assigned to one of the two experimental conditions (Affirmative or Negative). The final sample contained 11 participants in the negative condition (M*age*=38.9mo, range from 26 to 46.7months; *SD* = 6.9; 4 girls) and 9 in the affirmative (M*age*=40.1mo, range from 27.1 to 45.9months; *SD* = 6.09; 3 girls). An additional two children were tested but not included in the final analysis due to fussiness during the experiment. In addition, 22 adults (12 in the negative condition and 10 in the affirmative condition), participated in the same test to provide us with a baseline of how children should behave in our experiment if they have adult-like knowledge about the sentences used in our task. This research was approved by the local ethics committee of the University of Pennsylvania.

Apparatus. The apparatus for Experiment 2 was very similar to Experiment 1. The only difference is that we did not use an eye-tracker and children wore headphones to listen to the

audio stimuli. All participants were tested in a quiet room in their daycares/preschools. They sat facing a 23-in television positioned about 70cm away from them. Participants were told that they were going to play a game in which they would have to find the image that a lady would ask them about.

Materials. The stimuli were ten pairs of animated images illustrating stuffed animals moving slowly up and down on the screen (two pairs for the practice trials and eight pairs for the filler trials), and eight pairs of animated images illustrating novel colorful creatures moving slowly up and down for the test trials[3]. For the teaching phase, eight short videos of about 55 s each were created, four for the affirmative condition and four for the negative condition. Additionally, we created four short videos (presented to all participants): one introductory video (see Figure 5-A) to explain the task before the presentation of the first video of the teaching phase; and three short videos of encouragement (presented at the end of each test block, except the last) congratulating participants and encouraging them to keep doing the task (see e.g., Figure 5-D).

For the practice and filler trials, we chose twenty stuffed animals that preschoolers are likely to know. For the two practice trials we used *butterfly* vs. *fish* and *dog* vs. *turtle*. For the eight filler trials we used *zebra* vs. *duck*; *elephant* vs. *cat*; *bear* vs. *frog*; *squirrel* vs. *pig*; *mouse* vs. *monkey*; *lion* vs. *cow*; *horse* vs. *penguin*; *giraffe* vs. *bunny*. These pictures were yoked in pairs in each practice or filler trial (e.g., the butterfly always appeared with the fish and the dog always appeared with the turtle).

For the novel colorful creatures, we used four sets of novel creatures that vary along a perceptual continuum (Set 1, Set 2, Set 3 and Set 4, see Figure 6) created by Havy and Waxman (2016).

[3] The static images were animated (i.e., moving up and down) to better hold children's attention and interest.

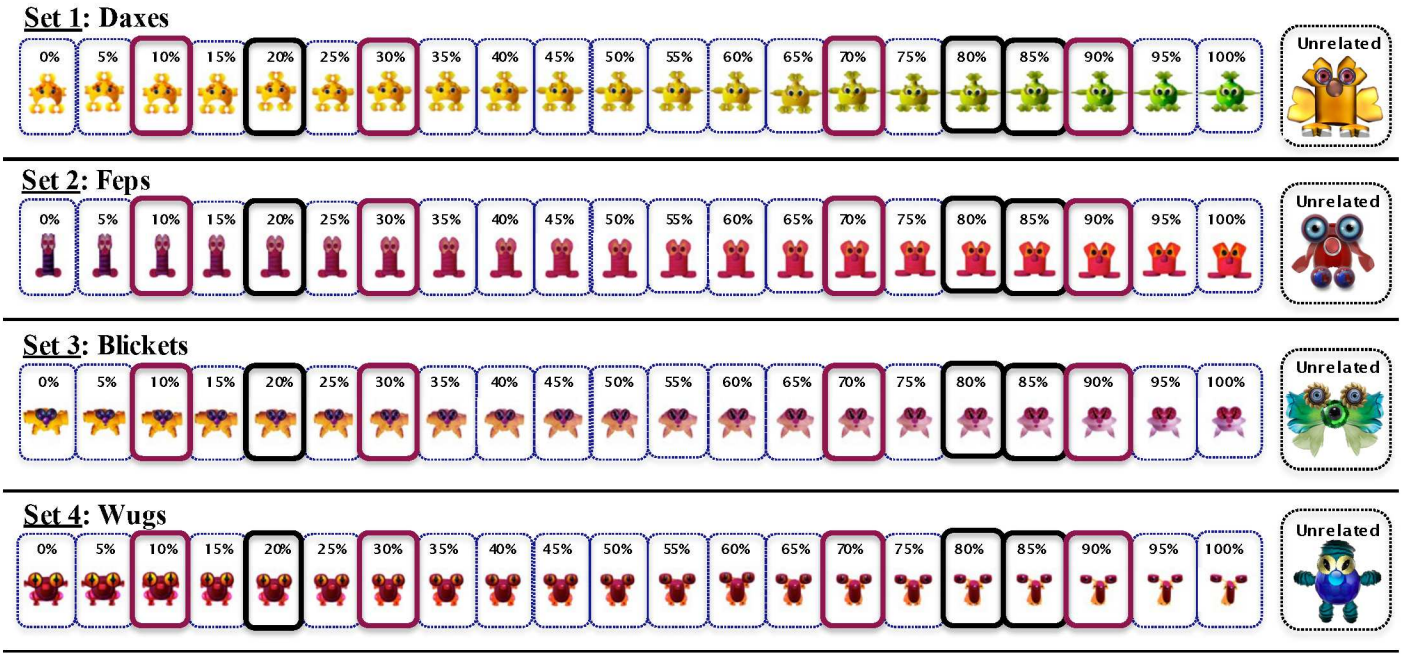

Figure 6: Sets of novel creatures varying along a perceptual continuum created by Havy & Waxman (2016) and the four unrelated creatures created specifically for the purpose of the current study. Exemplars presented during the teaching phase of Experiment 2 are circled in purple (the exemplars 10% and the 30% in TV1, and the exemplars 70% and the 90% in TV2). Exemplars used in the test phase are circled in black (the 20% and 80% for Test trial 1 and the 85% vs. an unrelated creature for Test trial 2).

To create each of these continua Havy and Waxman first created a pair of colorful creatures (e.g., creature A: a yellow croissant creature, and creature B: a pink bowl creature), and then morphed them together in a morphing program (MorphX, 2011) which resulted in a perceptual continua of twenty-one objects/pictures (i.e., going from A to B, from 0% to 100%), varying along a variety of dimensions (5% of changes from one picture to the other), including color, overall body shape, and feature details (see Havy & Waxman, 2016 for more details about how these continua were created). For the purpose of the current study, we selected seven objects from each continuum (n= 28 in total). 16 of these images were used for presentation during the teaching phase (four in each video, see images circled in purple in Figure 6): the exemplars 10% and the 30% in one television (e.g., to be initially labelled as blickets for all participants) and the exemplars 70% and the 90% in the other television (e.g., to be either labelled as "also blickets" in the affirmative condition, or "not blickets" in the negative condition). 12 other images of these

continua were used in the test phase (three for each novel word, see images circled in black in Figure 6): the exemplars 20% and 80% of a given continuum for Test trial 1 and the exemplar 85% for Test trial 2. Additionally, we have also created four novel unrelated colorful creatures for the Test trial 2 (see Figure 6 for the full set of colorful creatures used in this study). Our experiment contained four novel words in total: *blickets*, *daxes*, *feps*, and *wugs*. Each novel word was assigned to each of the four different perceptual continuums of novel creatures.

In each of the teaching videos, the woman would first turn on the television on the left side of the screen so that the participant could see two objects from one end of a given continuum of creatures (e.g., for the item blickets they saw yellowish croissant creatures – exemplars 10% and 30%) labeled six times with affirmative sentences. She then turned on the second television on the right side of the screen so that participants could see two other creatures from the other end of the continuum (e.g., for the item blickets they saw pinkish bowl creatures – exemplars 70% and 90%) and depending on the condition, the woman labeled these objects either with five additional affirmative sentences or five additional negative sentences (see Figure 5-B). See Appendix 1 for the full transcription of all sentences used in each video. All the videos used are freely available on our OSF folder (see Materials/Videos teaching phase folder).

Procedure. The procedure was similar to the preferential looking paradigm used in Experiment 1 in the sense that participants first watched a dialogue/teaching video showing a speaker uttering sentences containing a novel word and then, a test phase with a picture selection task assessed the interpretation participants assigned to the novel word.

The experiment began with a practice block to familiarize preschoolers with the procedure. In each trial, a pair of animated images was presented side-by-side, for 6 s, along with

a sound track encouraging preschoolers to look at one of the pictures (the presentation of these pictures followed the same procedure as in Exp 1, see Figure 7). The order of presentation and the side of the targets (left or right) were counterbalanced across participants. In each trial, participants had to choose (i.e., pointing at) which image matched the sentence they heard.

