ABSTRACT

Title of Dissertation: **SYNTACTIC BOOTSTRAPPING IN THE ACQUISITION OF ATTITUDE VERBS**

Kaitlyn P. Harrigan, Doctor of Philosophy, 2015

Directed By: Professor Jeffrey Lidz
Department of Linguistics

Attitude verbs (e.g., *think, want, hope*) report mental states. Learning the meanings of attitude verbs may be difficult for language learners for several reasons; including the abstractness of the concepts that they refer to, and the linguistic properties. In this dissertation, we investigate the learning process for these words, by looking at an asymmetry that has been observed in the acquisition trajectory: *want*, which refers to desires, has been claimed to be acquired before *think*, which refers to beliefs. We explore this asymmetry in attitude verb acquisition in two ways: by comparing interpretation of *think* and *want*, controlling for several methodological differences in the way they have previously been tested; and by investigating children's sensitivity to syntactic distribution in interpreting and learning attitude verbs.

We start with an observation that previous tasks comparing interpretation of *think* and *want* often tested these verbs under different experimental conditions. Tests of *think* required processing additional demands; including a conflict with reality, and a conflict with the child's own mental state. In experiments 1-3, we test interpretation of *want* adding these additional task demands; and find that children are still adult-like in interpreting *want* sooner than they have reliably shown to be adult-like in interpreting *think.* In Experiment 4, we directly compare *think*

and *want* in the same experimental context. We still find adult-like behavior with *want* and not *think.* These studies demonstrate that the observed asymmetry between *think* and *want* reflects a real acquisition asymmetry, and is not due to experimental artifacts.

After establishing in experiments 1-4 that the asymmetry between *think* and *want* reflects real acquisition facts, we explore children's learning mechanism for attitude verbs in experiments 5 and 6. We test children's sensitivity to syntactic distribution in hypothesizing an unknown attitude verb's syntax. In experiment 5, we find that children use syntactic complement to interpret sentences with a potentially unknown attitude verb. In experiment 6, we show that they integrate syntactic information into their semantic representation for this new verb; and continue to hypothesize a meaning based on syntactic frame in future experiences with the same verb.

SYNTACTIC BOOTSTRAPPING IN THE ACQUISITION OF ATTITUDE VERBS

by

Kaitlyn P. Harrigan

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2015

Advisory Committee:

Professor Jeffrey Lidz, Chair
Professor Valentine Hacquard
Professor Alexander Williams
Professor Yi Ting Huang
Professor Peter Carruthers

For Levi, who was there with me every day.

Acknowledgements

I am truly grateful for the contributions of many people in the development of this work. First and foremost, my advisors and collaborators. I am thankful for Jeff Lidz's tough criticism over the past 5 years, which has truly made me a better scientist. His guidance and experience in designing experiments has helped me winnow down a lot of crazy ideas into a set of experiments that have (mostly) worked out really well. Jeff's reminder that being a graduate student is like "being great at checkers, but playing against people who are great at chess" is something I come back to often, and has gotten me through many difficult moments during this process. I'm endlessly thankful for Valentine Hacquard's tireless reading of terrible first drafts. Her thorough input on pretty much anything I've ever written, and on many practice talks has been invaluable. Valentine has had such an important role in shaping this work, and in shaping the way I think about my work and my future in academia.

Each additional member of my committee has also shaped my work and my time at Maryland in important ways. Alexander Williams has been so supportive, and has spent many hours listening to practice talks over the years. His input is often long-winded, but it is *always* valuable and smart. I always come out of meetings with Alexander feeling like I have a deeper understanding of my own work, and a much better understanding of how to present it. I am truly thankful for all the time and thought Alexander has put into helping me. When I first saw Yi Ting give a talk at UMass in 2010, I was impressed not only by her work, but also by her quick thinking and her excellent presentation style. Since she arrived at Maryland several years ago, she has been such a valuable addition to our language science community. She provides excellent feedback and input in class, lunch talks, and lab meetings, and I am extremely grateful for the opportunity to have her read my work as part of this committee. I am also extremely thankful for the opportunities I have had to interact with Peter Carruthers, both during the cognitive science colloquia and in classes. His questions and comments are always thought provoking, and he does an excellent job of making philosophical reasoning accessible to non-philosophers. His extensive knowledge of the Theory of Mind literature makes him an excellent addition to this committee, and I greatly look forward to his insight on this work.

In addition to the faculty members serving as part of my committee, many other faculty members have influenced my work over the last 5 years, either through classes, lab meetings, practice talks, department parties, or any of the many other opportunities we have to interact and collaborate. I am thankful to Colin Phillips, Norbert Hornstein, Howard Lasnik, Paul Pietroski, Ellen Lau, Naomi Feldman, Tonia Bleam, Andrea Zukowski, Peggy Antonisse, Jonathan Beier and Elizabeth Redkay. I am so thankful to be part of a department and community with so many excellent teachers, who have influenced both my learning and my teaching; and where faculty are so willing to spend time listening and providing feedback to students presenting.

I was told when I started grad school that I would learn as much from my peers as I would from the faculty, and this has absolutely turned out to be true. I am thankful to several specific groups: the first is our Theory of Mind reading group. Jeff Lidz, Valentine Hacquard, Aaron Steven White, Shevaun Lewis, Morgan Moyer, Rachel Dudley, and Tom Roberts have all provided helpful feedback on early versions of many of the studies in this dissertation, on data analysis, and on how to present these studies once they were finished. I have enjoyed and benefitted so much from many of the discussions we have had in this reading group.

I am also thankful to our lab, the Project on Children's Language Learning. During my 5

years here, I have had the opportunity to run 418 subjects (!!!), 291 of which are part of the work in this dissertation. This would absolutely never have been possible without the great infrastructure we have in our lab, and without the hard work of many people. First and foremost, I am grateful to every single family that has come into our lab over the past 5 years. Obviously none of this work would be possible without you sacrificing your time and allowing us to test your children. Tara Mease, our lab manager, keeps things running smoothly, works to train undergraduate research assistants, and is genuinely invested in the work that happens in our lab. She has also become a personal friend, and I am especially thankful to her for facilitating a doggie babysitting stint that turned into an adoption.

During my time working in the PCLL, I have had the opportunity to work with many smart and talented undergraduate research assistants, who have helped move my studies forward, and often had great intellectual influence on the projects as well. I am thankful for the help of each of these students: Anna Ball, Courtney Cooper, Ashley Tipton, Sarah Brown, Morgan Moyer, Laura Sherry, Alisha Bonner, Irene Louizou, Emma Nguyen, Faina Kostyukovsky, Jessica Lee, and Jacqueline Phillips. I am especially grateful to Morgan Moyer, a great friend and collaborator, who helped bring Froggy to life; and Ashley Tipton, Courtney Cooper and Anna Ball, who have continued Morgan's legacy, making excellent "Froggys", and who have worked hard to make our task interesting and exciting. I appreciate every song, dance and 'sticker time!' Other graduate students who have worked as part of the PCLL have also greatly influenced this work; both in helping run subjects and providing a soundboard for thoughts and ideas. I am thankful for the input I have received over the years from: Annie Gagliardi, Shevaun Lewis, Megan Sutton, Angela He, Alexis Wellwood, Aaron Steven White, Naho Orita, Julie Gerard, Mike Fetters, Rachel Dudley and Laurel Perkins. I am also grateful to many other graduate students in the department who have listened to practice talks and ideas over the years, including Brad Larson, Dave Kush, Chris LaTerza, Sayaka Goto, Dustin Chacon, Chris Heffner, Zoe Schlueter, Kasia Hitczenko, Alix Kowalski, Dan Parker, and Sol Lago.

I am also grateful to the people who were part of my life as a researcher before I came to Maryland. Jill and Peter de Villiers, my undergraduate advisors, taught me so much about research, and were so involved in my grad school application process. Jill and Peter gave me so many opportunities that helped me get where I am: working in their lab, writing a thesis, designing a linguistics major and giving me my first real job as their lab manager. Jill and Peter have had a tremendous influence on my research, but have also been amazingly supportive of me personally, and I look forward to many years of visiting you in your cottage in Florence! I am also thankful to the other students who worked in the lab with me at Smith: Teresa Kenyon O'Leary, Abby Wilkins Bishop, Emma Thomas, Robin Spencer and Markiesha Grant became good friends and made doing research so much fun. I am also grateful to Angeliek van Hout and Bart Hollebrandse, who both helped me get started on research at Smith, and hosted me at the University of Groningen several times. I am also grateful to Smith College as an institution: your dedication to the education of women has influenced me so much. I could not be more thankful that I ended up there.

In addition to the academic and intellectual support I have received over the last 5 years, I have been so lucky to have an amazing support system in my personal life. I am grateful to my family to everything they have done for me. My mom doesn't talk about feminism, she lives it. She has always been an amazing role model, and has taught me to work hard, be confident, and use guidelines. We are both "intense" and "bossy" and I am so thankful that she passed these qualities on to me. My mom has been an amazing personal support system, but has also turned

out to be an excellent source for experimental materials. She made the wooden shapes we used in experiments 4-6, and has made beautiful drawings for a follow-up study that is in the works. I love that she has had this part in my work, and that even though I am an adult, she is still willing to help with school projects. My dad is smart and quiet, and has taught me the value of listening. He is such a kind and supportive person that it is impossible not to want him to like you. This makes him an excellent teacher, and this is a strategy that I have tried to adopt in my personal teaching and mentoring. My sister is basically a better version of me: she is smart and funny and kind and responsible and we look like twins; I am grateful every day for her friendship.

