2019

To be or not to be: Examining the Role of Language in a Concept of Negation

Ann E. Nordmeyer
Southern New Hampshire University

Jill de Villiers
Smith College, jdevilli@smith.edu

To be or not to be: Examining the role of language in a concept of negation

Anonymous CogSci submission

Abstract

Negation is a complex, abstract concept, despite the ubiquity of words like "no" and "not" in even young children's speech. One challenging aspect to words like "no" and "not" is that these words can serve many functions in speech, giving us tools to express an array of concepts such as denial, refusal, and nonexistence. Is there a single concept of "negation" that unites these separate negative functions – and if so, does understanding this concept require the structure of human language? In this paper we present a study demonstrating that adults spontaneously identify a concept of negation in the absence of explicit verbal instructions, even when the exemplars of negation are perceptually varied and represent many different functions of negation. Furthermore, tying up participants' language ability using verbal shadowing impairs participants' ability to identify a concept of negation, but does not impair participants' ability to identify an equally complex control concept (natural kinds). We discuss our findings in light of theories regarding the representation of negation and the relationship between language and thought.

Keywords: negation; philosophy of language; language and thought

Introduction

Due to the early emergence of words such as "no" and "not" in children, and their frequent use in human discourse, it is tempting to dismiss negation as a simple concept. However, the concept of negation has long been a puzzle to philosophers, psychologists, and cognitive scientists. In order to understand the complexity of this phenomenon, consider the following thought experiment:

> Consider, for example, negation. It's easy to tell somebody that it's not going to rain. Try drawing them a picture of it's not going to rain…Think about trying to draw a picture of "there's not a giraffe standing beside me" (Fodor, 1994).

The inherent difficulty in finding a way to depict negation raises questions about the nature of the representation of negation. Is language necessary to understand an abstract concept of negation?

One challenging aspect of negation is that the words ``no'' and ``not'' play many different functions in human speech (see Bloom, 1970; Pea, 1980; Choi, 1988 for discussions of several taxonomies of negation and their trajectory in children's language acquisition). For example, you can use negation to express the *nonexistence* of an object, e.g., "There is no food in the dog's bowl." You can also use negation to express *refusal,* e.g., "No, I don't want to read." And you can express *denial* or truth-functional negation by making statements about falsehoods, e.g. "The light is not on" [*i.e., it is not true that the light is on*]. It is possible to imagine ways to represent each of these statements perceptually or through simple positive concepts, e.g., an empty bowl, a girl looking away from a book on a table, a lamp that is off. Without the language of negation, however, there is nothing perceptually or conceptually similar about these concepts. One important goal of this study is to examine whether adults can spontaneously identify the similarity of these events (i.e., a unified concept of negation) in the absence of explicit language explaining the similarity between the events.

Under a propositional account of the representation of negation, negative sentences are represented as a negative operator acting over a proposition (Clark & Chase, 1972; Carpenter & Just, 1975; Just & Carpenter, 1971, 1976). That is, all of the sentences in the previous example are "unified" by the presence of a negative operator in their representations. Where, then, does this negative operator come from – or any of the structures that underlie human thought? Fodor (1975, 2008) proposed that there must be a "language of thought", which is language-*like* in the sense that it must contain an innate "lexicon" of concepts, as well as a syntax to organize those concepts. According to Fodor, concepts are learned through a process of linking one's experiences in the world with innate concepts. Without such an underlying system, Fodor argues, concept learning (and ultimately word learning) would not be possible. Under this hypothesis, the negative operator that creates a unified concept of negation exists in the lexicon of the language of thought.

Another possibility is that natural language itself is the vehicle for representing and structuring thought. According to Hinzen (2007), there is a conceptual framework that underlies human thought, and language is necessary to organize these concepts into complex propositions. If natural language can provide the same kind of structure that Fodor (1975) argues is necessary for complex thoughts to arise, then the existence of a separate Language of Thought becomes redundant (deVilliers, 2010; Collins, 2000). Under this hypothesis, the development of human language is required to understand a unified concept of negation.