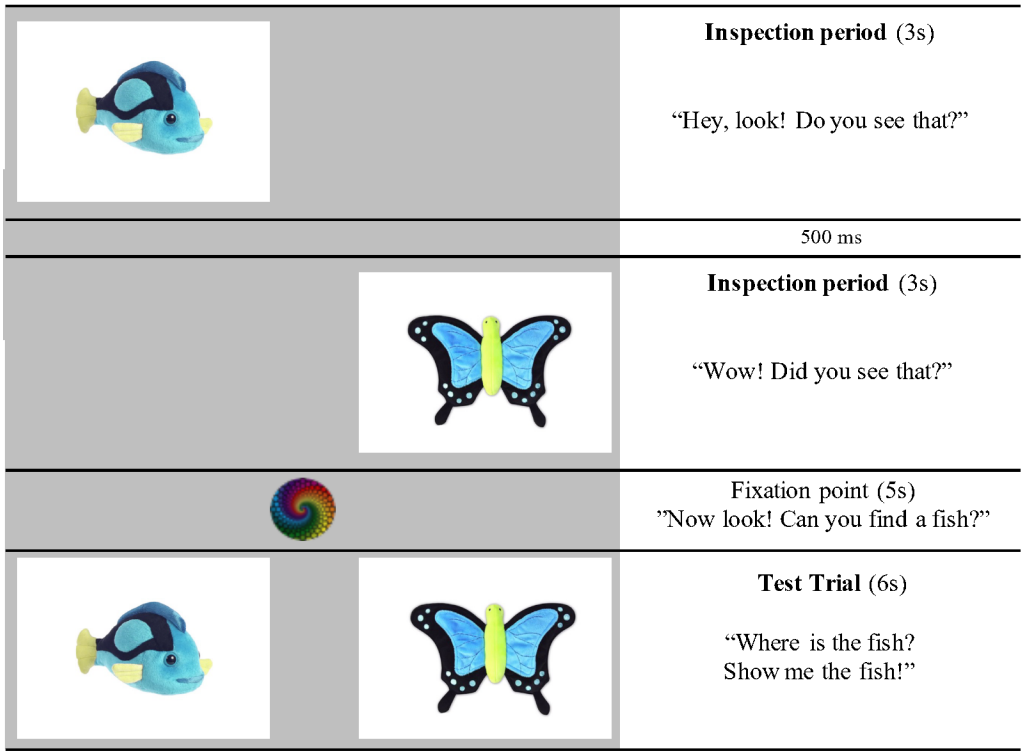

Figure 7: Time-course of the practice trials presentation.

After the two trials of the practice block, participants watched the introductory video in the middle of the screen for 20 s (see Figure 5-A). Immediately after that, the teaching phase started and participants saw the video of a woman talking about the new creatures that appeared on the TVs and labeled them using either affirmative sentences (in the Affirmative condition) or affirmative and negative sentences (in the Negative condition, see Figure 5-B). Since we had four novel words, we divided the teaching phase into four blocks following the procedure illustrated in Figure 5 (B-to-D) in which participants watched the teaching video appropriate for their assigned condition and immediately after went through a picture selection task containing

four trials, two test trials and two filler trials. All the 16 trials (8 fillers and 8 test of novel words, two of each presented in each block) were presented exactly in the same way described for the practice items in Figure 7.

The order of presentation of the Introductory and feedback videos was fixed across participants. The order of presentation of the novel items assigned to each block (i.e., blickets, daxes, wugs, feps) was random. The order of presentation of filler trials was also randomized.

Predicted results. If English-learning preschoolers are able to use the semantic information carried by negative sentences as a tool to understand the boundaries of a word-referent association, in Test trial 1 they should select the picture presenting the exemplar from the bottom of the continuum (i.e., 20%) more often than participants in the affirmative condition. In Test trial 2, the correct interpretation of affirmative and negative sentences would make participants in the affirmative condition select more often the new exemplar from the top of the continuum (i.e., the 85% picture) than participants in the negative condition. This is because in the affirmative condition participants would have learned that the novel word can apply to all members of the perceptual continuum (i.e., going from 10% to 90%, so the 85% picture is correct) while participants in the negative condition would have learned that the novel word can only refer to a smaller set of objects (i.e., going from 10% to 30%) which is not present in any of the pictures presented on the screen at Test trial 2. Therefore, participants in the negative condition will be either at chance when having to choose between the 85% picture and the unrelated picture (i.e., because they consider none of the options are correct) or they will be forced to select the unrelated picture by means of mutual exclusivity when asked to show “a blicket” which implies that there is a visible blicket on the screen.

If participants are able to use the restrictive information provided by negative sentences to apply a mutual exclusivity strategy when faced with a novel object (member of the not-blickets family) vs. an unrelated object in Test trial 2, participants in the negative condition should select more often the unrelated picture than the 85% picture. However, given the difficulty that 2-to-4-year-olds were attested to have in previous studies when they had to use a "mutual exclusivity" strategy based exclusively on the information provided by negative sentences (e.g., reasoning that if one of the creatures on the screen is not a "bamoule" then only the other one could be "a bamoule" in Exp 2 of de Carvalho et al., 2021; or if "It's not in this bucket" then it must be in the alternative container "the house", in Feiman et al., 2017) it is possible that they will fail to apply a mutual exclusivity strategy in Test trial 2. In this case, we will be able to at least dissociate preschoolers' ability to correctly parse and interpret negative sentences from their ability to make an additional inference from negation and to reason by exclusion (as it was the case in many of the previous studies).

Measurements and statistical analysis. Participants pointed for every trial. We measured the proportion of each picture selected at each of the test trials (i.e., exemplar 80% vs. exemplar 20% in Test trial 1 and exemplar 85% vs. Unrelated creature in Test trial 2). Because pointings toward the exemplar 80% vs. exemplar 20% in Test trial 1, or pointings toward exemplar 85% vs Unrelated creature in Test trial 2 were complementary, we chose the occurrence of pointing response toward exemplar 80% (0 or 1) as our dependent measure in Test trial 1 and the occurrence of pointing response toward the exemplar 85% (0 or 1) as our dependent measure in Test trial 2. Since we analyzed categorical responses, we modeled them using a generalized linear mixed-effects model using the *glmer* function in the lme4 package in R (Bates et al., 2018; Bates & Sakar, 2007; Bates, Mächler, Bolker, & Walker, 2015). We analyzed the results of Test trial 1 in a

generalized linear mixed-effects model with a fixed predictor Condition (2 modalities: negative condition; affirmative condition) and a random Subject and item effect. The model was specified as: (Prop_pointing_80%creature ~ condition + (1|subject) + (1+condition|word). The results of Test trial 2 were modeled in a generalized linear mixed-effects model with a fixed predictor Condition (2 modalities: negative condition; affirmative condition) and a random Subject and item effect. The model was specified as: (Prop_pointing_85%creature ~ condition + (1|subject) + (1+condition|word).

Results

Figure 8 presents the average proportion of pointings toward each of the creature pictures presented in Test trial 1 (i.e., the exemplar "80%" and the exemplar "20%" of the continua), averaged across the four novel words, for each condition and for each group of participants.

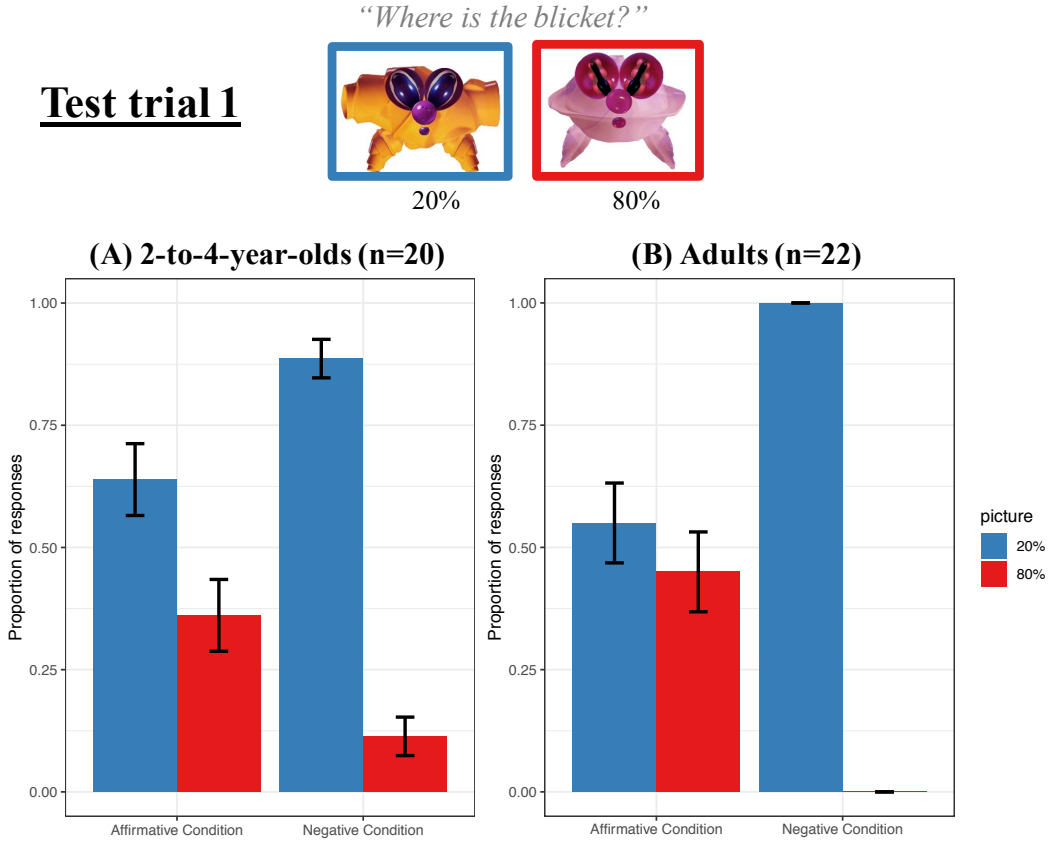

Figure 8: Proportion of pointings toward each exemplar (i.e., creature picture) presented in Test trial 1, for (A) 2-to-4-year-olds on the left and (B) Adults, on the right.

Children assigned to the negative condition pointed more often to the 20% creature (i.e., the exemplar from the bottom of the continuum, e.g., a new yellowish croissant creature for blickets) in Test trial 1 (*M*=.88, *SD*=.13) than children assigned to the affirmative condition (*M*=.64, *SD*=.22, see the first two blue bars on the left side of Figure 8). This was reflected in our mixed model analysis by a main effect of Condition (β= -1.42, SE=0.67, z=-2.11, *p*=.035). The same pattern of results was observed with adults (*M*neg=1, *SD*=0 and *M*aff=.55, *SD*=.25, β= -3.95, SE=1.82, z=-2.16, *p*=.0307)[4]. These results suggest that participants (both preschoolers and adults) in the negative condition correctly used the semantic information provided by negative sentences to narrow down the possible referents for the novel words.