I have so many friends who have become like family to me. Megan Sutton, an amazing camping partner and co-teacher, whose kindness and support on difficult days have helped me get through this program. My friends in my cohort: Aaron Steven White and Dustin Chacon. I don't think I've ever had friends who could simultaneously mean so much to me and also drive me so crazy. Aaron loves to pretend that he is aloof and doesn't care, but he is secretly a super nice and helpful guy. I am so thankful he has been here to reassure me when I need to vent, or I am worried that I am not smart enough for this. From my first experience with Dustin at grad student orientation, I realized it is impossible to be around Dustin and not have fun. I love that he makes me laugh when I need to laugh, feels sad with me when I am sad, and cried more than anyone else at my wedding. Morgan Moyer started as a research assistant on my project, and has become a very good friend. Morgan is kind and giving and a good listener. She is also a ton of fun, so if you ever want to stay out all night dancing and then eat a plate of sauce in bed, she is the friend to do it with. Mike Fetters has become my go-to person for almost everything over the past year. Mike makes me laugh, is a great listener and has spent so much time at my house that we call our guest room "Mike's room". Teresa Kenyon O'Leary has helped me through this process more than she could ever know. She texts me daily to make sure I am ok; and has sent me cards in the mail almost weekly for the past several months, even though she juggles a demanding career and family. Teresa is an amazing role model: she is kind and graceful and works super hard at everything she does. I am in situations almost daily where I find myself asking, "What would T do?" I don't know what my future holds, but I do know I want to live next door to you and be best friends forever. I am grateful for the friendship of many others who have been amazing and supportive over the past several years, including David Noftsier, Bruce O'Leary, Bonnie O'Keefe, Anna Ball, Shevaun Lewis and Faina Kostyukovsky.

Finally, I am thankful for my amazing husband, without whom the past 5 years would have been a lot more difficult, and a lot less fun. I have been hard to live with for a lot of the past year, and you have been kind and patient and supportive. I cannot thank you enough for that. Thank you for listening to countless practice talks, letting me take over all your devices for working, and doing pretty much all the cooking and dishes for the past 6 months. I love you and I like you.

TABLE OF CONTENTS

List of Tables

List of Figures

Chapter 1: Introduction

1.1 The Learning Problem

Attitude verbs, like *think, want* and *hope,* seem to be acquired later than other verbs. Additionally, some attitude verbs seem to be acquired later than others. Why should this be the case? Obervations about the difficulty of word-learning began with Quine's observation (1960) that given a rich context and a novel word, there are in infinite number of possible meanings that could be assigned to that word. Physically, there are an infinite number of possible referents given any visual scene; but in addition, the learner must be attuned to the *speaker's* representation of the scene. There is nothing about the world or about communication that forces everyone to see the same scene under the same description. Given this observation, the word-learning problem seems almost insurmountable. Fortunately, advances in cognitive development have revealed that humans share a lot of conceptual capacities. These cognitive capacities constrain how we see the world, even from infancy. From just a few months old, infants have rich concepts of continuity of objects, gravity, event representation and more (Behl-Chadha 1996, Carey 2009, Eimas & Miller 1990, Mandler 1988, Quinn & Eimas 1986, Soja, Carey & Spelke 1991, Spleke & Kestenbaum 1986, Spelke, Kestenbaun, Simons & Wein 1995, Xu & Carey 1996, and others). These rich cognitive and social capacities can help explain how children are able to overcome Quine's problem.

In the case of attitude verbs, however, there may still be problems to overcome. Perhaps observability is a bigger problem than in other cases of word-learning. After all, psychological events like *thinking* and *wanting* do not have direct physical correlates in the world; like objects, such as *dog* or *cat*, or even some actions, like *running* or *eating*. Although on the surface, this seems to be a huge problem, it may not be as difficult as it initially appears to be. In addition to sharing rich conceptual and perceptual abilities, infants have been shown to track the minds of others with astonishing ease. From the first months of life, infants give privileged status to human agents, and are sensitive to conversation partners' goals and perspectives. They attribute goal-directedness to human agents from as young as 5 months of age (Woodward 1996). This sensitivity to other people's minds also aids children in language acquisition. Children can track eye-gaze and use this to learn new words by 16 months old (Baldwin 1991, Bloom 2000, Moore & Corkum 1994, Smith, Jones & Landau 1996, Plunkett 1997). By 2 years old, children are adult-like in their interpretation of indexical pronouns, which shift reference based on conversational roles (Moyer, Harrigan, Hacquard & Lidz 2014). Given these facts, linking psychological concepts with words may be something that can occur just as easily as learning other words; even given the lack of physical evidence in the world. If, due to this richness of the learners' representations of other minds, this linking is indeed straightforward, we expect children should acquire attitude verb meanings with relative ease.

This appears to be the case for some attitude verbs. Children are producing sentences with *want* to express desires as young as 18 months (Bartsch &

Wellman 1995), and seem to be very good at understanding sentences with *want* by around 3 years of age (Wellman & Wooley 1990, Stein & Levine 1989, Wellman & Bartsch 1988, Yuill 1984, Hadwin & Perner 1991, Wellman & Banerjee 1991, Bartsch & Wellman 1995, Repacholi & Gopnik 1997, and others). This is consistent with the idea that the concept of desire is readily available to very young children, that they are proficient from a very young age at tracking others' minds, *and* that their sophisticated cognitive capacities allow them to link the word *want* with the concept of desire with relative ease. For the verb *think*, however, we see a different trajectory. Many studies have found that children have difficulty understanding sentences with *think* well into their fourth year, in particular when the sentences refer to someone's false belief (de Villiers 1995, 2005, 2007, de Villiers & de Villiers 2000, de Villiers & Pyers 2002, Johnson & Maratsos 1977, Lewis 2013, Perner et al. 2003, Wellman, Cross & Watson 2000, Wimmer & Perner 1983, and others). Given the evidence for children's rich cognitive capacities and social sensitivity that make other word learning, including some attitude verbs, so easy, why should we see such difficulty with *think*?

1.1.1 Potential difficulties in attitude verb acquisition

Learning the meanings of attitude verbs may be particularly challenging to learners for a variety of reasons. One potential difficulty is the fact that they refer to mental states, which can differ from reality, or from the child's own mental states. For example, either of the sentences below can be true, even if Aaron is not

actually at Qualia, or the speaker of the sentence holds different beliefs or desires about Aaron's location.

(1) *Mike thinks that Aaron is at Qualia.*

(2) *Mike wants Aaron to be at Qualia*.

In order to truly understand *think* and *want* in an adult-like way, the child must be able to interpret sentences about mental states even when they conflict with reality, or the child's own mental state. This may be difficult, as it requires keeping track of both reality, as well as the (potentially false) mental state.

Perhaps there are linguistic factors making attitude verbs more difficult than other verbs. Attitude verbs can occur in syntactically complex contexts—often times occurring with a sentential complement.

(3) *Aaron thinks [that Qualia has the best coffee in DC.]*

Many other verbs can occur with no complement, or with just a Noun Phrase (NP) complement (4)-(5).

(4) *Aaron walks.*

(5) *Aaron drinks coffee.*

While some attitude verbs can occur with a simple NP complement (6), others cannot (7). This means that some attitude verbs, like *think*, will only occur in syntactically complex contexts.

(6) *Aaron believes the story.*

(7) **Aaron thinks the story.*

Perhaps the delay in attitude verb acquisition is due to the fact that, compared to other verbs, a greater amount of syntactic competence on the part of the child may be required for some attitudes.

Another possible difficulty that may arise for children learning attitude verbs is the pragmatic contexts in which attitude verbs often get used. At times, what a speaker intends to convey by using a particular utterance goes beyond the literal meaning of the sentence. This is sometimes referred to as the 'speaker meaning.' For example, see the exchange in (8).

(8) Speaker A: *Would you like some coffee?*

Speaker B: *I need to be up early in the morning!*

In this case, speaker B's utterance is on the surface irrelevant to speaker A's question. But, speaker A understands B's meaning here, because A *assumes* B to be following a set of conversational principles, first proposed by Grice (1975), and additionally, the two participants share some world knowledge. Grice observed that speakers attempt to be as informative as possible, giving as much information as is needed, and no more (*maxim of quantity*); to be truthful, not giving false information (*maxim of quality*); to be relevant, only saying this that are pertinent to the discussion (*maxim of relation*); and finally to be clear and brief (*maxim of manner*). In this case, speaker A understands B's utterance as a polite refusal of her offer. A knows, given facts about the world that are common knowledge to most adults, that coffee has caffeine, caffeine keeps people awake, if B needs to get up early then she should go to bed early, which will be difficult if she has caffeine at the time of the exchange. A assumes that B is following the

maxim of relation, and that although the utterance is on the surface irrelevant, A works to understand the relevance in this context. Additionally, B is likely not spelling out her entire thought process because she is attempting to follow the maxim of quantity—not giving more information than is necessary to convey one's intended meaning. Because we, as speakers and listeners, follow these conversational principles and assume our conversation partners do as well, A likely has no difficulty interpreting B's utterance as meaning something like in (9).

(9) Speaker A: *Would you like some coffee?*

Speaker B: *I need to be up early in the morning! = No, I would not like coffee.*

Speaker A computes a "relevance implicature", understanding that what B intends to convey goes beyond the literal meaning of the utterance.