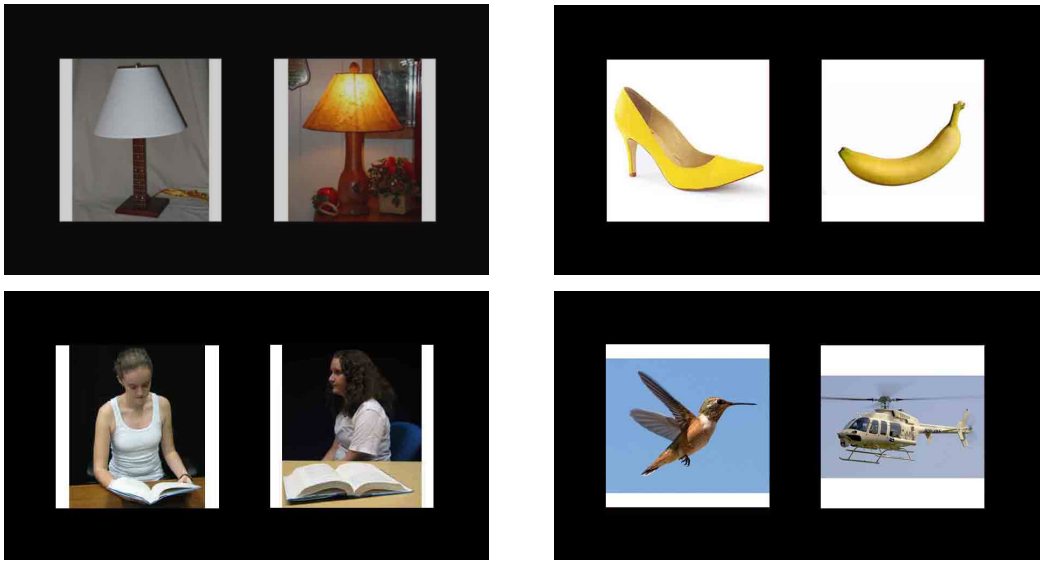

Figure 1: Examples of Negation stimuli (left) and Natural Kind stimuli (right).

The purpose of the present study is to examine, first, whether people have a general concept of negation – that is, a concept of negation that unifies a variety of negated events, actions, objects, and states of being, despite these all having very different perceptual features. That is, do adults recognize the similarity between an empty food bowl, a person refusing to read, and a lamp that is off, without someone explicitly describing these scenes using negation? Second, the study will examine the role that language plays in forming and understanding this concept. If negations are represented as propositions, in an organized and structured way, there must be some mechanism for representing them as such. We propose that natural language can provide an individual with the necessary structures to represent thoughts propositionally, and that natural language might be required to hold a generalized concept of negation.

Method

To test our first question of whether people can identify an abstract concept of negation in the absence of verbal descriptions, we created a non-verbal anticipatory looking task. Participants viewed pairs of photographs in which one image represented an affirmative event and the other image represented the negated version of that event; after several seconds, an animation occurred around the negative event. These stimuli were designed to create a "context of plausible denial" – that is, a context in which the formation of a negative proposition would be a likely response (Wason, 1965). This allowed us to test whether participants would spontaneously identify an abstract concept of negation when looking at pictures without hearing language, allowing the role of language to be manipulated and evaluated separately.

To manipulate participants' ability to use language during this task, half of our participants engaged in a language interference/verbal shadowing task, in which participants listened to a story through headphones and repeated what they heard out loud simultaneously. This task has been shown to interfere with adults' ability to utilize language in abstract cognitive tasks (Hermer-Vazquez, Spelke, & Katsnelson, 1999, Newton & de Villiers, 2007). We hypothesized that participants would be able to identify the negative event in the absence of verbal interference, but would perform at chance when shadowing language.