It is also important to notice that since the pointing responses toward the exemplar 80% vs. exemplar 20% in Test trial 1 are complementary, the significant effect of condition also confirms that preschoolers and adults in the affirmative condition selected more often the 80% picture than participants in each age group in the negative condition (see red bars in Figure 8) which is correct since in the teaching videos participants in the affirmative condition learned that exemplars from the top of the continuum (i.e., the exemplar 70% and the exemplar 90%) could also be labelled as "blickets."

Figure 9 presents the average proportion of pointings toward each of the creature pictures presented in Test trial 2 (i.e., the exemplar "85%" of the continua vs an "Unrelated" creature), averaged across the four novel words, for each condition and for each group of participants.

[4] Note that since adults were 100% correct in the Negative Condition and we did not have any pointing towards the alternative picture in the negative condition, in order to run our mixed model in the adult data, we added a bit of noise to this data by randomly shifting the condition of 3% of our data, which is a standard procedure in these cases.

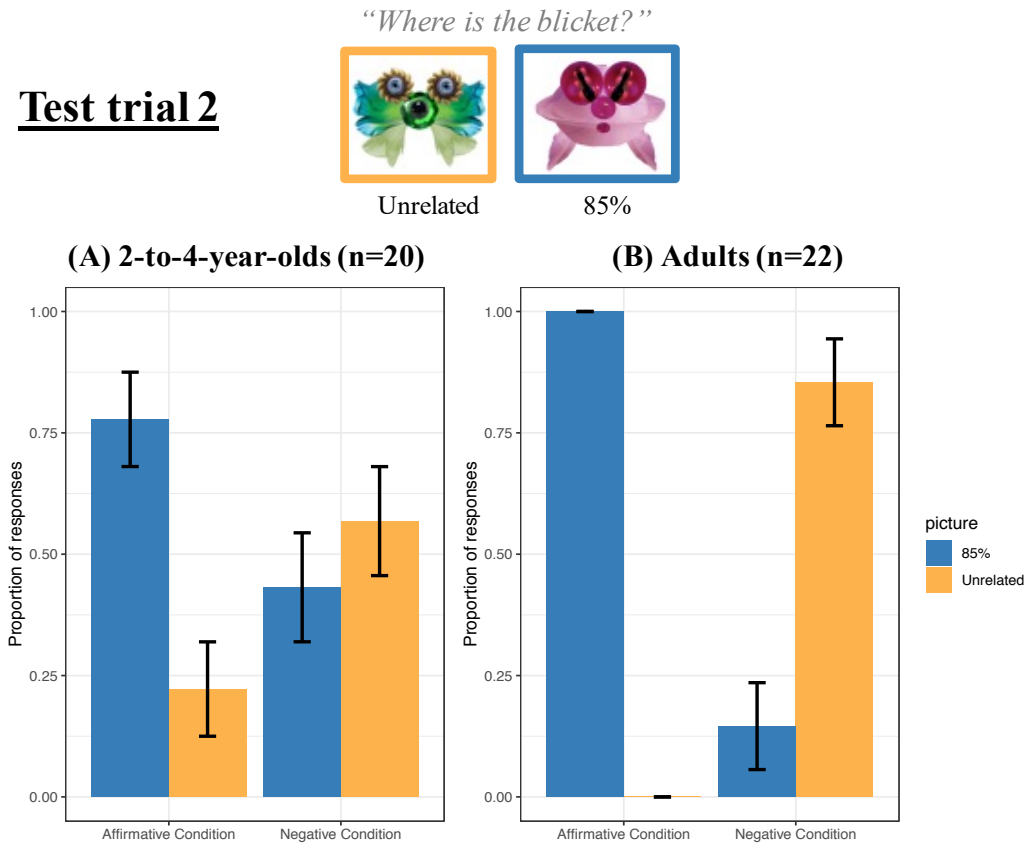

Figure 9: Proportion of pointings toward each exemplar (i.e., creature picture) presented in Test trial 2, for (A) 2-to-4-year-olds on the left and (B) Adults, on the right.

In Test trial 2, as expected, preschoolers in the affirmative condition selected more often the 85% creature (*M*=.77, *SD*=.29) than preschoolers in the negative condition (*M*=.43, *SD*=.37; β=-2.28, SE=1.05, z=-2.16, *p*=.030, see first two blue bars on the left of Figure 9). The same pattern of results was observed with adults (*M*aff=1, *SD*=0 and *M*neg=.14, *SD*=.31; β= -31.63, SE=9.80, z=-3.23, *p*=.001). Because pointing responses toward the 85% creature vs. the unrelated creature in Test trial 2 are complementary, these results also show that preschoolers and adults in the negative condition selected more often the unrelated picture than participants in the affirmative condition (see orange bars in Figure 9).

It is important to note however that within participants in the negative condition the proportion of pointings toward the unrelated creature vs. the 85% creature is not significantly different from each other in preschoolers (*t*(10)=.60; *p*=.55) while it is in adults (*t*(11)=3.95;

p=.002). These results suggests that while adults were able to use the restrictive information provided by negative sentences to apply a mutual exclusivity strategy in Test trial 2 (i.e., selecting more often the unrelated creature rather than the 85% creature), preschoolers in the negative condition were at chance in this situation and did not show any preference for the unrelated creature in Test trial 2.

Additionally, in a post-hoc analysis we have also investigated whether the age of child participants could interact with their performance in our task. To do that, we ran an additional analysis using age in months as a predictor in our model, specified as: (Prop_pointing_80%creature ~ condition * age + (1|subject) + (1+condition+age|word) for Test trial 1 and as (Prop_pointing_85%creature ~ condition * age + (1|subject) + (1+condition+age|word) for Test trial 2. We did not find any significant main effects or interactions with the tests of interest in our study. This suggests that the youngest participants in our sample are producing results similar to older children.

Discussion

The results obtained in Experiment 2 with 2-to-4-year-olds (and adults) are consistent with the findings of Experiment 1 and with the results of de Carvalho et al., (2021) in French and Reuter et al., (2018) in English, showing, once again, that young children are able to correctly parse and compute the meaning of negative sentences in situations that use negative sentences in pragmatically felicitous contexts and do not tax young children's executive function abilities. However, the current experiment provides additional and more direct evidence about how exactly the semantic information provided by negative sentences can guide word learning and show that preschoolers can use negative sentences as a tool to understand the boundaries of a word's meaning. In Experiment 2, children ages 2-4 years were able to use negative labeling

events to restrict the meaning of novel words when categorizing novel objects. In our study, all children initially heard “These are daxes” paired in front of certain objects (e.g., yellowish objects, exemplars 10% and 30% from the continuum); and then when seeing other objects (e.g., pinkish objects, 70% and 90%), in the negative condition they heard “These are not daxes” and in the affirmative “These are also daxes.” At test, when children saw two novel exemplars from the continuum on the screen (e.g., exemplar 20% vs 80%) and were asked to find “a blicket”, children in the negative condition selected the exemplar from the bottom of the continuum (i.e., the 20%) more often than participants in the affirmative condition, suggesting that children in the affirmative condition learned that “blickets” could apply to all objects from the continuum, while participants in the negative condition learned that the novel word applied only to a smaller set of objects of the continuum. These results suggests that the contrasting information provided by negative sentences seem to have helped children to discard the possibility that “blickets” referred to all creatures in our teaching phase while without such information, participants in the affirmative condition interpreted both members of the bottom (e.g., yellowish croissant creatures) and the top of the continuum (e.g., pinkish bowl creatures) as possibly being “blickets.” Thus preschoolers took advantage of negative sentences to constrain the extension of a word’s meaning.

Crucially, Experiment 2 also allowed us to investigate two different aspects of the processing and interpretation of negative sentences. First, with Test trial 1, we were able to test whether young children were able to distinguish affirmative from negative sentences (“*These are also blickets*” vs “*These are not blickets*”) and whether they could correctly interpret the meaning of the negative sentences to narrow down their interpretation of novel noun meanings in a categorization task. Our results showed very clearly that 2-to-4-year-olds were perfectly able to

parse and interpret the negative sentences: in Test trial 1, they selected the more restrictive option (the 20% creature) more often than participants in the affirmative condition.

Second, with Test trial 2, we went a step further and tested whether young children were able to make an additional inference from negation and to reason by exclusion, because this was the case in previous studies in which 2-to-4-year-olds had difficulty to interpret negative sentences appropriately (see e.g., Austin et al., 2014; Feiman et al., 2017; Nordmeyer & Frank, 2014; see also Exp2 in de Carvalho et al., 2021). The results of Test trial 2 showed that when asked to find a new exemplar of the novel word (e.g., "Where's the blicket? Show me the blicket!") while seeing a new exemplar similar to the creatures labeled as "not a blickets" in the teaching phase (e.g., exemplar 85%) vs a novel completely unrelated creature, participants in the negative condition were able to remember the restrictive information provided by negative sentences to not select the incorrect picture (i.e., the 85% creature). In other words, they used the information provided by negative sentences to wipe out a potential label-reference link. However, contrary to adults in the same situation, 2-to-4-year-olds were unable to find an alternative referent in this situation and failed to apply a mutual exclusivity strategy, e.g., by reasoning that if one of the creatures was not a "blicket" but the speaker asks them to point to "a blicket", then there is still one present and the unrelated picture should have been the best alternative.