Attitude verbs can often be used to convey more than the literal meaning of the utterance. For example, a parent uttering the sentence in (10) to a child probably means something more than the desire expressed in the sentence.

(10) *I want you to be in bed by the time I get home!*

The sentence in (10) is easily interpreted in this context as an indirect command—the parent is telling the child to go to bed by a certain time (11).

(11) *I want you to be in bed by the time I get home! = Go to bed.*

If children have learned the literal meanings of attitude verbs, they may have difficulty computing these relevance implicatures, and understanding what the point of the utterance is. However, research in several different domains,

including infant cognition and experimental pragmatics, shows that children seem to be very good at tracking speaker's perspectives and intentions, and understanding a speaker's meaning even when it differs from the literal meaning of an utterance. We have seen that from infancy, humans are very sensitive to the perspectives of others, and to social cues in communication. Additionally, by 3 years old, children have been shown to be quite pragmatically sophisticated. Although traditionally, children were found to have difficulty with computing implicatures, more recent work has shown that given the right methodology, children compute scalar implicatures (Papafragou 2006, Papafagou & Musolino 2003, Papafragou & Skordos, to appear, Papafragou & Tantalou 2004); and they have been shown to be adult-like in their understanding of indirect requests (Lewis, Harrigan & Lidz 2012, Lewis 2013), both cases where literal meaning differs from speaker meaning. The difficulty with attitude verbs may actually be driven by this pragmatic sophistication: perhaps children are so attuned to speaker meanings in sentences with attitude verbs that they have difficulty extracting the literal meanings.

The problem this thesis will address is *why* we should see difficulty in learning the meaning of the word *think*, but ease in learning the meaning of the word *want*; given the observed facts about their cognitive capacities and social awareness. Children seem to share many cognitive capacities from birth, and there is a rich body of evidence that they are very sensitive to the minds of others and sophisticated in their pragmatic reasoning. The purpose of this thesis is to better understand this asymmetry, and to apportion credit and blame between syntactic,

semantic pragmatic, and conceptual factors, using this evidence to explain children's behavior. Whatever the source of the asymmetry in the acquisition of *think* and *want*, children have difficulty with *think* but not *want.* In particular, we explore whether one learning cue for children in acquiring these verbs is their syntactic distribution.

We will explore both methodological concerns in comparing *think* and *want* (experiments 1-4), and children's sensitivity to syntactic environment in interpreting and learning attitude verbs (experiments 5-6). We will ultimately conclude that previous and current findings are consistent with the hypothesis that children's difficulties with belief reports are due to pragmatic difficulties. We will argue that the semantic properties, and the pragmatic factors that may be causing difficulty in the case of interpreting *think* may be accessible to the child, at least in part, because of the syntactic complements that each verb takes. The studies presented here will show that children are sensitive to syntactic complement in interpreting attitude verbs, providing further evidence that difficulty with *think* could be caused by pragmatic differences between *think* and *want*, which may be accessible to children via the syntax.

1.2 Contribution

It has been observed in previous literature that children are adult-like in interpretation of sentences containing *want* before they are adult-like in interpretation of sentences with *think* (Wellman & Wooley 1990, Stein & Levine 1989, Wellman & Bartsch 1988, Yuill 1984, Hadwin & Perner 1991, Wellman &

Banerjee 1991, Bartsch & Wellman 1995, Repacholi & Gopnik 1997, Wimmer & Perner 1983, Wellman et al. 2000). Specifically, they have been shown to make errors in interpreting sentences about someone's false beliefs, responding based on reality, or their own knowledge, and not taking into account the mental state of the subject of the sentence (de Villiers 1995, 2005, 2007, de Villiers & de Villiers 2000, de Villiers & Pyers 2002, Perner et al. 2003, Lewis 2013). Regardless of the cause of children's errors in interpreting *think*, many studies have shown differences in acquisition trajectories for *want* and *think;* suggesting that whatever the cause of *think*-errors, children are susceptible to reality-errors in one case, but not the other by their preschool years.

This dissertation will fill in some missing pieces in the landscape of our understanding of children's knowledge of *want* and *think*. Additionally, we will ask whether syntactic distribution plays a role in children's acquisition of attitude verbs. I will present 6 studies looking at preschoolers' knowledge of *want* and *think*; as well as the verb *hope*, which we will use to test children's sensitivity to syntactic frame in their acquisition of attitude verbs. This dissertation addresses two specific topics related to attitude verb acquisition:

1. Is the performance asymmetry observed between *want* and *think* due to an acquisition difference? Or have differences in tasks demands inflated children's knowledge of *want* or masked understanding of *think*?
2. If the observed asymmetry reflects an acquisition difference, is the syntax of these verbs cuing them in to semantic class?

In chapter 2 I review the literature on children's interpretation of sentences with *think* and *want*, as well as their performance on related belief- and desire-tracking tasks. I briefly review several proposals explaining children's difficulty with *think,* summarizing how they fit in with the observed data. I then point out several specific methodological differences in the conditions under which *think* and *want* have been tested, which may have made tests of *think* more difficult than tests of *want.* These factors include setting up a conflict with reality, and a conflict with the child's own mental state. We conclude that these task difference may have contributed to the observed difficulty with *think* and ease with *want*, and experiments designed to control for these lingering unresolved factors are necessary. These manipulations are particularly critical for some accounts that blame the difficulty with *think* with on task demands. If this is the case, we expect to see the same difficulty in interpreting *want* when the same task demands are introduced.

In chapter 3, we present 4 original experiments addressing the concerns raised in chapter 2. In Experiments 1-3, we test the verb *want* under conditions more analogous to the way *think* has traditionally been tested, increasing the task demands of interpreting sentences with *want* as compared to previous studies. In experiment 1, we introduce a conflict with reality. In experiments 2 and 3, we introduce a conflict between a character's mental state and the participant's mental state. We show that children are still adult-like in their interpretation of *want*, and it has not been the conditions under which *think* has been tested that are the cause of children's reality errors. In Experiment 4, we test *want* and *think* directly,

comparing them under the same experimental conditions. Again, we find success in interpreting *want,* and see the influence of reality on children's interpretations of sentences with *think*. This suggests that the difficulty with *think* cannot entirely be due to task demands created in explicit belief-reasoning tasks.

In chapter 4, we will further explore the role of linguistic features that may contribute to children's acquisition trajectories for each of these verbs. We explore the relation between the syntactic distributions of attitude verbs, their semantic features and pragmatic uses. We review our bootstrapping account of attitude verb acquisition (following Gleitman 1990, Landau & Gleitman 1895, and others). Given that we do replicate the asymmetry between *think* and *want*, we will explore whether syntactic distribution serves as a cue to learners. We introduce the verb *hope* as a test case. *Hope* shares syntactic and semantic features with both *think* and *want*, making it an ideal probe for sensitivity to syntactic frame. In experiments 5 and 6, we test interpretation of sentences with the verb *hope*, manipulating syntactic frame both between (experiment 5) and within (experiment 6) subjects. We show that children are in fact sensitive to the syntax when interpreting a potentially unknown attitude verb.

In chapter 5 I will summarize the findings in this dissertation, and further discuss the proposals for difficulty with *think*, reviewing how each of them fit with the findings presented in this dissertation. I then discuss future directions, which will focus on better understanding the mechanism for learning attitude verbs. The 6 experiments in this dissertation address questions left open in the literature. Each experiment addresses predictions made by accounts of the delay

in interpretation of *think* sentences. Experiments 1-4 address differences in task demands that may have contributed to the observed asymmetry between acquisition of *think* and *want*, and show that even under the most stringent comparison, children are adult-like in interpreting sentences with *want* before *think.* Experiments 5-6 further explore the role of linguistic features in the acquisition trajectories of *think* and *want*. We demonstrate that children are sensitive to syntactic distribution in interpreting attitude verbs, and propose that children may be using the syntactic and pragmatic features to access information about attitude semantics; and that differential pragmatic uses for *think* and *want* are ultimately responsible for the asymmetry.

Chapter 2: Background

2.1 The *think/want* Asymmetry

Across many studies looking at explicit belief and desire reasoning with conflicting mental states, children have been shown to have difficulty reasoning about beliefs and interpreting sentences with *think;* but have no such difficulty reasoning about desires and interpreting sentences with *want.*

2.2.1 *Think* and the False Belief Task

In a series of classic studies in the late 70's and early 80's (Wimmer & Perner 1983, Johnson & Maratsos 1977, and others), It was observed that children have difficulty predicting the actions of agents based on false beliefs, or beliefs not in accordance with the child's own. In a representative study by Wimmer & Perner (1983), an agent has a false belief about the location of an object, and the child is asked where the agent will look for the object. A sample story from this study is below:

> *"Mother returns from her shopping trip. She bought chocolate for a cake. Maxi may help her put away the things. He asks her: 'where should I put the chocolate?' 'In the blue cupboard', says the mother.*
>
> *'Wait, I'll lift you up there, because you are too small.'*
>
> *Mother lifts him up.*

Maxi puts the chocolate into the blue cupboard. [A toy chocolate is put into the blue match box.] Maxi remembers exactly where he put the chocolate so that he could come back and get some later. He loves chocolate. Then he leaves for the playground. [The boy doll is removed.] Mother starts to prepare the cake and takes the chocolate out of the blue cupboard. She grates a bit into the dough and then she does not put it back into the blue but into the green cupboard. [Toy chocolate is thereby transferred from the blue to the green match box.] Now she realizes that she forgot to buy eggs. So she goes to her neighbor for some eggs. There comes Maxi back from the playground, hungry, and he wants to get some chocolate. [Boy doll reappears.] He still remembers where he had put the chocolate."