To test whether the effects of verbal interference are specific to an abstract concept like negation, as opposed to simply distracting participants from the task, we developed a control task to test participants' ability to form a different concept – one that was equally varied but that potentially would not require language to understand. We selected "natural kind objects" as a control concept because it is a broad, complex concept, which cannot be organized around single perceptual cues alone, but which we believed would not require language. For example, young children (Gelman, 1988; Gelman & O'Reilly, 1988) and pre-verbal infants (Booth & Waxman, 2002; Shutts, Markson, & Spelke, 2009) appear to be sensitive to the distinction between natural kinds vs. artifacts. This work suggests that it may be possible to represent the natural kind concept without requiring propositions with a language-like structure.

Participants

Participants were recruited through two psychology courses. The participants were all undergraduate students and all but one of the participants were female (due to the nature of the institution's population). Participants received credit towards their final grades for participation. After excluding participants for lack of attention to the task (see "Data Processing"), our final sample included 84 participants (negation, no shadowing: n=18; negation, shadowing: n=17;

natural kind, no shadowing: n=27; natural kind, shadowing: 20).

Stimuli

Stimuli consisted of pairs of photographs that portrayed either an affirmative or negated event (in the experimental condition) or a natural kind or an artifact object (in the control condition). To ensure that the photographs in each pair were equally salient, we conducted a pilot test in which adults (N = 12) viewed a total of 72 pairs of photographs for three seconds. Paired-samples t-tests were conducted to determine if the total looking time was greater for one picture more than the other in each pair using a conservative alpha level of .1. This resulted in the removal of 9 pairs from the negation condition and 8 pairs from the natural kind condition. One additional pair was randomly selected to be removed from the natural kind group, in order to have an equal number of pairs in each group. This left 22 pairs of photographs in each group for the final study. Figure 1 shows examples of the stimuli used in each task.

One of our primary hypotheses for the study was to examine whether participants would be able to identify a unified concept of negation from perceptually varied stimuli, without explicit verbal descriptions. To do this, we needed to be sure that the negative stimuli were sufficiently varied (i.e. drawing from many different types/functions of negation) and could not be united by some other concept. To do this, we created four different categories of negation: non-functional (4 exemplars, e.g., affirmative = a digital alarm clock that is showing the time, and negative = a digital alarm clock that is not showing the time), nonexistence (5 exemplars, e.g., affirmative = a dog with food in its bowl, and negative = a dog with an empty food bowl), unexpected state (6 exemplars, e.g., affirmative = a lamp that is on, and negative = a lamp that is off), and refusal (7 exemplars, e.g., affirmative = a girl who is reading, and negative = a girl sitting next to but looking away from an open book).

During the experiment, the pairs of photographs were animated so that each pair of photographs would be presented as still photographs for three seconds, after which the target photo (the negated photograph in the experimental condition, and the natural kind photograph in the control condition) would animate. The animation consisted of a cartoon foot emerging and moving down to squish the target photo to 20% of its original height. The foot then moved back up and the photograph returned to its original height as the foot receded. The animation, from the emergence of the foot to its disappearance, took a total of three seconds. Thus, each pair of photographs was on the screen for a total of six seconds, half of which consisted of the animation phase. Five seconds of black screen separated each animation.

The experiment was constructed in Tobii Studio. Two pseudo-random lists were created, specifying the order in which the participants would see the stimuli, and participants in all of the conditions were randomly assigned to one of the two lists. In both conditions, four photographs were selected as "example photographs". In the negation task, the four example photos included one from each negation type. Participants were not told that these were example photographs, but the examples differed in that each was displayed twice, once with the target picture on the left and once with the target picture on the right. This was done to draw participants' attention to the content of the photographs themselves (as opposed to simply the position on the screen), and to familiarize them to the kinds of stimuli and animation that they would be seeing.