Several studies in the literature suggest that well before age two, children are able to apply a mutual exclusivity strategy to infer the meaning of novel words. For instance, when faced with a novel object vs. one or more familiar objects, if children hear a novel word (e.g., "Where's the blicket?"), they look towards the novel object (Bion, Borovsky, & Fernald, 2013; Byers-Heinlein & Werker, 2009; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Halberda,

2003; Houston-Price, Caloghiris, & Raviglione, 2010; Kalashnikova, Escudero, & Kidd, 2018; Markman & Wachtel, 1988; Markman, Wasow, & Hansen, 2003; Schmale, Cristia, & Seidl, 2012). However, in such cases it is easy for young children to link the novel word "*blicket*" to the novel object, because they already have a clear familiar label "to eliminate" one of the candidates. In our Test trial 2, the situation was much harder. With the information provided by the negative sentences, children only knew that one of the creatures on the screen was "not a blicket," however they never learned how it was called then. So, in this case children might have found it hard to choose between two novel creatures without having a label for at least one of them. In future studies we will need to investigate when children become able to apply a mutual exclusivity strategy in this case (i.e., like adults), and whether they could perform any better in this task if they have learned a label for one of the creatures in Test trial 2. An alternative explanation that could justify the behavior of children assigned to the negative condition of Test trial 2 is that unlike adults, children had difficulty understanding the pragmatic structure of the experiment, and failed to make an additional inference at test. Adults in the negative condition might have inferred that the unrelated creature was a "blicket" simply because the verbal prompt "Where's the blicket? Show me the blicket!", implied that there was a blicket on the screen. In this case, adults were more likely to use a "mutual exclusivity" strategy and reasoned that since the 85% creature was certainly not a blicket, then only the unrelated creature could be "a blicket." Preschoolers might not have showed the same behavior because they were unable to make these additional pragmatic inferences.

General Discussion

Summary

The studies reported here show that from 22 months of age, English-learning children can correctly parse and interpret negative sentences to guide their interpretation of novel noun and verb meanings in situations that use negative sentences in pragmatically felicitous contexts and do not tax young children's executive function abilities. In a verb-learning experiment (Experiment 1), 22-month-olds were able to correctly parse negative sentences to learn about a new verb's combinatorial privileges from brief exposure to dialogues, without referential context that hinted at the verb's semantic content. If they later encountered the verb in a visual referential context, they retrieved this combinatorial information presented in negative sentences and used it to guide their attention to possible candidate events. These results suggests that before 27 months children are not simply confused by negative sentences as previously thought. In a categorization task using novel nouns (Experiment 2), we went a step further and tested whether 2-to-4-year-olds could use the semantic information provided by negative sentences even more directly to restrict the meaning of novel nouns and find candidate referents when categorizing novel objects. All children initially heard sentences like "*These are blickets*" paired in front of certain objects. Then, while seeing additional objects, children heard either "*These are not blickets*" (negative condition) or "*These are also blickets*" (affirmative condition). At test when they later encountered the novel noun (e.g., *blickets*) in a referential context, they retrieved the information presented in affirmative vs negative sentences to guide their attention to possible candidate referents. Children in the affirmative condition learned that "blickets" applied to all objects presented, while in the negative condition they learned that "blickets" could only apply to a smaller set of objects. Taken together, our studies show that English-learning children correctly

parse and interpret negative sentences and that 2-to-4-year-olds can even use the semantic information provided in negative labeling events to understand the boundaries of a word's meaning.

Placing these findings in the context of prior work

In our introduction we mentioned that many previous studies about the understanding of negative sentences in English suggested that before 27 months, English-learning infants were unable to interpret negative sentences correctly (e.g., Austin et al., 2014; Feiman et al., 2017; Grigoroglou et al., 2019) and even 2-to-4-year-olds showed difficulty interpreting negative sentences in certain tasks (e.g., Doyle et al., 2019; Kim, 1985; Nordmeyer & Frank, 2014; Pozzan et al., 2019). But a recent study in French suggested that from 18 months of age, infants can understand negative sentences (de Carvalho, et al., 2021). The discrepancy between these results could be interpreted either as being due to differences between the experimental designs used or due to a cross-linguistic difference between English and French. de Carvalho and colleagues found it unlikely that a cross-linguistic difference between English and French children's processing of negative sentences existed. But they acknowledged that their experimental paradigm seemed less demanding for young children than the ones used in previous studies, for instance, because it did not tax infants' inhibitory skills while they were processing negative sentences. When participants had to process negative sentences in their task, they were presented with only a single video, and the sentences were repeated several times, which gave infants ample time to process them correctly while in previous studies in English infants had to make a choice between two pictures or containers at the same time that they were processing the negative sentences.

The success of English-learning participants in the current study lends support to this interpretation. In our tasks, both in Experiment 1 and in Experiment 2, when participants had to process negative sentences, they were presented with only a single video (i.e., dialogue phase in Exp 1, and teaching phase in Exp 2) and they did not have to make a response at that time. Our negative sentences were also repeated several times in both experiments and children succeed in our tasks while they failed in previous studies in English.

The recent findings in French (de Carvalho et al., 2021), along with our current results in English, lend support to the hypothesis that, from their second year of life, infants are already able to parse and interpret negative sentences, and likely in different languages. Previous difficulties detecting this ability were likely due to the complexity of the tasks used, or the context in which negative sentences were presented and tested. In cases where this ability was tested in less demanding tasks with supportive context, we observe that English-learning children are just as sensitive to negative sentences as one might expect them to be given that they are able to build negative mental representations from their first year of life (Hochmann & Toro, 2021) and they produce negation in their own speech very early on (e.g., Bloom, 1970; Choi, 1988; Pea, 1980, 1982).

Finally, it is important to note that our own results found evidence that children understand negation but can nevertheless be challenged by implications the negation had for the task. In particular, in Experiment 2 we investigated two different aspects of young children's processing and interpretation of negative sentences, namely 1) whether children can distinguish affirmative from negative sentences (i.e., also A vs. not A) and use the semantic information provided by negative sentences to narrow down their interpretation of novel noun meanings, and 2) whether young children can make an additional inference from the semantic information

provided by negation and to reason by exclusion (i.e., if not A, then B). Our results showed that 2-to-4-year-olds were perfectly able to parse and interpret the negative sentences to narrow down their interpretation of word meanings in a categorization task (i.e., as evidenced by their near adult-like performance on Test trial 1, where they demonstrated an understanding of which objects could be labeled as blickets and which objects could not be blickets). However, in Test trial 2 they were not as good as adults in making the additional inference, namely, that the other unrelated object should be a blicket. Since this additional inference from negation was required in many of the previous studies showing that 2-to-4-year-olds have difficulty interpreting negative sentences, it is possible that these failures might be due to the complexity of the tasks used rather than a simple difficulty in children's ability to understand negative sentences *per se*. In other words, it is possible that children's difficulty in previous studies was not a difficulty in interpreting negative sentences *per se* (e.g., A vs not A), but rather a difficulty in using the restrictive information provided by negative sentences to make an additional inference in certain tasks (e.g., if not A, then B). Note however that there is evidence in the literature showing that infants can engage in reasoning by the disjunctive syllogism non-linguistically (Cesana-Arlotti, Kovács, & Téglás, 2020; Cesana-Arlotti, Téglás, & Bonatti, 2012; Cesana-Arlotti et al., 2018; Feiman et al., 2017), which therefore suggests that their difficulty might be more related to the ability to trigger the disjunctive reasoning exclusively from the linguistic information provided by negative sentences in the context of these experiments rather than an inability to access the concept of a disjunctive syllogism *per se*.

Negation, contrast and word meaning

The present findings, particularly those from Experiment 2, also indicate that the contrastive nature of negation led to its effects on word learning and restriction of word meaning.

Several studies about language acquisition suggest that to learn the meaning of a novel word (e.g., *blicket*), children can substantially benefit from contrasting semantic information (see e.g., Ankowski, Vlach, & Sandhofer, 2013; Au & Markman, 1987; Booth & Waxman, 2003, 2009; Clark, 1988, 1997; Hall & Belanger, 2005; Klibanoff & Waxman, 2000; Namy & Gentner, 2002; Price & Sandhofer, 2021; Wang & Trueswell, 2019; Waxman & Markow, 1995): knowing for instance what kind(s) of objects can be called *blickets* and what kind(s) of objects cannot be called *blickets*. The use of negation is one of the more effective ways to communicate such semantic restrictions, and indeed our study suggests that English-learning children ages 2 to 4 years can not only correctly parse and interpret these types of sentences but can take advantage of them to determine the extension of a word's meaning.

Related to this point, it is important to consider that there are certain conditions where negation might be especially helpful to word learning and other conditions where it might not. Negative sentences are likely only to be useful and informative for young children if they are used in pragmatically felicitous contexts, for instance to mark a contrast with a proposition that has been uttered previously or to negate an expectation that is supposed to be entertained by the listener (see e.g., Nordmeyer & Frank, 2018; Reuter et al., 2018). Thus, sentences like "This is not a blicket" are only pragmatically appropriate if a child is about to hold an incorrect expectation about two easily confused concepts/referents under discussion (e.g., the novel creatures in our Exp 2). However, this same negative sentence would certainly be unhelpful for a child if it was used to say that something a child already knows is not a blicket (e.g., a banana), without any sign that the child was confused about this or considering it to be "a blicket".