Belief Question: 'Where will Maxi look for the chocolate?'

The classic finding for this type of task is that by 5 years old, are able to answer correctly: Maxi will look where he last saw the chocolate, because he does not know that mother has moved it. Younger children, 3-year-olds and some 4-year olds, answer based on reality, or their own beliefs: Maxi will look for the chocolate in the location where it *actually is*, and not the location where Maxi last saw it, or believes it to be.

The findings for children's performance on this type of task are extremely robust, and persist even through many different instantiations of the task. Wellman, Cross & Watson (2001), conducted a meta-analysis of false belief tasks,

spanning 178 different tasks conducted to look at children's explicit belief representation abilities. This study looked very thoroughly at many different possible factors that may influence performance on false belief tasks. They find a clear developmental pattern emerge across this range of studies, showing a substantial age effect across every analysis. From the youngest age tested, around 30 months, children respond significantly below chance on false belief questions, giving "reality" responses most of the time. At around 44 months, we see a shift occur: as a group, children perform at chance, around 50% correct on false belief questions. And finally, at an average of around 48 months, children perform significantly above chance; and several months after that, they perform like adults. Errors persist with younger preschoolers whether the question is asked in terms of Maxi's actions (i.e., *where will Ma*xi *look for the chocolate*), his beliefs (i.e., *where does Maxi think the chocolate is?*), or his speech (i.e., *where will Maxi say the chocolate is?*).

A few task manipulations were found to improve younger children's performance. The first is deception: children's performance was found to improve in cases where the protagonist of the story was explicitly trying to trick another person. A second factor found to slightly improve children's performance was that of the salience of the false belief in the story. These two factors may be related. It is possible that deception in this case is a subcategory of salience; perhaps the only role of deception in this case is that it increases the salience of the belief. It should be noted, however, that while tasks involving these factors did find slightly earlier success on false belief tasks, neither factor affected

performance enough to show children in the youngest age groups passing the task consistently. The authors of this meta-analysis argue that this demonstrates that it is ultimately not task factors driving children's errors on these tasks, but an underlying developmental change that occurs sometime around 4 years of age.

2.2.2 *Want* and Testing Desires

In addition to the interest in children's belief representation capacities, researchers have also explores children's ability to predict the actions of others based on their differing desires. In a task that was very similar to the traditional false belief task, Wellman & Woolley (1990) gave 2-year-olds information about different characters' desires in a story, and participants were asked to make predictions about each person's actions. They found that 2-year-olds were successful at predicting actions related to people's simple desires.

2.2.3 Comparing *think* and *want*

2.2.3.1 Production

Children start producing the verb *think* soon after their second birthday. The early uses of *think*, however, are generally formulaic, and do not refer to genuine mental states. It is not until around three years of age that they begin to use *think* in a way that refers to beliefs, and even later until uses of *think* that refer to conflicting beliefs show up in natural speech (Bartsch & Wellman, 1995). Children are begin producing the verb *want* by around 18 months, and it has been argued that by two years of age their use of the verb *want* is well-established.

Unlike with *think*, by this age, uses of *want* seem to represent genuine references to desire. In one analysis, as many as 74% of their desire references appeared to refer to genuine desires as opposed to conversational or idiomatic uses (Bartsch & Wellman, 1995). Of course, the vast majority of early uses of *want* are in its simplest syntactic frame (*want + Noun Phase (NP)*), and thus make for a difficult comparison with *think*, which is not grammatical in this syntactic frame.

2.2.3.2 Comprehension

Previous studies also indicate that children understand sentences with *want* sooner than sentences with *think.* However, we will see upon closer inspection of the literature, that these studies have not always compared desire and belief situations in a fair way.

A classic study by Perner et al. (2003) directly compares German-speaking children's understanding of sentences with *want* and sentences with *think*, in situations that were minimally different. In this study, children (2;5-4;5) saw six stories, each of which were accompanied by a drawing. For example, in one story, Mom and Dad are in one room and their son Andy was watching television in his bedroom. In the *want* condition, Mom asks Dad to see what Andy is doing. Dad asks Mom what Andy should do, and Mom answers, "Andy should go to bed." Then the child was asked the *want* test question, shown in (61).

(12) *Was will die Mutter, dass Andreas tut?*
What wants the Mom that Andy does?
'What does Mom want Andy to do?'

In the *think* condition, Dad asks Mom what Andy is doing and she answers,

"Andy is going to bed." Then the child is asked the *think* test question, shown in (62).

(13) *Was glaubt die Mutter, dass Andreas tut*

What thinks the Mom that Andy does?

What does Mom think that Andy is doing?

They find that children are much better at answering the questions with *want* than with *think*, and conclude that it is easier for children to remember discrepant desires than discrepant beliefs.

2.2.4 Implicit Belief and Desire tracking

In recent years, we have seen advances in implicit methodologies designed to test children's conceptual knowledge. These methods measure eye gaze and looking time, which can be used with children as young as a few months old. These measures can shed light on the knowledge of children much younger than children can appropriately participate in tasks that require them to answer questions or point.

2.2.4.1 Implicit belief tracking

In what appears to be a stark contrast to the robust results for children's performance on explicit false belief tasks, recent studies using implicit methods have found that children seem to be able to track the belief states of others, and predict actions based on these belief states, from a very young age. In a study looking at children's ability to track beliefs in an implicit task, Onishi & Baillargeon (2005) test 15-month-olds using a violation of expectations task. In this type of task, children see a story unfold in a short video, and then two groups

see two different endings: one in which the "expected" outcome occurs, and one in which an "unexpected" outcome occurs. Researchers then compare the time that each group of infants spent looking at the outcome. A significant difference in looking time between the two outcomes demonstrates that infants are sensitive to the difference between them.

In the classic Onishi & Baillargeon task, infants see an agent put an object in a location, and then leave the scene. While the agent is gone, the object moves to a new location. During the test phase, infants in one group see the agent reach for the object in the first location, where the agent would appropriately reach to get the object. Infants in another group see the agent reach for the object in the second location. The second location is the current location of the object, but the agent reaching here is unexpected, given that she has no reason to know that this is the object's current location. They find that infants in the second group were surprised by her behavior. They look longer at "unexpected" outcome during the test phase, showing that they are able to track her beliefs about the object's location, and are surprised when she does not act accordance with these beliefs.

In another study demonstrating very young children's sensitivity to beliefs in implicit tasks, Southgate (2007) shows that children's eye gaze patterns are consistent with their expectations for agents to act in accordance with their false beliefs. She tests 2-year-olds in an eyetracking task. In this task, an agent reaches into a box to get an object. While the agent is distracted, another character comes in and moves the object to a second box. Participants' eye movements are tracked to gauge which box they think she will reach into when she returns her attention

to the boxes to get the toy. Southgate finds that 2-year-olds expect the agent to reach into the box consistent with her false beliefs about the location of the object, not the box where the object actually is.

In the past 10 years since the original Onishi & Baillargeon study was published, researchers have found evidence of infants' sensitivity to beliefs using many different variations of belief tests adapted for younger children and implicit measures. Children as young as 7 months old have been shown to be sensitive to others' false beliefs on this type of task (Kovaks 2010), suggesting that the concept of belief may be in place much earlier than the 4 years of age that was originally proposed.

2.2.4.2 Implicit desire tracking

Unlike the belief literature, the desire literature has long found children to be successful in desire-representation tasks as young as they can be tested using explicit measures. Children as young as 2 years of age have been shown to be good at representing the desires of others, and have been shown to expect agents to act in accordance with their desires. Using explicit tasks, there is a lower limit on the age at which children can pass, or even participate in a task, given that a certain level of verbal skills must already be in place in order for the child to participate. Researchers were concerned very early on with implementing more implicit tasks to tap desire representation, as it was clear that children seemed to succeed at such a young age in explicit tasks.

In a classic "implicit desires" task, Repacholi & Gopnik (1997) examined whether 14- and 18-month-olds could appropriately represent the desires of an

agent that potentially differed from the child's own. They designed a non-verbal task, requiring an ecologically valid response, appropriate for children of this age. In the task, the child is introduced to two familiar and distinctive foods: goldfish crackers and broccoli. After introducing each food, the researcher produces a salient response—either positive or negative—toward each of the foods, and then requests that the child give her some food. In order to control for the possibility that children assume that everyone has the same desires, or the possibility that the child will give the experimenter their own non-desired food in order to keep the desired food for themselves, experimenters manipulated whether the experimenter expressed preference for the same or the opposite food from the child's preferred food. The authors find that most of the children preferr the crackers. They find that at 14-months, children are more likely to give the researcher the crackers, regardless of which food she had expressed preference for. By 18 months, however, the children are more likely to give the experimenter the food that she preferred, regardless of whether it matched the child's preference or not. This study shows that by 18 months, children seem to represent that different people may have different desires from their own.

Other studies have tested even younger children's desire representation using eye gaze measures. Woodward (1998) tests 5- and 9-month olds in a looking-time paradigm. In her task, infants see an agent reach for one of two objects situated next to each other. After children are habituated to this action, the positions of the objects switch, and the agent either reaches for the same toy (now in a new position), or makes the same arm movement (reaching for a new toy).