Procedure

This experiment used a 2x2 between-subjects design. Half of the adults were tested on the negation task, and half were tested on the natural kind task. Within each of these conditions, half of the participants were tested with verbal shadowing and half were tested without verbal shadowing.

The experiment was run on a Tobii 1750 eye tracker. Participants were told that they would see pairs of photos on the screen in front of them, and that their job was to watch the pictures and pay attention to what they saw on the screen. Participants in the verbal shadowing condition were told that they would listen to an audio book through a pair of headphones (a passage from 1984 by George Orwell), and would have to repeat what they heard out loud as they listened. Participants were told to speak as simultaneously as possible with the speech they heard, and to be as accurate as possible, but to continue speaking if they made any mistakes, as the most important thing was that they spoke as continuously and fluidly as possible. Participants were then reminded that as they listened and spoke, they would have to keep their attention on the pictures they saw on the screen in front of them.

After the tasks were explained, the experimenter asked the participants in the shadowing condition to practice the verbal shadowing for 30 seconds. Participants in the verbal shadowing condition were videotaped throughout the duration of the experiment so that their performance on the shadowing task could be evaluated at a later point. After 30 seconds of practice, the experimenter started the videocamera and began the experiment. Participants who were not in the shadowing condition were not videotaped, and the experiment was started immediately after explaining the eyetracking task. In both conditions, the experimenter stepped out of the room as soon as the experiment began.

Data Processing

Areas of Interest (AOIs) were created around each photograph in each pair, with the negated event or the natural kind image designated the "target" photograph. The Total Fixation Duration (a measure of the durations of all fixations within an AOI in seconds) within each AOI was collected for the three seconds prior to the start of the animation began. The AOIs were constructed so that the computer would only record a fixation if a person's gaze fixated within the boundaries of the photograph. Thus, although the combined total fixation time possible between

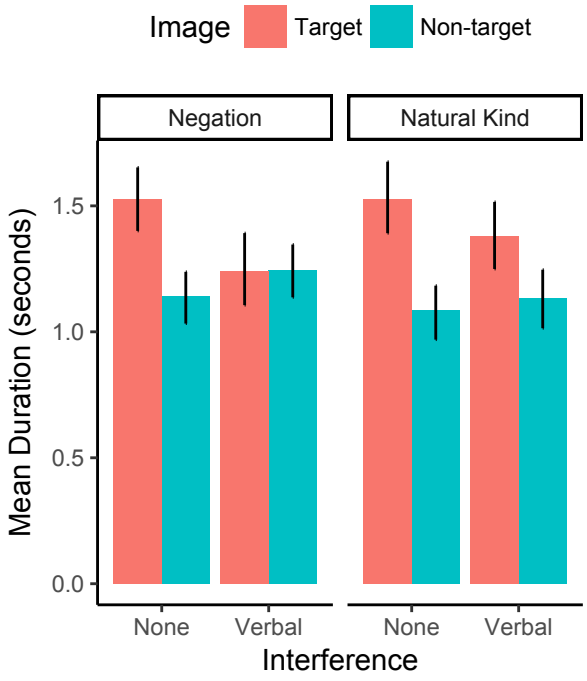

Figure 2: Mean Total Fixation Duration for each condition. Mean looks to the target image (negative event, natural kind) are shown in red and mean looks to the non-target image (affirmative event, artifact) are shown in green. Error bars portray 95% confidence intervals.

the target and non-target AOI was 3 seconds, it is possible that the combined total fixation time would be less than that if participants were fixating their gaze anywhere on the black screen outside of the pictures. The percentage of time that a person's gaze was anywhere on the screen throughout the experiment was also noted, and participants whose total gaze dropped below 60% were excluded from the analysis. This resulted in the exclusion of 18 participants from analysis.

The videotapes of the participants in the shadowing condition were analyzed to determine that the participants had continued speaking throughout the duration of the experiment. Any participant who stopped shadowing for more than 2 seconds was excluded from the analysis. This analysis resulted in the exclusion of three participants, two from the negation group and one from the natural kind group.