A central problem in language acquisition is to understand how learners deal with the problem of semantic uncertainty (e.g., Quine, 1960) and what are the linguistic cues that they can

use to guide their acquisition of word meanings. For example, if in the presence of a Dalmatian a speaker says “Look! A blicket!” it is unclear whether the novel word means Dalmatian, dog, animal, etc. Previous studies suggested that in this situation children tend to apply a basic level interpretation and think that the novel word “blicket” meant “dog”, not “Dalmatian”, the subordinate meaning, nor “animal”, the superordinate meaning (e.g., Golinkoff, Shuff-Bailey, Olguin, & Ruan, 1995; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Wang & Trueswell, 2019). If children have a strong basic level bias when learning words paired with objects, how do they come to learn other concrete terms that can describe objects, such as subordinate meanings like “Dalmatian” for “dogs”? Many studies suggest that the learning of non-basic-level terms requires special referential circumstances in which the child’s interlocutor needs to offers additional evidence regarding the word’s meaning, often using explicit semantic comparison and contrast (e.g., “See this dog? It’s a poodle!”, or “Look at this Dalmatian! It’s a kind of dog!”; e.g., Blewitt, 1983; Callanan, 1985; Clark & Wong, 2002; Shipley, Kuhn, & Madden, 1983). Our results showing that young word-learners can correctly interpret the contrasting semantic information provided by negative sentences suggests that this cue could also be used to teach subordinate meanings to young children. For instance, if a child hears “*This is a blicket!*” in the presence of a Dalmatian, hearing “*This is not a blicket*” in the presence of a beagle will certainly be helpful in more precisely establishing the extension of the new concepts (i.e., *blicket* applies only to Dalmatians, not all dogs).

Conclusions

Previous studies about the understanding of negative sentences with familiar words suggested that before 27 months, English-learning children were unable to interpret negative sentences. A lack of understanding of negative sentences at an age where children are exploiting

the syntactic structure of sentences to make inferences about word meanings could dramatically impact language acquisition. To investigate this issue, our study tested how negative sentences affected children's ability to learn novel words. We demonstrated that contrary to what has been observed in previous studies, 22-month-olds and 2-to-4-year-olds in our tasks successfully parsed and interpreted negative sentences. Children in this age range were able to correctly integrate syntactic and semantic context together with the meaning of negative elements in a sentence to constrain their interpretations of novel word meanings. We argue that success in our studies occurred because children were tested in a supportive context for the use of negation and in situations that do not seem to tax infants' inhibitory/switching skills. We believe that the ability to understand negative sentences so early may positively impact children's education, because it can give them access to what their caregivers do or "do not" allow them to do. Moreover, since negative sentences can be used to introduce a semantic contrast and give children explicit evidence concerning the space of possible referents for a word, the ability to understand negative sentences may represent an important tool for infants to support their acquisition of word meanings and language acquisition more generally.

References

Althaus, N., & Westermann, G. (2016). Labels constructively shape object categories in 10-month-old infants. *Journal of Experimental Child Psychology*, *151*, 5–17.

Ankowski, A. A., Vlach, H. A., & Sandhofer, C. M. (2013). Comparison Versus Contrast: Task Specifics Affect Category Acquisition. *Infant and Child Development*, *22*(1), 1–23.

Arunachalam, S., & Dennis, S. (2018). Semantic detail in the developing verb lexicon: An extension of Naigles and Kako (1993). *Developmental Science*, (June 2017), e12697.

Arunachalam, S., Escovar, E., Hansen, M. A., & Waxman, S. R. (2013). Out of sight, but not out of mind: 21-month-olds use syntactic information to learn verbs even in the absence of a corresponding event. *Language and Cognitive Processes*, *28*(4), 417–425.

Arunachalam, S., Escovar, E., Hansen, M., & Waxman, S. R. (2011). Verb Learning from Syntax Alone at 21 Months. In N. Danis, K. Mesh, & H. Sung (Eds.), *Proceedings of the 35th Boston University Conference on Language Development* (pp. 21–24).

Arunachalam, S., Syrett, K., & Chen, Y. (2016). Lexical Disambiguation in Verb Learning: Evidence from the Conjoined-Subject Intransitive Frame in English and Mandarin Chinese. *Frontiers in Psychology*, *7*(February), 1–14. https://doi.org/10.3389/fpsyg.2016.00138

Arunachalam, S., & Waxman, S. R. (2010). Meaning from syntax: Evidence from 2-year-olds. *Cognition*, *114*(3), 442–446. https://doi.org/10.1016/j.cognition.2009.10.015

Arvindam, V. S., Tulling, M. A., & Cournane, A. (2020). Online processing of negation in 2-year-olds : Evidence from eye-tracking. In *Poster presented at the 33rd Annual CUNY Human Sentence Processing Conference* (p. 1551628).

Au, T. K., & Markman, E. M. (1987). Acquiring word meanings via linguistic contrast. *Cognitive Development*, *2*(3), 217–236. https://doi.org/10.1016/S0885-2014(87)90059-1

Austin, K., Theakston, A., Lieven, E., & Tomasello, M. (2014). Young children's understanding of denial. *Developmental Psychology*, *50*(8), 2061–2070. https://doi.org/10.1037/a0037179

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., … Green, P. (2018). Package 'lme4'. Retrieved from http://lme4.r-forge.r-project.org/

Bates, D, & Sakar, D. (2007). lme4: Linear mixed-effects models using S4 classes, R package version 2.6.

Bates, Douglas, Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*(1).

Berger, F., & Höhle, B. (2012). Restrictions on addition: children's interpretation of the focus particles auch 'also' and nur 'only' in German. *Journal of Child Language*, *39*(2), 383–410.

Bergsma, W. (2006). (Un) stressed ook in child Dutch. In V. Van Geenhoven (Ed.), *Semantics in acquisition* (pp. 329–348). Netherlands: Springer Science & Business Media.

Bion, R. A. H., Borovsky, A., & Fernald, A. (2013). Fast mapping, slow learning: Disambiguation of novel word-object mappings in relation to vocabulary learning at 18, 24, and 30months. *Cognition*, *126*(1), 39–53. https://doi.org/10.1016/j.cognition.2012.08.008

Blewitt, P. (1983). Dog versus collie: Vocabulary in speech to young children. *Developmental Psychology*, *19*(4), 602–609. https://doi.org/10.1037/0012-1649.19.4.602

Bloom, L. (1970). *Language Development; Form and Function in Emerging Grammars*. MIT Press. Retrieved from https://books.google.ie/books?id=gGLdAAAACAAJ

Booth, A. E., & Waxman, S. R. (2003). Mapping Words to the World in Infancy: Infants' Expectations for Count Nouns and Adjectives. *Journal of Cognition and Development*, *4*(3), 357–381. https://doi.org/10.1207/S15327647JCD0403_06

Booth, A. E., & Waxman, S. R. (2009). A horse of a different color: Specifying with precision infants' mappings of novel nouns and adjectives. *Child Development*, *80*(1), 15–22.

Byers-Heinlein, K., & Werker, J. F. (2009). Monolingual, bilingual, trilingual: Infants' language experience influences the development of a word-learning heuristic. *Developmental Science*, *12*(5), 815–823. https://doi.org/10.1111/j.1467-7687.2009.00902.x

Callanan, M. A. (1985). How Parents Label Objects for Young Children: The Role of Input in the Acquisition of Category Hierarchies. *Child Development*, *56*(2), 508.

Cameron-Faulkner, T., Lieven, E., & Theakston, A. (2007). What part of no do children not understand? A usage-based account of multiword negation. *Journal of Child Language*, *34*(2), 251–282. https://doi.org/10.1017/S0305000906007884

Carpenter, P. A., & Just, M. A. (1975). Sentence Comprehension: A Psycholinguistic Processing Model of Verification. *Psychological Review*, *82*(1), 45–73.

Cepeda, N. J., & Munakata, Y. (2007). Why do children perseverate when they seem to know better: Graded working memory, or directed inhibition? *Psychonomic Bulletin and Review*, *14*(6), 1058–1065. https://doi.org/10.3758/BF03193091

Cesana-Arlotti, Nicolò, Kovács, Á. M., & Téglás, E. (2020). Infants recruit logic to learn about the social world. *Nature Communications*, *11*(1), 1–9. doi.org/10.1038/s41467-020-19734-5

Cesana-Arlotti, Nicoló, Martín, A., Téglás, E., Vorobyova, L., Cetnarski, R., & Bonatti, L. L. (2018). Precursors of logical reasoning in preverbal human infants. *Science*, *359*(6381), 1263–1266. https://doi.org/10.1126/science.aao3539

Cesana-Arlotti, Nicolò, Téglás, E., & Bonatti, L. L. (2012). The Probable and the Possible at 12 Months, *43*, 1–25. https://doi.org/10.1016/b978-0-12-397919-3.00001-0

Choi, S. (1988). The semantic development of negation: a cross-linguistic longitudinal study. *Journal of Child Language*, *15*(3), 517–531. https://doi.org/10.1017/S030500090001254X

Clark, E., & Wong, A. (2002). Pragmatic directions about language use: words and word meanings. *Language in Society*, *31*, 181–212.

Clark, H. H., & Chase, W. G. (1972). On the process of comparing sentence agaist pictures. *Cognitive Psychology*, *3*, 472–517.

Clark, E. V. (1988). On the logic of contrast. *Journal of Child Language*, *15*(02), 317.

Clark, E. V. (1997). Conceptual perspective and lexical choice in acquisition. *Cognition*, *64*(1), 1–37. https://doi.org/10.1016/S0010-0277(97)00010-3

Dautriche, I., Cristia, A., Brusini, P., Yuan, S., Fisher, C., & Christophe, A. (2014). Toddlers Default to Canonical Surface-to-Meaning Mapping When Learning Verbs. *Child Development*, *85*(3), 1168–1180. https://doi.org/10.1111/cdev.12164

de Carvalho, A., Babineau, M., Trueswell, J. C., Waxman, S. R., & Christophe, A. (2019). Studying the Real-Time Interpretation of Novel Noun and Verb Meanings in Young Children. *Frontiers in Psychology*, *10:274*(February), 1–16.

de Carvalho, Alex, Crimon, C., Barrault, A., Trueswell, J., & Christophe, A. (2021). " Look! It is not a bamoule! ": 18- and 24-month-olds can use negative sentences to constrain their interpretation of novel word meanings. *Developmental Science*, *24*(4), 1–17.

de Carvalho, Alex, Dautriche, I., Fiévet, A., & Christophe, A. (2021). Toddlers exploit referential and syntactic cues to flexibly adapt their interpretation of novel verb meanings. *Journal of Experimental Child Psychology*, *203*, 105017.