Infants look longer when the agent reaches for a new toy, even though in this case the agent's arm motion is the same as in familiarization. Woodward finds that this pattern holds for both 9-month olds, and (although with weaker results) also for 5-month olds. The same pattern does not hold for 9-month olds when a non-human grasping device was used. This set of studies demonstrates that by as young as 5 months old, infants can encode the actions of agents, attributing goals to them. This could be seen as an early form of "desire representation." The literature investigating children's sensitivity to the beliefs and desires of others suggests that both concepts seem to be online early, but that in explicit tasks intended to tap others' beliefs, children have difficulty.

2.2.5 Summary of *Think-Want* Asymmetry

The results from the literature looking at belief and desire reports, and the literature looking at infants' ability to represent the contents of other minds show an interesting pattern. Both the concepts of belief and desire may be in place from very early on, but only in the case of desire are children able to explicitly reason about conflicting cases.

2.3 Explanations for the difficulty with *think*

A range of explanations have been proposed to explain the observed difficulty with belief reports. These explanations fall into two basic categories, what we will call *conceptual accounts* and what we will call *deployment accounts*. Conceptual accounts have claimed that the difficulty with belief is conceptual in nature: that the concept of belief is simply more difficult than the

concept of desire. This difference causes children to acquire the concept of belief, or have access to it, later than the concept of desire. Others have claimed that the difficulty with belief is not strictly conceptual in nature, but that there are interactions between the belief concept and other cognitive systems, such as executive function or language. These interactions may occur in the case of belief but not desire for several different reasons, including the particular methodological conditions under which belief, but not desire, has been tested, which I will address in section 1.4.

2.3.1 Conceptual accounts

Several research groups, including Perner and colleagues and Gopnik and colleagues, have claimed that there is difficulty with the concept of belief. In particular, they have proposed that the concepts of belief and desire are acquired or learned over the course of the child's development (Flavell 1988, Forguson & Gopnik 1988, Perner 1988, 1981, Perner et al. 2003, Perner et al. 2005, Perner & Ruffman 2005). Perner and Gopnik have explained the asymmetry by proposing that the concept of belief is simply acquired later than the concept of desire; perhaps due to the inherent complexity of each concept, and perhaps due to environmental factors, such as the amount of experience children are likely to receive that guides them toward learning each concept. If this the case, then it reasonably follows that we would see later acquisition of verbs that reference this mental state.

In some ways, a conceptual account for differences in the emergence of the ability to represent desire and belief concepts is extremely compelling. For

example, we see desire emerging early and belief later across many kinds of tasks. Belief follows desire in tasks that aim specifically to test conceptual representation of these concepts, such as cases where children are asked to predict the actions of an agent; as well as in linguistic tasks testing children's interpretation of sentences with *think* and *want*. A conceptual development account can explain why we see children's performance on these two types of tasks tracking each other—children can neither predict action based on belief *nor* interpret sentences with *think* if they do not yet have access to the concept of belief.

The recent studies, however, presented in the above section 2.2.4, demonstrating that given the right type of task, much younger children show sensitivity to the false beliefs of others, potentially create a problem for a conceptual account. It is difficult to reconcile these results with the robust findings showing difficulty with preschoolers in belief-tracking tasks. Proponents of the conceptual account argue that children may be using "complex behavioral rules" to pass these tasks, even without an adult-like ability to represent beliefs (Heyes 2014, Thoermer et al. 2012, and others). Heyes (2014) has argued that due to the indirect nature of implicit tasks, that it's hard to interpret the results, and that the looking-time responses that some have claimed measure "surprise" could in fact be a "low-level novelty" response, and therefore not successfully demonstrating infants' representation of the mental state of the agent. Thoermer et al. (2012) have claimed that the infant data is worrying based on longitudinal findings, which suggest that longitudinal continuity is task-specific.

In perhaps the most compelling explanation of the seemingly contradictory evidence from infants and preschoolers, Apperly, Butterfill and colleagues have argued that humans use two distinct belief-reasoning mechanisms: a fast, efficient, low-level system, which infants have, and can use to perform on the implicit tasks; and a slower, but more powerful system, which is required to truly track beliefs in an adult-like way, which infants do not have (Apperly & Butterfill 2009, Butterfill & Apperly 2013).

Even if the infant tasks are truly measuring adult-like belief tracking, it is still necessary to explain *why* we see this implicit-explicit asymmetry on performance in belief tracking studies. If this belief concept is not available from an early age, what exactly is allowing children to perform in an adult-like way on the implicit tasks? If the concept is available from an early age, what is causing them to fail on explicit belief tasks, but not desire tasks? The account proposed by Butterfill, Apperly and colleagues makes progress in explaining why we see the observed pattern of results on implicit and explicit belief tasks, although this account does not provide a satisfying explanation for the belief-desire asymmetry.

While it is always still possible there is a conceptual difference is the root of children's difficulty in interpreting *think*; the recent work with infants sheds doubt on a conceptual hypothesis which claims children must *learn* the concept of belief, and they do not do so until the preschool years. If in fact, as the infant data suggests, that both the concepts of belief and desire are in place early, then the difficulty that we see in interpretation of *think* may be due to some other factor, such as task demands required in the experiments that have been designed to test

children's knowledge of *think*, or linguistic factors that differ between *think* and *want.*

2.3.2 Deployment Accounts

While some researchers have claimed that the difficulty with *think* ultimately lies with representing the concept of belief, many others have argued that there is no deficit with children's ability to represent beliefs. Other proposals have claimed that the difficulty observed with interpretation of *think*-sentences is a result of the *deployment* of the belief concept, and the interaction between this concept and other cognitive systems. This is to say, children's ability to represent others' beliefs is fully intact, but children are failing in explicit tasks for other reasons. There are several different proposals for where exactly the failure lies: some have claimed that certain elements of the tasks that have been used to test *think* are masking children's competence with beliefs. In particular, one prominent account has claimed that deficits in executive function are interfering in the tasks that have been used to test belief reasoning, and ultimately causing children to fail on these tasks.

Other accounts have claimed that the failure in belief tasks is due to language factors. Claims about language factors have taken shape in several different ways: some have claimed that the failure is due to deficits in syntactic abilities, or the semantic representation for the word *think*. Others have claimed that children's syntactic and semantic abilities for interpreting sentences with attitude reports are adult-like, and the observed difficulty with *think* is due to

pragmatic deficits. In the following section, we will walk through each of the hypotheses.

2.3.2.1 Interaction with Task Demands

Many researchers have proposed alternative accounts to the conceptual hypothesis; claiming that there is no conceptual difference between children's abilities to represent beliefs and desires; but that certain elements of the belief and desire tasks that have been used give rise to the appearance of an asymmetry. The first type of argument says that children are actually *worse* at representing desires than it initially appears that they are.

Moore and colleagues, and Rakoczy and colleagues explore whether the difficulty in belief but not desire tasks is due to traditional belief tasks requiring children to understand *think* under the most difficult possible conditions. Both Moore and Rakoczy explore whether testing sentences with *want* in an equally complex way reveals such difficulties in desire situations as well.

Rakoczy et al. (2007) probed the belief/desire asymmetry by asking whether children are better at talking about desires earlier than beliefs because they have an *objective* concept of desirability, and so cannot represent different people having *non-compatible* preferences in a given situation. To test this, they tested children's understanding of incompatible desire situations, comparing their performance on this task to their performance on a traditional false belief task. In the incompatible desires task, they show children (3;0-3;6) stories in which two characters "quarrel" about which of two either compatible or incompatible outcomes they preferred. In the compatible desires stories, two characters are each

in boats. One character wants his boat to go to one location; the other wants her boat to go to another location. The boats then go to one of the two locations. The incompatible desires stories are the same, except that both characters are in a boat together, thus it is impossible for each character's desire to be satisfied simultaneously. After the story, the children were asked the test questions shown in (63) and (64).

(14) *Susi wanted the boat to go where?*

(15) *And Tom wanted the boat to go where?*

Children perform significantly better on these questions in incompatible desires tasks than on false belief tasks. Because children in this study were younger than the age at which they perform well on tasks testing *think*, the authors conclude that children can represent incompatible desires before they can represent false beliefs.

In another test looking at representation of conflicting desires, Moore et al. (1995) look at three year olds' interpretation of conflicting desires in a task in which they play a game against a puppet, "Fat Cat." Both the child and Fat Cat have to solve their own jigsaw puzzle for which they need parts from a blue or red box. In each round, a card is drawn from a stack, turned around and shown to be either blue or red. Both players can then take a piece from the corresponding box. At first, both players need pieces from the same box. However, there comes a point where their needs diverge, and thus their desires for card color become incompatible. At this point children are asked three control questions and two test questions, shown in (65) and (66).

(16) *Which color card does Fat Cat want now?*

(17) *Which color card did you want last time?*

Only 7 of 20 children passed both test questions on the conflicting-desire task, leading Moore et al. to conclude that children have just as much trouble on a conflicting desires task like this as they do with the traditional false belief task.

Another study by Rakoczy et al. (2007) looked at incompatible desires, using a similar game format, and testing both conflicting "third person desires", where two puppets play against each other, and conflicting "first person desires", where the child played against a puppet. In this task, children (3;0-3;6) work together with a puppet to make a sticker book, but only one sticker can go inside. This was determined by a "chance machine." A marble comes out of the chance machine out to determine one of two sticker possibilities: one is an exciting sticker, and one is a boring sticker. The child always preferred the more exciting sticker, and the puppet expressed interest in the other sticker. The children are asked the test questions shown in (67)-(68).