Results

Can participants spontaneously identify a unified concept of negation?

First, we asked whether adults would be capable of spontaneously identifying the negative concept in the negation task. To do this, we looked only at the negation/no interference condition to determine if participants looked more to the target picture compared to the non-target picture when they were not subject to verbal interference.

Mean looking times to the target and non-target picture for all conditions are shown in Figure 2. In the negation/no shadowing condition (left-most bars of Figure 2), mean looking time towards the target picture was greater than the mean looking time to the non-target picture (M_{target} = 1.53 s, $M_{non\text{-}target}$ = 1.14 s). A paired-sample t-test showed that this difference was significant, t(17) = -3.82, p<.01, suggesting that participants were able to spontaneously identify the negative concept and look to the correct picture in anticipation of the animation.

To make sure that participants were truly responding to the general concept of negation, and not a simpler sub-concept such as "refusal" or "failure", we examined each of the four subtypes of negation separately. Participants looked more to the target image compared to the non-target image in the non-functional subtype (t(17) = -2.20, p <.05), the nonexistence subtype (t(17) = -3.23, p < .01), and the refusal subtype (t(17) = -4.47, p<.001), but not the unexpected state subtype (t(17) = -1.47, p = .16). The fact that participants spontaneously looked towards the target picture for a wide range of subtypes (i.e., many perceptually different types of images and events) suggests that participants were identifying and responding to a general concept of negation.

Does verbal interference impair participants' ability to identify a concept of negation?

The previous analysis indicated that participants were able to spontaneously identify the negative concept, looking significantly more to the target (negative event) picture compared to the non-target (affirmative event) picture prior to the animation (t(17) = -3.82, p<.01). In the negation/verbal shadowing condition, however, mean looking time was nearly identical between the target and non-target images (M_{target} = 1.239 s, $M_{non\text{-}target}$ = 1.243 s, t(16) = 0.04, p = .97), suggesting that participants' ability to identify the negative concept was impaired under verbal interference. In the natural kind task, mean looking time to the target picture was greater than the mean looking time to the non-target picture in both the no shadowing condition (M_{target} = 1.53, $M_{non\text{-}target}$ = 1.08 s, t(26) = -3.66 s, p < .01) and the shadowing condition (M_{target} = 1.38 s, $M_{non\text{-}target}$ = 1.13 s, t(19) = -2.22, p < .05).

To examine the effect of the interference condition on whether participants looked more to the target or the non-target photograph, separate two-way ANOVAs were conducted for the negation condition and the natural kind condition. In the negation condition, there was a significant interaction between the target image and verbal interference (F(1,66) = 9.39, p<.01), suggesting that participants' ability to spontaneously identify the negative concept was significantly impaired by verbal interference. In the natural kind condition, there was a significant effect of target image (F(1, 90) = 26.12, p < .001) but no effect of verbal interference (F(1, 90) = 0.56, p = .46) and no interaction

between target image and verbal interference ($F(1.90) = 2.09$, $p = 0.15$), suggesting that participants' ability to spontaneously recognize the natural kind concept was not impaired under verbal interference.

General Discussion

We hypothesized that language is necessary for adults to implicitly recognize a unified concept of negation. We expected participants in the non-interference negation condition would implicitly learn to look towards the target picture in the seconds before it animated; that is, with implicit language abilities intact the resemblance across the items as negatives would be evident. Under conditions of verbal interference, where participants cannot implicitly use language to understand the concept, we predicted that participants would be unable to identify the resemblance across the diverse instances of negation. Conversely, we predicted that participants in the natural kind condition (a concept that would not necessarily require propositional structure) would look to the target picture regardless of verbal interference.

These results offer support for our hypotheses. First, participants in the negation condition without verbal interference *were* able to spontaneously identify exemplars of the negative concept despite a lack of verbal instructions telling them what concept to look for. The fact that participants, who were not told anything about the images they would see and were simply told to look at the pictures, were able to look at the negative event in anticipation of the animation suggests that there is some concept of negation that unites these very different exemplars.