Déprez, V., & Espinal, M. T. (2020). *The Oxford handbook of negation*. USA: Oxford University Press.

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology*, *64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Doyle, A. W., Friesen, K., Reimer, S., & Pexman, P. M. (2019). Grasping the alternative: Reaching and eyegaze reveal children's processing of negation. *Frontiers in Psychology*, *10*(MAY). https://doi.org/10.3389/fpsyg.2019.01227

Feiman, R. (2015). *The structure and development of logical representations in thought and language*. Harvard University, Cambridge, MA.

Feiman, R., Mody, S., Sanborn, S., & Carey, S. (2017). What Do You Mean, No? Toddlers' Comprehension of Logical "No" and "Not." *Language Learning and Development*, *13*(4), 430–450. https://doi.org/10.1080/15475441.2017.1317253

Ferguson, B., Graf, E., & Waxman, S. R. (2014). Infants use known verbs to learn novel nouns: evidence from 15- and 19-month-olds. *Cognition*, *131*(1), 139–146.

Ferguson, B., Graf, E., & Waxman, S. R. (2018). When Veps Cry: Two-Year-Olds Efficiently Learn Novel Words from Linguistic Contexts Alone. *Language Learning and Development*, *14*(1), 1–12. https://doi.org/10.1080/15475441.2017.1311260

Fernandes, K. J., Marcus, G. F., Di Nubila, J. A., & Vouloumanos, A. (2006). From semantics to syntax and back again: Argument structure in the third year of life. *Cognition*,*100*(2),10–20.

Ferry, A., & Guellai, B. (2021). Labels and object categorization in six- and nine-month-olds: tracking labels across varying carrier phrases. *Infant Behavior and Development*, *64*(August 2020), 101606. https://doi.org/10.1016/j.infbeh.2021.101606

Fisher, C. (1996). Structural Limits on Verb Mapping: The Role of Analogy in Children's Interpretations of Sentences. *Cognitive Psychology*, *31*(1), 41–81.

Fisher, C. (2002). Structural limits on verb mapping: The role of abstract structure in 2.5-year-olds' interpretations of novel verbs. *Developmental Science*, *5*(1), 55–64.

Fisher, C., Jin, K., & Scott, R. M. (2020). The Developmental Origins of Syntactic Bootstrapping. *Topics in Cognitive Science*, *12*(1), 48–77.

Gagliardi, A., Mease, T. M., & Lidz, J. (2016). Discontinuous development in the acquisition of filler-gap dependencies: Evidence from 15- and 20-month-olds. *Language Acquisition*, *23*(May), 234–260. https://doi.org/10.1080/10489223.2015.1115048

Gelman, S. A., Wilcox, S. A., & Clark, E. V. (1989). Conceptual and lexical hierarchies in young children. *Cognitive Development*, *4*(4), 309–326. https://doi.org/10.1016/S0885-2014(89)90022-1

Gertner, Y., & Fisher, C. (2012). Predicted errors in children's early sentence comprehension. *Cognition*, *124*(1), 85–94. https://doi.org/10.1016/j.cognition.2012.03.010

Gillette, J., Gleitman, H., Gleitman, L., & Lederer, A. (1999). Human simulations of vocabulary learning. *Cognition*, *73*(2), 135–176.

Gleitman, L. (1990). The Structural Sources of Verb Meanings. *Language Acquisition*, *1*, 3–55.

Gleitman, L., Cassidy, K., Nappa, R., Papafragou, A., & Trueswell, J. (2005). Hard words. *Language Learning and Development*, *1*(1), 23–64.

Gliga, T., Mareschal, D., & Johnson, M. H. (2008). Ten-month-olds' selective use of visual dimensions in category learning. *Infant Behavior and Development*, *31*(2), 287–293.

Golinkoff, R. M., Hirsh-Pasek, K., Bailey, L. M., & Wenger, N. R. (1992). Young Children and Adults Use Lexical Principles to Learn New Nouns. *Developmental Psychology*, *28*(1), 99–108. https://doi.org/10.1037/0012-1649.28.1.99

Golinkoff, R. M., Shuff-Bailey, M., Olguin, R., & Ruan, W. (1995). Young Children Extend Novel Words at the Basic Level: Evidence for the Principle of Categorical Scope. *Developmental Psychology*, *31*(3), 494–507. https://doi.org/10.1037/0012-1649.31.3.494

Grigoroglou, M., Chan, S., & Ganea, P. A. (2019). Toddlers' understanding and use of verbal negation in inferential reasoning search tasks. *Journal of Experimental Child Psychology*, *183*, 222–241. https://doi.org/10.1016/j.jecp.2019.02.004

Halberda, J. (2003). The development of a word-learning strategy. *Cognition*, *87*(1), B23–B34.

Hall, D. G., & Belanger, J. (2005). Young children's use of range-of-reference information in word learning. *Developmental Science*, *8*(1), 8–15. https://doi.org/10.1111/j.1467-7687.2005.00388.x

Havy, M., & Waxman, S. R. (2016). Naming influences 9-month-olds' identification of discrete categories along a perceptual continuum. *Cognition*, *156*, 41–51.

Hochmann, J.-R. (2020). Cognitive Precursors of Negation in Preverbal Infants. In Viviane Déprez & M. T. Espinal (Eds.), *The Oxford Handbook of Negation* (pp. 588–598). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198830528.013.39

Hochmann, J.-R., & Toro, J. M. (2021). Negative mental representations in infancy. *Cognition*, *213*, 104599. https://doi.org/10.1016/j.cognition.2021.104599

Höhle, B., Berger, F., Müller, A., Schmitz, M., & Weissenborn, J. (2009). Focus Particles in Children's Language: Production and Comprehension of Auch 'Also' in German Learners from 1 Year to 4 Years of Age. *Language Acquisition*, *16*(1), 36–66. https://doi.org/10.1080/10489220802584550

Horn, L. R. (2001). *A Natural history of negation*. *David Hume series*. Chicago, IL: University of Chicago Press. https://doi.org/10.1016/0024-3841(90)90064-R

Houston-Price, C., Caloghiris, Z., & Raviglione, E. (2010). Language experience shapes the development of the mutual exclusivity bias. *Infancy*, *15*(2), 125–150. https://doi.org/10.1111/j.1532-7078.2009.00009.x

Jasbi, M., McDermott-Hinman, A., Davidson, K., & Carey, S. (2020). Parents' and children's production of English negation. In *Paper presented at the 45th Boston University Conference on Language Development*. Boston - MA.

Jin, K., & Fisher, C. (2014). Early evidence for syntactic bootstrapping : 15-month-olds use

sentence structure in verb learning. In W. Orman & M. J. Valleau (Eds.), *Proceedings of the 38h Annual Boston University Conference on Language Development*. Boston - MA: Cascadilla Press. Retrieved from http://www.bu.edu/bucld/supplementvol38/

Just, M. A., & Carpenter, P. A. (1971). Comprehension of negation with quantification. *Journal of Verbal Learning and Verbal Behavior*, *10*(3), 244–253. https://doi.org/10.1016/S0022-5371(71)80051-8

Kalashnikova, M., Escudero, P., & Kidd, E. (2018). The development of fast-mapping and novel word retention strategies in monolingual and bilingual infants. *Developmental Science*, (March), e12674. https://doi.org/10.1111/desc.12674

Kaup, B., Dudschig, C., Kaup, B., & Dudschig, C. (2020). Understanding Negation. *The Oxford Handbook of Negation*, (February), 634–655. https://doi.org/10.1093/oxfordhb/9780198830528.013.33

Kaup, B., Lüdtke, J., & Zwaan, R. A. (2006). Processing negated sentences with contradictory predicates: Is a door that is not open mentally closed? *Journal of Pragmatics*, *38*(7), 1033–1050. https://doi.org/10.1016/j.pragma.2005.09.012

Kaup, B., Yaxley, R. H., Madden, C. J., Zwaan, R. a, & Lüdtke, J. (2007). Experiential simulations of negated text information. *Quarterly Journal of Experimental Psychology (2006)*, *60*(907681673), 976–990. https://doi.org/10.1080/17470210600823512

Kim, K. (1985). Development of the concept of truth-functional negation. *Developmental Psychology*, *21*(3), 462–472. https://doi.org/10.1037/0012-1649.21.3.462

Klibanoff, R. S., & Waxman, S. R. (2000). Basic Level Object Categories Support the Acquisition of Novel Adjectives: Evidence from Preschool-Aged Children. *Child Development*, *71*(3), 649–659. https://doi.org/10.1111/1467-8624.00173

Koring, L., Meroni, L., & Moscati, V. (2018). Strong and Weak Readings in the Domain of Worlds: A Negative Polar Modal and Children's Scope Assignment. *Journal of Psycholinguistic Research*, *47*(6), 1193–1217. https://doi.org/10.1007/s10936-018-9573-8

Kronmüller, E., Noveck, I., Rivera, N., Jaume-Guazzini, F., & Barr, D. (2017). The positive side of a negative reference: The delay between linguistic processing and common ground. *Royal Society Open Science*, *4*(2). https://doi.org/10.1098/rsos.160827

Kurokami, H., Lidz, J., Valentine, H., & Goodhue, D. (2021). Children's interpretation of additive particles mo 'also' and also in Japanese and English. *Proceedings of the 45th Annual Boston University Conference on Language Development*, 449–461.