(18) *You want the marble to roll where?*

(19) *Rudi wants the marble to roll where?*

Children performed better on questions (67) and (68) than on a false belief task, although accuracy was only around 55% overall. They found no differences between first and third person conditions. Although children did not perform at ceiling here, they still displayed better performance than they do on typical false belief tasks. Consequently, the authors conclude that while representing conflicting desires is still easier than representing false beliefs.

Both Litchermann (1991) and Moore et al. (1995) present evidence that in cases where children were required to represent differing and incompatible desires about the same event, they do not succeed. Rakoczy et al. (2007) argued that these studies may have been too complicated for children of this age, and that improving on the methodology causes children to do much better at this kind of task.

Another type of skepticism raised suggests the opposite kind of argument—that children are actually *better* at representing beliefs that has been claimed. Alan Leslie and colleagues have claimed that children do not have as much difficulty with belief as the literature has claimed; that both the concepts of belief and desire are in place early. They propose that the difficulty in ascribing beliefs arises due to task demands present in the belief but not the desire case. One specific proposal is that there are increased executive function demands present in belief tasks, namely, that inhibiting one's *own* beliefs about a situation interferes with the ability to attribute different beliefs to another person (German & Leslie 2000, Leslie and Polizzi 1998, Leslie and Thaiss, 1992, Leslie & Roth 1993, Roth & Leslie 1998, Leslie, German & Polizzi 2005). Given that in many every day situations, beliefs are shared, it is common for children to succeed by assuming their beliefs match the beliefs of those around them. In the false belief task, that is not the case, and they are unable to override their own beliefs.

This view makes several specific predictions. If it is the case that difficulty with belief-reasoning tasks is caused by difficulty with inhibition, then we should expect to see correlations between children's executive function development and

their belief representation capabilities. A plethora of studies have explored the nature of the relation between these two developing systems. A recent meta-analysis (Devine & Hughs 2014) looked at 102 separate studies investigating the relation between executive function and false belief reasoning, and found that the relation is quite consistent and robust. This raises a question, however, about why these executive demands would apply only in the case of belief reasoning, and not for desire reasoning, which also requires inhibiting one's own mental state. In fact, this proposal seems to make an explicit prediction that if we increase the executive function demands in a desire-reasoning task, we should see a similar delay in children's performance.

Experiments 2 and 3 of this dissertation will address both Moore and Litchermann's claim that children are unable to represent differing desires about the same event; and additionally provide evidence that inhibition of one's own mental state alone cannot be driving difficulty with *think.* We test a case where an agent has a desire that differs from the participant's desire in a game task. This provides both a context where two agents have different and incompatible desires, as well as a situation where children must override their own mental state. We find that children are adult-like in interpreting sentences with *want,* even in cases that involve representing incompatible desires, and where the child must inhibit their own desires.

2.3.2.2 Interaction with Language Capacities

Some researchers have claimed that children do not have difficulty with the belief concept, in deploying the belief concept due to the interference of non-

adult-like language capacities. This type of "linguistic interference" hypothesis has been proposed to manifest in several different ways. de Villiers and colleagues have argued that children have difficulty with the syntactic or semantic properties of *think*, which masks their conceptual capabilities. Lewis, Hacquard and Lidz propose that the failures in belief tasks are not due to conceptual factors, or syntax/semantics, but pragmatic factors. This hypothesis claims that because of specific semantic properties of verbs like *think*, they can occur in certain pragmatic contexts. The difficulty children have is figuring out the appropriate context.

2.3.2.2.1 Syntax/Semantics

de Villiers, de Villiers, Hale, Tager-Flusburg, Pyers, Senghas, and others have proposed that language competence interferes with children's performance on false belief tasks. A large body of research has pointed to a relation between language development and children's performance on false belief tasks. In another task looking at children's understanding of sentences with *think*, de Villiers and colleagues test children's understanding of *think* with a false complement (de Villiers, 1995; de Villiers & de Villiers, 2000; de Villiers & Pyers, 2002). In this task, children hear sentences such as (75), and see pictures to go along with them.

(20) *The girl thought she had a bug in her hair, but it was only a leaf.*

Then, the children are asked test questions about what the character thought; such as in (76).

(21) *What did the girl think she had in her hair?*

Children were given twelve trials, and had to get at least ten correct to "pass" the task. Participants were tested three times over the course of about seven months, the first session occurring when they were 3;1-3;10. In the first session, fewer than 30% of children passed the task, and by the last session, 90% of the children passed. The authors conclude that these results indicate that children are not able to represent false complements until around four years of age.

Several studies also show that language delay can lead to a delay in belief representation abilities. de Villiers and Pyers (2002) found that late-signing Deaf children born to hearing parents (who are language delayed) did not pass the false belief tasks until later than their non-delayed peers, both signing and hearing. A similar result was found for children with Specific Language Impairment (SLI). Children with SLI are language delayed, but not delayed in any other aspect of development. de Villiers, Burns and Pearson (2003) found that a group of children with SLI also show delay in belief representation abilities. Pyers, Senghas, Morgan and Kegl looked at a special population of adults in Nicaragua. Adults living in a Deaf community here were not exposed to normal language input before the age of 10. Research suggests that difficulty with the false belief tasks persists into adulthood (Morgan & Kegl, 2006; Pyers & Senghas, 2009). Typical adults can also provide evidence of this relation. Newton and de Villiers (2007) found that adults failed a false belief task while shadowing language, but not while copying rhythmic tapping pattern, which was shown independently to be equally difficult.

Jill and Peter de Villiers propose a specific language interference theory (de Villiers & de Villiers 2000, de Villiers 2005, de Villiers 2007, de Villiers & de Villiers 2009). They propose that the difficulty is related to the syntactic features associated with different subclasses of attitude verbs. In English, *want* and *think* appear in different syntactic frames. As shown in (13)-(16), *want* can take a complement that is a simple Noun Phrase (NP), or it can take a non-finite complement with either a covert or an overt subject. It cannot take a finite sentential complement (16).

(22) *Jeff wants the ship.*

(23) *Jeff wants to be in Annapolis.*

(24) *Jeff wants the ship to be in Annapolis.*

(25) **Jeff wants that the ship is in Annapolis.*

Think has exactly the opposite distribution. As shown in (17)-(20), it can take a finite sentential complement, but not a NP or a non-finite complement.

(26) *Jeff thinks that the ship is in Annapolis.*

(27) **Jeff thinks the ship.*

(28) **Jeff thinks to be in Annapolis.*

(29) **Jeff thinks the ship to be in Annapolis.*

In English, finiteness of the complement is a critical difference between the syntactic distributions of *want* and *think*.

In this dissertation I will further explore the role of syntax in children's acquisition of attitude verbs. Many linguists have also observed the differences in syntactic distributions (Bolinger 1968, Hacquard 2014, Hooper & Thompson

1973, Ross 1973, White 2015, and others), and some have suggested that syntactic differences are relevant to the acquisition patterns we see for *want* and *think* (Gleitman, Cassidy, Nappa, Papafragou & Trueswell 2005, Gleitman 1990, Landau & Gleitman 1985, Papafragou et al. 2007). Experiments 5-6 of this dissertation further explore the role of linguistic features in the acquisition trajectories of *think* and *want*. We demonstrate that children are sensitive to syntactic distribution in interpreting attitude verbs, and propose that this is at least one of the learning strategies that helps them acquire the semantics for attitude verbs.

2.3.2.2.2 Pragmatics

More recently, Lewis and colleagues have claimed that it is actually pragmatic difficulties that are responsible for children's difficulty in interpreting sentences with *think*. At times, speakers intend to convey a meaning beyond the literal meaning of an utterance. Lewis (2013) has recently proposed that the difficulty with *think* is ultimately caused by children's difficulty in determining when the speaker meaning for a sentence differs from the literal meaning. She proposes that children have acquired the adult-like semantics for *think* early on, but have difficulty determining what a speaker might mean in a given context, when this may go beyond the literal meaning.

Lewis argues that errors in interpreting *think* are due to children over-interpreting sentences with *think* as pragmatically enriched endorsement uses. She proposes that because children are trying so hard to accommodate speakers, they sometimes interpret the additional information on top of the literal meaning, even

in experimental cases where the adult-like interpretation of the utterance is simply the literal meaning. Lewis (2013) presents several studies in support of this pragmatic hypothesis. In a truth-value judgment task, children hear a short story about a hide-and-seek game, and are then asked to judge the truth-value of sentences containing *think,* uttered by a "silly puppet". A sample story is below:

> *"Swiper is gonna hide, and Dora will look for him. So she'll wait in the other room where she can't see." [Dora leaves, and the child watches as Swiper hides behind the curtain. His yellow tail remains visible, protruding from behind the curtain. Then a squirrel (the Distracter) hides behind the toy box, leaving an identical yellow tail visible. The experimenter points out the two clues to ensure that the child knows what evidence Dora will be using to guess Swiper's location. Dora reappears to state a guess about Swiper's location based on one of the clues]*
>
> *"Hmm, where should I look? Oh! I see a yellow tail behind the toy box! I know--Swiper is there! I'll look for Swiper behind the toy box"[Dora moves toward the toy box]*

Children then heard a puppet utter a sentence about one character's belief (77).