Second, participants' ability to identify the tested concept was impaired by verbal interference in the negation condition, but not the natural kind condition. Non-shadowing participants in the negation group looked significantly more to the negation picture than the affirmative picture, while shadowing participants did not look significantly more to one photograph more than the other. In the natural kind group, participants looked more to the natural kind photograph than the artifact photograph, and, critically, this difference was not affected at all in the shadowing condition. This provides support for the hypothesis that language is required to understand a concept of negation, but not to understand other concepts, such as natural kinds.

One possible limitation of this study is that participants may have "passed" the negation task by identifying a simpler concept, rather than truly identifying a general concept of negation. We attempted to address this in our design by creating stimuli that represented a wide range of types of negation. In our analysis of the data, we found that participants were significantly more likely to look to the target picture in three of the four subtypes of negation that we included in our stimuli, suggesting that participants were responding to a general concept of negation rather than succeeding on only a small subset of trials.

Another possible limitation of this study is that the control task (natural kinds) may have simply been easier than the negation task. Although we do not think this is the case (overall looking time to the target picture in the no interference condition was identical across the two conditions, $M = 1.53$ seconds), this could be addressed in future work by using additional control tasks. For example, we could examine a wider range of control concepts thought to not require propositional structure, or use an attentional control task such as rhythmic tapping, which has been used in past verbal shadowing studies (Hermer-Vazquez, Spelke, & Katsnelson, 1999, Newton & de Villiers, 2007).

Our results suggest that some kind of linguistic structure is necessary to understand a general concept of negation. The language-like structure that is required to support propositional thinking could come from a "language of thought" (e.g. Fodor, 1975), or it could come from the structure of natural language (e.g., Hinzen, 2007). One way to tease apart these possibilities would be to examine whether pre-verbal children or non-verbal animals can understand a general concept of negation. Many "language of thought" hypotheses propose that the LOT exists preverbally in children (and facilitate the development of natural language), and perhaps to some extent in non-verbal animals as well (Fodor, 1975, 2008). In the domain of animal research, Premack (1980) attempted to teach three chimpanzees a symbolic system based on plastic tokens that included a token for the word "not." The attempt was only partially successful for one chimp, and unsuccessful for the other two. This would suggest that chimpanzees, at least, are unlikely to be able to represent an abstract concept of negation.

Research on children's acquisition of negation suggests that children begin producing the word "no" to express refusal as early as 12 months (Pea, 1980), and that children as young as 26 months understand denial negation (Austin, Theakston, Lieven, & Tomasello, 2014; Feiman, Mody, Sanborn, & Carey, 2017), though this may be task or context-dependent (Nordmeyer & Frank, 2014; 2018; Reuter, Feiman, & Snedeker, 2017). Under a "language of thought" hypothesis, children should be able to identify and understand a general, non-verbal concept of negation even if they cannot yet articulate this concept in natural language, and therefore children would perhaps be capable of passing a task similar to ours. If natural language is providing the structure to represent propositional negation, however, we would expect to see developmental changes in whether children are capable of understanding a general concept of negation, with pre-verbal (or pre-negation) children failing and older children succeeding.

Future work could examine the role of language in understanding other logical operators, such as "and" and "or", or quantifiers such as "some" and "all". Many philosophers of language have suggested that an important role of language is linking and connecting simple concepts into an infinite number of thoughts and combinatorial, complex concepts (Fodor, 1975, 2008; Carruthers, 2002;

Hinzen, 2007). If this is true, words such as "and" and "or" would be vital to a system of thought, and conversely, it is possible that language is again necessary to form thoughts that require these logical connectives. These logical connectives and quantifiers are necessary aspects of human reasoning, and studying the role that language plays in understanding them could push our understanding beyond simply how we *perceive* the world, providing insight as well into how we reason about the world around us.