Lagattuta, K. H., Sayfan, L., & Monsour, M. (2011). A new measure for assessing executive function across a wide age range: Children and adults find happy-sad more difficult than day-night. *Developmental Science*, *14*(3), 481–489. https://doi.org/10.1111/j.1467-7687.2010.00994.x

Landau, B, & Gleitman, L. (1985). *Language and experience: Evidence from the blind child*. Cambridge, MA: Harvard University Press.

Landau, Barbara, & Shipley, E. (2001). Labelling patterns and object naming. *Developmental*

Science, *4*(1), 109–118. https://doi.org/10.1111/1467-7687.00155

LaTourrette, A. S., & Waxman, S. R. (2020a). Naming guides how 12-month-old infants encode and remember objects. *Proceedings of the National Academy of Sciences*, *117*(35), 21230 LP – 21234. https://doi.org/10.1073/pnas.2006608117

LaTourrette, A. S., & Waxman, S. R. (2020b). Naming guides how 12-month-old infants encode and remember objects. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(35), 21230–21234. https://doi.org/10.1073/pnas.2006608117

LaTourrette, A., & Waxman, S. R. (2019). A little labeling goes a long way: Semi-supervised learning in infancy. *Developmental Science*, *22*(1), 1–9. https://doi.org/10.1111/desc.12736

Lew-Williams, C., & Fernald, A. (2010). Real-time processing of gender-marked articles by native and non-native Spanish speakers. *Journal of Memory and Language*, *63*(4), 447–464. https://doi.org/10.1016/j.jml.2010.07.003

Loder, L. S. (2006). *Early understanding of negation: the word "not."* University of Maryland, College Park.

Lüdtke, J., Friedrich, C. K., De Filippis, M., & Kaup, B. (2008). Event-related potential correlates of negation in a sentence-picture verification paradigm. *Journal of Cognitive Neuroscience*, *20*(8), 1355–1370. https://doi.org/10.1162/jocn.2008.20093

Magnuson, A., Skaug, H., Nielsen, A., Berg, C., Kristensen, K., Maechler, M., … Brooks, M. (2021). Package 'glmmTMB.' R Package version 1.1.2. Retrieved from https://github.com/glmmTMB/glmmTMB

Mandler, J. M. (2000). Perceptual and Conceptual Processes in Infancy. *Journal of Cognition and Development*, *1*(1), 3–36. https://doi.org/10.1207/S15327647JCD0101N_2

Mandler, J. M. (2004). A synopsis of The foundations of mind: Origins of conceptual thought (2004). New York: Oxford University Press. *Developmental Science*, *7*(5), 499–505. https://doi.org/10.1111/j.1467-7687.2004.00369.x

Markman, E. M., & Wachtel, G. F. (1988). Children's use of mutual exclusivity to constrain the meanings of words. *Cognitive Psychology*, *20*(2), 121–157. https://doi.org/10.1016/0010-0285(88)90017-5

Markman, E. M., Wasow, J. L., & Hansen, M. B. (2003). Use of the mutual exclusivity assumption by young word learners. *Cognitive Psychology*, *47*(3), 241–275. https://doi.org/10.1016/S0010-0285(03)00034-3

Matsuo, A., Kita, S., Shinya, Y., Wood, G. C., & Naigles, L. (2012). Japanese two-year-olds use morphosyntax to learn novel verb meanings. *Journal of Child Language*, *39*(3), 637–663. https://doi.org/10.1017/S0305000911000213

Medina, T. N., Snedeker, J., Trueswell, J. C., & Gleitman, L. R. (2011). How words can and cannot be learned by observation. *Proceedings of the National Academy of Sciences*, *108*(22), 9014–9019. https://doi.org/10.1073/pnas.1105040108

Messenger, K., Yuan, S., & Fisher, C. (2015). Learning Verb Syntax via Listening: New

Evidence From 22-Month-Olds. *Language Learning and Development*, *11*(4), 356–368. https://doi.org/10.1080/15475441.2014.978331

MorphX, N. (2011). Norrkross MorphX. Retrieved from: http://www.norrkross.com/software/morphx/morphx.php.

Moscati, V. (2020). Children (and Some Adults) Overgeneralize Negative Concord: the Case of Fragment Answers to Negative Questions in Italian. *University of Pennsylvania Working Papers in Linguistics*, *26*(1), 169–178.

Müller, A., Höhle, B., Schmitz, M., & Weissenborn, J. (2009). Information structural constraints on children's early language production: The acquisition of the focus particle auch ('also') in German-learning 12- to 36-month-olds. *First Language*, *29*(4), 373–399. https://doi.org/10.1177/0142723709105314

Naigles, L. (1990). Children use syntax to learn verb meanings. *Journal of Child Language*, *17*(2), 357–374. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2380274

Namy, L. L., & Gentner, D. (2002). Making a silk purse out of two sow's ears: Young children's use of comparison in category learning. *Journal of Experimental Psychology: General*, *131*(1), 5–15. https://doi.org/10.1037//0096-3445.131.1.5

Nappa, R., Wessel, A., McEldoon, K. L., Gleitman, L. R., & Trueswell, J. C. (2009). *Use of speaker's gaze and syntax in verb learning*. *Language Language and Development* (Vol. 5). https://doi.org/10.1080/15475440903167528

Nordmeyer, A. E., & Frank, M. C. (2014). The role of context in young children's comprehension of negation. *Journal of Memory and Language*, *77*(C), 25–39. https://doi.org/10.1016/j.jml.2014.08.002

Nordmeyer, A. E., & Frank, M. C. (2015). The pragmatics of negation across contexts. In *Proceedings of the 37th Annual Conference of the Cognitive Science Society*.

Nordmeyer, A. E., & Frank, M. C. (2018). Early Understanding of Pragmatic Principles in Children's Judgments of Negative Sentences. *Language Learning and Development*, *14*(4), 262–278. https://doi.org/10.1080/15475441.2018.1463850

Noveck, I., Petit, N., Tian, Y., & Turco, G. (2021). Revealing pragmatic processes through a one-word answer: When the French reply Si. *Journal of Memory and Language*, *120*(May), 104245. https://doi.org/10.1016/j.jml.2021.104245

Papeo, L., de Vega, M., Papeo, L., & de Vega, M. (2020). The Neurobiology of Lexical and Sentential Negation. *The Oxford Handbook of Negation*, (February 2021), 739–756. https://doi.org/10.1093/oxfordhb/9780198830528.013.44

Papeo, L., Hochmann, J.-R., & Battelli, L. (2016). The default computation of negated meanings. *Journal of Cognitive Neuroscience*, (3), 194–198. https://doi.org/10.1162/jocn

Pauen, S. (2002). Evidence for Knowledge-Based Category Discrimination in Infancy. *Child Development*, *73*(4), 1016–1033. https://doi.org/10.1111/1467-8624.00454

Pea, R. D. (1980). The Development of Negation in Early Child Language. In D. R. Oslon (Ed.),

The Social Foundations of Language and Thought (pp. 156–186). New York and London: W W Norton & Company.

Pea, R. D. (1982). Origins of verbal logic: spontaneous denials by two- and three-year olds. *Journal of Child Language*, *9*(3), 597–626. https://doi.org/10.1017/S0305000900004931

Perkins, L., Feldman, N. H., & Lidz, J. (2022). The Power of Ignoring: Filtering Input for Argument Structure Acquisition. *Cognitive Science*, *46*(1). https://doi.org/10.1111/cogs.13080

Perkins, L., & Lidz, J. (2020). Filler-gap dependency comprehension at 15 months: The role of vocabulary. *Language Acquisition*, *27*(1), 98–115. https://doi.org/10.1080/10489223.2019.1659274

Plunkett, K., Hu, J. F., & Cohen, L. B. (2008). Labels can override perceptual categories in early infancy. *Cognition*, *106*(2), 665–681. https://doi.org/10.1016/j.cognition.2007.04.003

Pomiechowska, B., & Gliga, T. (2019). Lexical Acquisition Through Category Matching: 12-Month-Old Infants Associate Words to Visual Categories. *Psychological Science*, *30*(2), 288–299. https://doi.org/10.1177/0956797618817506

Pozzan, L., Feiman, R., Snedeker, J., Guasti, M. T., Dorn, K., Weinert, S., … Trueswell, J. C. (2019). Not getting ahead of ourselves: A cross-linguistic investigation of children's understanding of negation. In *Paper presented at the 44th Boston University Conference on Language Development*. Boston - MA.

Price, G. F., & Sandhofer, C. M. (2021). One versus many: Multiple examples in word learning. *Journal of Experimental Child Psychology*, *209*, 105173. https://doi.org/10.1016/j.jecp.2021.105173

Quine, W. V. O. (1960). *Word and object*. Cambridge MA: MIT Press.

Quinn, P. C. (2006). On the Emergence of Perceptual Organization and Categorization in Young Infants: Roles for Perceptual Process and Knowledge Access. In L. Balter & C. S. Tamis-LeMonda (Eds.), *Child psychology: A handbook of contemporary issues* (pp. 109–131). Psychology Press.