(1) *Dora thinks that Swiper is behind the toy box.*

Lewis tested children's interpretations under several conditions. First, she asks whether children's performance improved when the relevance of belief was made more salient. She compares cases where one "seeker" has a belief about the

hider's location to cases where two "seekers" have differing beliefs about the hider's location. She finds that this improves young 4-year-olds' performance from below chance (in the 1-seeker condition) to chance performance (in the 2-seeker condition).

A second experiment looked at whether blocking an interpretation of the sentence as an indirect assertion improved children's performance. In this task, children were again asked to judge the truth-value of sentences about a character's false belief. In this case, however, she manipulated whether the sentence itself was true or false. In the traditional tests of children's understanding of belief reports, researchers find that children make errors in saying a sentence is false, when the proposition in the embedded clause is false, even when the sentence is true. Lewis finds above-chance performance in rejecting false sentences about false beliefs. She argues that this provides evidence that in the traditional case, with true sentence, children assume certain speaker meanings; but when the sentence is false, speaker meanings are irrelevant and children are able to correctly reject the sentences.

The results presented in this dissertation may also indirectly provide evidence for the pragmatic hypohthesis. In experiments 5 and 6, I explore the role of syntax in children's acquisition of attitude verbs. Some linguists have observed the relation between syntactic distribution and semantic and pragmatic properties of attitude verbs (references). Thus, if children's errors with *think* are in fact driven by a pragmatic deficit, it is possible that they have access to the pragmatic features through the syntactic distribution, to which this work demonstrates their

sensitivity.

2.3.3 Summary and Integration

I have reviewed in this section several different hypotheses that have been proposed to account for the difficulty that has been observed with children's interpretation of sentences with *think*. Each of the hypotheses makes progress in explaining the difficulty with *think*. Given the evidence, and the accounts that have been proposed to explain the asymmetry, several questions are left open. In this dissertation, we present 6 original studies which will answer some of the questions left unsolved in the literature.

Perner and Gopnik and colleagues have proposed conceptual hypotheses, arguing that children fail in interpreting sentences with *think* because they have not yet developed the relevant concept of belief. A conceptual account explains why we see success on all explicit tasks emerge around the same time, but cannot explain why language development seems to be tied to conceptual development in this domain. Conceptual accounts also have difficulty explaining recent findings showing infant success on implicit belief-tracking tasks.

Different deployment hypotheses have been proposed to account for the difficulty with *think*. These accounts have claimed that there is no deficit with the belief concept, but that other factors interfere with children's ability to deploy the belief concept in tasks. The studies in this dissertation will further explore predictions from several deployment accounts that have been proposed.

First, we will further explore the role of methodological differences between tests of *think* and *want*, and the possible role of inhibition in errors with

think. Some deployment accounts have focused on the role of task factors; such as methodological set-up, or executive function, in explaining the different observed trajectories between *think* and *want.* Experiments 1-4 will compare *think* and *want,* controlling for several different methodological factors, and ultimately be informative about whether any of these factors is driving the errors with *think.* I spell this out in section 2.4 below.

Other deployment accounts have focused on the role of language. De Villiers' syntax-semantic hypothesis explores the role that the syntactic features of *want* and *think* may play in their acquisition; Lewis' pragmatic hypothesis says that children's errors with *think* are driven by a pragmatic delay. In experiments 5-6, I explore the role of language in the acquisition of attitude verbs, testing whether children are sensitive to syntactic complement when interpreting a potentially unknown attitude verb. I spell this out in section 2.5 below. In the final chapter, I discuss the pragmatic hypothesis in more detail as it relates to the findings presented in this dissertation, and ultimately demonstrate that the pragmatic hypothesis can account for the observed asymmetry between *want* and *think.* I will also discuss how it may be related to the syntactic features show in experiments 5 and 6 to be relevant to attitude verb acquisition.

The 6 experiments in this dissertation address questions left open in the literature, which address specific predictions made by deployment accounts for interpretation of *think* sentences. Experiments 1-4 will address differences in task demands that may have contributed to the observed asymmetry between acquisition of *think* and *want*, and show that even under the most stringent

comparison, children are adult-like in interpreting sentences with *want* before *think.* Experiments 5-6 further explore the role of linguistic features in the acquisition trajectories of *think* and *want*. I demonstrate that children are sensitive to syntactic distribution in interpreting attitude verbs. In this final chapter, I will return to the pragmatic hypothesis in more detail, and speculate that children may use the syntactic features to access information about semantic properties and pragmatic uses; and that differential pragmatic uses for *think* and *want* may ultimately be driving the asymmetry.

2.5 Unresolved Issues in Comparing *think* and *want*

Many studies have found differences in the acquisition trajectory of the verb *think* vs. the verb *want.* As detailed in the above section, several hypotheses have been proposed to explain children's difficulty with *think.* One such hypothesis, has been explored by both Moore and colleagues and Rakoczy and colleagues, and suggests that the conditions under which these verbs were tested has not been fair. Although several studies were specifically designed to test *want* in a way more similar to the way *think* has been tested (Moore et al. 2005, Rakoczy et al. 2007), we still notice methodological differences between these studies and traditional false belief tasks. In a thorough examination of the literature, we have noticed several differences between the conditions under which *think* and *want* have previously been tested; even in the studies which are that provide the most rigorous comparison to date.

We notice two specific differences in task demands that need to be properly controlled for between the traditional tests of *think* and the *want*. The first methodological difference that we observed is the future-orientation of sentences with *want*, which leads to the confound that *want*-sentences do not necessarily set up situations in which a desire conflicts with reality. Correctly interpreting sentences with *think* requires maintaining two conflicting belief states in memory, both of which are occurring in the present. It requires maintaining in mind both the *reality* in the story as well as the character's *false belief* about the current reality. Often when we use the verb *want*, especially with an eventive, it is future-oriented (Stowell, 2004). For example, see the sentence in (78).

(30) *Jeff wants the ship to go to Annapolis.*

In this sentence, there is an implication that the desire is for the event to occur in the future; it doesn't say anything about what Jeff wants at the moment. If a desire is future-oriented, it still has the possibility of being fulfilled. In this way, it is impossible to have a conflict with reality in the same way that occurs while interpreting *think*, where both the belief state and the reality in the story are necessarily occurring at the same time, and incompatible, thus in conflict. In all of the studies presented here, a future-orientation interpretation was possible.

A second difference between the traditional studies looking at *want* and studies looking at *think* is the potential conflict with the child's own mental state. In the case of beliefs, the participant is automatically generating beliefs while they are listening to a story, therefore a conflicting with "reality" in the story is automatically a conflict with the child's own mental state as well. In these studies

with *want*, there was no conflict with the child's own desires, because they did not have personal desires about the outcome of the story. In order to test whether or not this kind of conflict is what is making *think* harder than *want*, we need a test that looks at a conflict with the child's own desires. Both of these differences in the conditions under which *think* and *want* have been tested ultimately mean that the previous tests of *think* have much higher processing demands than even the most comparable tests of *want*. We will argue that the results that have guided the arguments that there is an asymmetry between the acquisition of *think* and *want* could be due, or at least influenced by, to this fact. In order to demonstrate what is required to make a better comparison of these two verbs, I will explain more specifically how each of the previous tasks which have claimed to be a fair comparison were flawed.

2.5.1 Conflict with Reality

In Perner (2003), children heard stories about parents and a child, and the parent had either a belief or a desire that conflicted with reality in the story. We will demonstrate here, however, that this study did not set up a conflict with reality due to the potential future-orientation reading possible for the test sentences using *want.* Thus, the claim that this study demonstrates that children are better at *want* than *think* is unfounded. This study tested German-speaking children, which Perner argued made a better comparison of *think* and *want* due to the syntactic properties of these verbs in German. In English, *think* takes a tensed complement, while *want* takes an untensed complement. By default, the untensed

complement of *want* receives a future-orientation when the verb is eventive (as in (79)).

(31) *Jeff wants the ship to go to Annapolis.*

The temporal interpretation of the complement of *think* depends on the tense in the complement: with a present tense, as in (80), the belief is present-oriented (a future-orientation would require a future tense morpheme, as in '*Mom thinks that Andy WILL go to bed*). In German, both *think* and *want* take tensed complements. However, with *want* (but not with *think*), it is still possible to get a future-orientation with a present tense in the complement (in fact it is the preferred interpretation). Sentence (80) can be interpreted in two ways. It can get the interpretation in (81), which does set up a conflict between the desire and reality, but it also allows the interpretation in (82), which is future-oriented and thus avoids a conflict with reality.

(32) *Was glaubt die Mutter, dass Andreas tut?*

(33) *What does Mom want Andy to be doing (right now)?*

(34) *What does Mom want Andy to do (later)?*

If children interpret (80) as meaning (82), Mom's desire can still be satisfied if Andy's future actions match her current desire, thus there is no conflict between her desire and reality. In the *think* case, no future-oriented reading is possible. If Andy is not doing *at the moment* what Mom thinks he is doing *at the moment*, she has a false belief and there is a conflict between her beliefs and reality. The future orientation of *want* thus renders claims about the relative age of acquisition of *think* and *want* unpersuasive.

The same critique holds for the Rakoczy (2007) study. This study also attempts to test *want* sentences under the same conditions as the traditional false belief task sets up for *think*. In the incompatible desires task, two characters "quarreled" about which of two either compatible or incompatible outcomes they preferred, and children heard sentences like (83) and (84).