References

Austin, K., Theakston, A., Lieven, E., & Tomasello, M. (2014). Young children's understanding of denial. *Developmental Psychology*, *50*, 2061–2070.

Bloom, L. (1970). *Language development: Form and function in emerging grammars*. Cambridge: The MIT Press.

Booth, A. E., & Waxman, S. (2002). Object names and object functions serve as cues to categories for infants. *Developmental Psychology, 38*(6), 948-957.

Carpenter, P., & Just, M. (1975). Sentence comprehension: A psycholinguistic processing model of verification. *Psychological Review*, *82*, 45–73.

Carruthers, P. (2002) The cognitive functions of language, *Behavioral and Brain Sciences, 25*, 657-726.

Choi, S. (1988). The semantic development of negation: A cross-linguistic longitudinal study. *Journal of Child Language*, *15*, 517–531.

Clark, H. H., & Chase, W. G. (1972). On the process of comparing sentences against pictures. *Cognitive Psychology, 3*, 472-517.

Collins, J. (2000). Theory of mind, logical form and eliminativism. *Philosophical Psychology, 13*(4), 465-490.

de Villiers, J. (2010). Structured thought: Language and false belief reasoning. In A. M. Leslie, & T. C. German (Eds.), *Handbook of theory of mind*. Psychology Press.

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.

Fodor, J. A. (1975). *The language of thought*. Cambridge: Harvard University Press.

Fodor, J.A. (Contributor). *The human language series: Part 1: Discovering the human language.* Searchinger, G. (Director). (1994). [Video/DVD]

Fodor, J. A. (2008). *LOT 2: The language of thought revisited*. Oxford: Oxford University Press.

Gelman, S. A. (1988). The development of induction within natural kind and artifact categories. *Cognitive Psychology, 20*, 65-95.

Gelman, S. A., & O'Reilly, A. W. (1988). Children's inductive inferences within superordinate categories: The role of language and category structure. *Child Development, 59*, 876-887.

Hermer-Vasquez, L., Spelke, E. S, & Katsnelson, A.S., (1999). Sources of flexibility in human cognition: Dual-task studies of space and language. *Cognitive Psychology*, *39*, 3-36.

Hinzen, W. (2007). *An essay on names and truth*. Oxford: Oxford University Press.

Just, M., & Carpenter, P. (1971). Comprehension of negation with quantification. *Journal of Verbal Learning and Verbal Behavior*, *10*, 244–253.

Just, M., & Carpenter, P. (1976). Eye fixations and cognitive processes. *Cognitive Psychology*, *8*, 441–480.

Newton, A. & de Villiers, J.G. (2007) Thinking while talking: adults fail non-verbal false belief reasoning. *Psychological Science, 18*(7), 574-579.

Nordmeyer, A. E., & Frank, M. C. (2014). The role of context in young children's comprehension of negation. *Journal of Memory and Language*, *77*, 25–39.

Nordmeyer, A. E., & Frank, M. C. (2018). Early Understanding of Pragmatic Principles in Children's Judgments of Negative Sentences. *Language Learning and Development*, 1-17.

Pea, R. D. (1980). The development of negation in early child language. In D. R. Olson (Ed.), *The social foundations of language and thought* (pp. 156-186). New York, NY: W.W. Norton & Co.

Premack, D. (1976). Early concepts: Same-different, no, and the interrogative. In *Intelligence in ape and man* (pp. 131-161). Hillsdale: Lawrence Erlbaum Associates.

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.

Shutts, K., Markson, L., & Spelke, E. S. (2009). The developmental origins of animal and artifact concepts. In B. Hood, & L. Santos (Eds.), *The origins of object knowledge* (pp. 189-210). Oxford: Oxford University Press.

Wason, P.C. (1965). The contexts of plausible denial. *Journal of Verbal Learning and Verbal Behavior, 4*(1), 7-11.