Quinn, Paul C., Schyns, P. G., & Goldstone, R. L. (2006). The interplay between perceptual organization and categorization in the representation of complex visual patterns by young infants. *Journal of Experimental Child Psychology*, *95*(2), 117–127. https://doi.org/10.1016/j.jecp.2006.04.001

Quinn, Paul C, & Bhatt, R. S. (2009). Transfer and Scaffolding of Perceptual Grouping Occurs Across Organizing Principles in 3- to 7-Month-Old Infants. *Psychological Science*, *20*(8), 933–938. https://doi.org/10.1111/j.1467-9280.2009.02383.x

Rakison, D. H., & Oakes, L. M. (2008). *Early Category and Concept Development* (Vol. 25). New York, NY: Oxford University Press. Retrieved from https://books.google.com/books?id=2dQJCAAAQBAJ&pgis=1

Rakison, D. H., & Yermolayeva, Y. (2010). Infant categorization. *Wiley Interdisciplinary Reviews: Cognitive Science*, *1*(6), 894–905. https://doi.org/10.1002/wcs.81

Ramscar, M., Dye, M., Gustafson, J. W., & Klein, J. (2013). Dual routes to cognitive flexibility: Learning and response-conflict resolution in the dimensional change card sort task. *Child Development*, *84*(4), 1308–1323. https://doi.org/10.1111/cdev.12044

Reuter, T., Feiman, R., & Snedeker, J. (2018). Getting to No : Pragmatic and Semantic Factors in Two- and Three-Year-Olds' Understanding of Negation. *Child Development*, *89*(4), e364–e381. https://doi.org/10.1111/cdev.12858

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. *Cognitive Psychology*, *8*(3), 382–439. https://doi.org/10.1016/0010-0285(76)90013-X

Schmale, R., Cristia, A., & Seidl, A. (2012). Toddlers recognize words in an unfamiliar accent after brief exposure. *Developmental Science*, *15*(6), 732–738. https://doi.org/10.1111/j.1467-7687.2012.01175.x

Scott, R. M., & Fisher, C. (2012). 2.5-Year-Olds Use Cross-Situational Consistency To Learn Verbs Under Referential Uncertainty. *Cognition*, *122*(2), 163–180.

Shipley, E. F., Kuhn, I. F., & Madden, E. C. (1983). Mothers' use of superordinate category terms. *Journal of Child Language*, *10*(3), 571–588. https://doi.org/10.1017/S0305000900005377

Spivey, M. J., Tanenhaus, M. K., Eberhard, K. M., & Sedivy, J. C. (2002). Eye movements and spoken language comprehension: effects of visual context on syntactic ambiguity resolution. *Cognitive Psychology*, *45*(4), 447–481. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12480476

Staab, J., Urbach, T., & Kutas, M. (2009). Negation processing in context is not (always) delayed. *Center for Research in Language Technical Report*, *20*(3), 3–34. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Negation+processing+in+context+is+not+(always)+delayed.#4

Suzuki, T., & Kobayashi, T. (2017). Syntactic Cues for Inferences about Causality in Language Acquisition: Evidence from an Argument-Drop Language. *Language Learning and Development*, *13*(1), 24–37. https://doi.org/10.1080/15475441.2016.1193019

Syrett, K., LaTourrette, A., Ferguson, B., & Waxman, S. R. (2019). Crying helps, but being sad doesn't: Infants constrain nominal reference online using known verbs, but not known adjectives. *Cognition*, *193*(July), 104033. https://doi.org/10.1016/j.cognition.2019.104033

Team, R. C. (2015). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.r-project.org/

Thornton, R. (2020). Negation and First Language Acquisition. In Viviane Déprez & M. T. Espinal (Eds.), *The Oxford Handbook of Negation* (pp. 598–614). Oxford University Press.

Tian, Y., Breheny, R., & Ferguson, H. J. (2010). Why We Simulate Negated Information: A Dynamic Pragmatic Account. *Quarterly Jounal of Experimental Psychology*, *63*(12), 2305–2312. https://doi.org/10.1080/17470218.2010.525712

Trueswell, J., Sekerina, I., Hill, N., & Logrip, M. (1999). The kindergarten-path effect: studying

on-line sentence processing in young children. *Cognition*, *73*(2), 89–134.

Wang, F. H., & Trueswell, J. C. (2019). Spotting Dalmatians: Children's ability to discover subordinate-level word meanings cross-situationally. *Cognitive Psychology*, *114*(January), 101226. https://doi.org/10.1016/j.cogpsych.2019.101226

Waxman, S., & Markow, D. B. (1995). Words as Invitations to Form Categories: Evidence from 12- to 13-Month-Old Infants. *Cognitive Psychology*, *29*(3), 257–302.

Westermann, G., & Mareschal, D. (2014). From perceptual to language-mediated categorization. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1634), 20120391. https://doi.org/10.1098/rstb.2012.0391

Wright, I., Waterman, M., Prescott, H., & Murdoch-Eaton, D. (2003). A new Stroop-like measure of inhibitory function development: Typical developmental trends. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *44*(4), 561–575.

Yuan, S., & Fisher, C. (2009). "Really? She Blicked the Baby?" : Two-Year-Olds Learn Combinatorial Facts About Verbs by Listening. *Psychological Science*, *20*(5), 619–626.

Yuan, S., Fisher, C., & Snedeker, J. (2012). Counting the Nouns: Simple Structural Cues to Verb Meaning. *Child Development*, *83*(4), 1382–1399.

Zelazo, P. D., Müller, U., Frye, D., Marcovitch, S., Argitis, J. B., Chiang, J. K., … Carlson, S. (2003). The development of executive function in early childhood. *Monographs of the Society for Research in Child Development*, *68*(3), i-iii+v+vii-viii+1-151.

Zhou, P., Shi, J., & Zhan, L. (2020). Real-time comprehension of garden-path constructions by preschoolers: A Mandarin perspective. *Applied Psycholinguistics*, 1–25.

Appendix 1: Sentences used in each video of Experiment 2

<table>
<tr><th colspan="4"><u>Videos used during the teaching phase</u></th></tr>
<tr><th>Item</th><th>Condition</th><th>Sentences uttered while presenting creatures-like objects in TV1</th><th>Sentences uttered while presenting creatures-like objects in TV2</th></tr>
<tr><td rowspan="2">Daxes</td><td>Negative</td><td rowspan="2">Oh look at these daxes! These are really nice daxes. Do you see these daxes? Yes! They are daxes! Do you see these daxes? I love these daxes.</td><td>Now let’s see what we have over here.

Oh look! These are not daxes!
Do you see?
These are not daxes!
They are really nice!
But they are definitely not daxes.
No, these are not daxes.
Just look, and you will see,
they are not daxes,
but I love them.

Now, let’s play a game!</td></tr>
<tr><td>Affirmative</td><td>Now let’s see what we have over here.

Oh look! These are also daxes!
Do you see? These are also daxes!
They are really nice!
And they are definitely daxes too. Yes, these are daxes too.
Just look, and you will see,
they are daxes too,
and I love them.

Now, let’s play a game!</td></tr>
<tr><td rowspan="2">Blickets</td><td>Negative</td><td rowspan="2">Oh look! These are blickets! Do you see? These are blickets! These are really nice blickets. Yes! They are blickets! Do you see these blickets? I like these blickets.</td><td>Oh look! These are not blickets!
Do you see? These are not blickets!
They are really cool!
But they are clearly not blickets.
No, these are not blickets. Just look!
You can see they are not blickets, right?
But I like them!

Now, let’s play the game!</td></tr>
<tr><td>Affirmative</td><td>Oh look! These are also blickets!
Do you see? These are also blickets!
They are really cool!
And they are clearly blickets too. Yes, these are blickets too. Just look! You can see they are also blickets, right?
And I like them!

Now, let’s play the game!</td></tr>
</table>

<table>
<tr><td rowspan="2">Feps</td><td>Negative</td><td rowspan="2">Oh look! These are feps! Do you see? These are feps! These are really beautiful feps. Yes! They are feps! Do you see these feps? I adore these feps!</td><td>Oh look! These are not feps! Do you see? These are not feps! They are very nice! But they are definitely not feps. Nooo, these are not feps. Just look! They are not feps, right? But I adore them!

Now, let’s play the game!</td></tr>
<tr><td>Affirmative</td><td>Oh look! These are also feps! Do you see? These are also feps! They are very nice! And they are definitely feps too. Yeah, those are feps too. Just look! They are also feps, right? And I adore them!

Now, let’s play the game!</td></tr>
<tr><td rowspan="2">Wugs</td><td>Negative</td><td rowspan="2">Let’s see what we have here now… Oh look! These are wugs! Do you see? These are wugs! These are very nice wugs. Yes! They are very nice wugs! Do you see these wugs? I love these wugs very much!</td><td>Oh look! Did you see? These are not wugs! Can you see? These are not wugs! They are very cute! But they are clearly not wugs. Nah, these are not wugs. You can see that they are not wugs, right? But I like them very much!

Now, let’s play the game!</td></tr>
<tr><td>Affirmative</td><td>Oh look! Did you see? These are also wugs! Can you see? These are also wugs! They are very cute! And they are clearly wugs too. Yep, these are wugs too. You can see that they are also wugs, right? And I like them very much!

Now, let’s play the game!</td></tr>
<tr><td colspan="4"><u>Videos used for Introduction and Feedback</u>
(common to all participants)</td></tr>
<tr><td>Introduction video</td><td colspan="3">Hey! Do you see what I have with me?
These are my televisions! And these televisions are amazing!
And guess what? We are going to watch some cartoons! Do you wanna watch? So, let’s go!</td></tr>
<tr><td>Feedback 1</td><td colspan="3">Did you like that game? It was fun, right? Do you wanna play some more? All right! So let’s watch some more cartoons and play the game!</td></tr>
<tr><td>Feedback 2</td><td colspan="3">You are doing a great Job! I think you’re gonna win this game! Are you ready to play some more? Cool! So let’s watch more cartoons!</td></tr>
<tr><td>Feedback 3</td><td colspan="3">Good job! Are you ready to play one more time? Yay! Let’s play one more time!</td></tr>
</table>