(35) *Susi wanted the boat to go where?*

(36) *And Tom wanted the boat to go where?*

Because children in this study were younger than the age at which they perform well on tasks testing *think*, the authors concluded that children can represent incompatible desires before they can represent false beliefs. While these results are suggestive, the future orientation of (83) and (84) could still possibly prevent a conflict between reality and the desire, and hence not provide a stringent test of children's ability to represent incompatible desires. The question in (83) describes a past desire about an outcome future to this past desire time. Although the boat did go to one of the two locations at a time future to this desire time (namely, at the end of the story), the future is open, and it is possible that the boat could still subsequently go to a second location, and the desire be satisfied in the near future. To rule out this possibility, we would need to make explicit that the desire is about a *concurrent* state of affairs. Experiment 1 of this dissertation will address this issue by setting up a situation where a desire conflicts with reality.

A pilot study reported in de Villiers (2005) attempts to better control for the possibility of future-oriented readings with *want*. This study compared children's interpretation of *think* sentences with a sentential complement to their

interpretation of *want* sentences with a gerund complement in English. Because *think* and *want* take different types of complements in English, test sentences could not be an exact match syntactically. But, the gerund complement with *want* does eliminate the possibility for a future-oriented reading in the desire sentence, making this a closer comparison to the previous tests of *think*. In this study, children saw pictures and heard stories where someone had an unfulfilled desire or a false belief, and had to assess sentences such as in (85) and (86).

(37) *Mom wants Bella playing on the computer.*

(38) *Mom thinks Bella is playing on the computer.*

De Villiers found that children are able to interpret the sentences with *want* at a younger age than the sentences with *think*. Although the gerund does not allow a future orientation, the sentences with *want* here do not have sentential complements, which makes it a less ideal comparison to *think*.

2.5.2 Conflict with the Child's Mental State

Even if these studies are taken to show that children can represent desires that are incompatible with reality, none of these studies set up a conflict with the child's own desire. Thus, children's difficulties with *think* in false belief situations could also be due to the conflict between the reported mental state and the mental state of the child. A few other studies have attempted to probe conflicts between a reported desire and the desire of the child. Taking these studies together, however, leaves the issue unresolved.

Both the Moore et al. and the second Rakoczy et al. study look at children's ability to interpret sentences with *want* where there is a conflict with

the child's own desires. However, their results are somewhat contradictory. Moore et al. claim that their results show that conflicting desires are just as hard as false beliefs; Rakoczy et al. claim that conflicting desires are easier than false beliefs. Furthermore, both studies raise methodological concerns. In both tasks, there were only one or two critical trials. Additionally, the games were fairly complex for preschoolers, and the authors did not report training on the task or having a criterion determining whether children understood the rules of the game. This potentially underestimates children's ability to interpret sentences with *want* where there is a conflict with their own desires. If some participants were confused about how the game worked, the numbers may be deflated relative to what children are actually able to do. To sum up, although many studies suggest that children are able to interpret *want* before *think*, there are still methodological differences that could account for this asymmetry, notably in the demands of the tasks used to test the two verbs, that may account for the observed differences.

2.5.3 Summary of Unresolved Task Issues

Looking at all these studies together, it becomes evident that in previous studies, *want* has been tested under different conditions than *think.* Specifically, interpreting *think* has required children to process several kinds of conflict that are not present in the tests of *want*. We argue that these additional conflicts mean that tests of *think* carry increased task demands as compared to tests of *want.* In addition to the intuition that more conflict will make a task harder, there is independent reason to believe that increased processing demands like these should affect reasoning about the mental states of others. A number of studies

demonstrate that executive function reasoning is related to children's performance on false belief tasks, thus it is a reasonable assumption that increasing the task demands in a desire task may lower performance. A recent meta-analysis (Devine & Hughs 2014) looking at 102 separate studies investigating the relation between executive function and false belief reasoning They found that the relation is quite consistent and robust. Several studies have also looked specifically at the relation between executive function and both belief and desire reasoning. Rakoczy (2010) looked at the relation between executive function and 3- and 4-year-olds' ability to reason about the beliefs and desires of others. Replicating many other studies, they found that executive function abilities were correlated with children's performance on false belief tasks. Additionally, they found that executive function abilities were also correlated with the ability to reason about incompatible desires. They found that the correlations held, even when they controlled for age, vocabulary and working memory. Fiske et al. (2014) also examined the relation between executive function abilities and belief and desire reasoning. They also found that executive function abilities were related to false belief ascription, and also desire ascription when both are matched in terms of logical complexity, such that two agents have conflicting mental states in both cases. Additionally, they found that the effect was even bigger in cases where one of the mental state holders was the participant themselves. These results suggest that task demands, in particular executive function demands, play a role in children's previously observed difficulty with ascribing false beliefs. This suggests that if a task testing desire was truly a comparable complexity match for the traditional false belief

tasks, that we may see equal difficulty on desire tasks, further demonstrating how critical it is for us to set up the right kind of comparison. Experiments 1-4 of this dissertation will address this, setting up tests of *want* which involve task demands and inhibition more comparable to previous tests of *think.*

2.5 Syntactic Bootstrapping for Attitudes

Another set of hypotheses regarding the asymmetry between the acquisition of *think* and *want* focuses on the linguistic differences between these attitude verbs. In experiments 5 and 6 of this dissertation, we will further probe the role of linguistic features by exploring whether children are sensitive to syntactic complement when interpreting and learning a potentially unknown attitude verb.

It is reasonable to assume, especially given the lack of information available for attitude verb meanings in the situational context, that children may be using the linguistic environments to help guide their learning. Children have been shown in many studies to be sensitive to syntactic structure (Fisher, Gertner, Scott & Yuan 2009, Fisher, Gleitman & Gleitman 1991, Fisher, Klinger & Song 2006, Gleitman 1990, Gleitman et al. 2005, Landau & Gleitman 1985, Lidz, Gleitman & Gleitman 2003, Naigles 1990, Naigles 1996, Naigles & Kako 1993, Scott 2009, Pinker 1989, Yuan & Fisher 2009, and others). This hypothesis was originally proposed as a learning account for exactly this kind of case: words like attitude verbs, which might be particularly difficult to learn given their abstractness. Much of the experimental evidence that has been presented for

syntactic bootstrapping over the years has specifically looked at number of arguments. Some distributional work has shown that attitude verbs can be identified by their syntax, but experimental work in syntactic bootstrapping has not focused on the subclasses of attitudes.

This dissertation will explore whether attitude verb learning is a case where the syntax guides the learner, using experimental evidence. In the first part of this section, we will review some of the syntactic bootstrapping literature, demonstrating that children have shown sensitivity to syntactic distribution in many studies. In the second part of this section, we will propose a syntactic bootstrapping strategy for attitude verb learning, spelling out exactly what that would entail. Finally, we will combine the pragmatic hypothesis with a syntactic bootstrapping for attitudes hypothesis, spelling out the exact learning strategy that we propose for acquisition of attitude verbs.

2.5.1 Evidence for Syntactic Bootstrapping

A large body of evidence demonstrates that children use syntactic structure to guide their word learning. They are able to do this for verbs, using the syntax of an utterance to relate a sentence to an event (Fisher, Gertner, Scott & Yuan 2009, Fisher, Gleitman & Gleitman 1991, Fisher, Klinger & Song 2006, Gleitman 1990, Gleitman et al. 2005, Landau & Gleitman 1985, Lidz, Gleitman & Gleitman 2003, Naigles 1990, Naigles 1996, Naigles & Kako 1993, Scott 2009, Pinker 1989, Yuan & Fisher 2009, and others). A classic study by Naigles (1996) uses a preferential looking paradigm to gauge young children's ability to link up novel words with events. Naigles compare interpretation of transitive sentences

(37) to interpretation of intransitive sentences (38) using novel verbs. They find that 25-month-olds who hear transitive sentence look longer at an event which depicted an agent acting on another character; while children who hear intransitive sentences do not.

(2) The duck is gorping the bunny!

(3) The duck and the bunny are gorping!

Other studies show that children can use syntactic information to learn noun meanings (Lidz, White & Baier, under review, White, Baier & Lidz, 2010, 2011). In a recent set of studies, White et al. (2010, 2011), look at 19-month-olds' interpretation of sentences with (39) and without an instrument construction (40). They find that children will correctly hypothesize the novel noun refers to the patient when they hear transitive sentences (40), but hypothesize that the novel noun refers to the instrument when they hear a sentence with an instrument construction (39).

(4) *She's meeking with the tig!*

(5) *She's meeking the tig!*

Interestingly, these studies along with others (Snedeker & Truesdwell 2004, and others) also find that children's are sensitive to the distributional information in the input. White and colleagues find that when 19-month-olds hear the same sentences, but with known verbs (41)-(42), they override the syntactic information presented to them, and default to the interpretation most consistent with the input distribution for those particular verbs.

(6) She's pushing with the tig!

(7) She's pushing the tig!

So, for example, because the verb *push* usually occurs in a transitive sentence, even when children are presented with *push* in an instrument construction (41), they will get a patient interpretation for the novel noun; until they are able to integrate both distributional *and* syntactic information at 28 months. This suggests that children are sensitive to syntactic information, both in real time, and over the course of development; and in fact there may be stages of development where integrating syntactic information from both of these sources is challenging.

These studies, along with many others, demonstrate that children can use syntactic information to make hypotheses about word meaning. In all of these cases, children have to link a novel word to an object or an event that is presented to them. Additionally, all of the methodologies used here only elicit *preference* responses, but do not tell us anything about which interpretations are *disallowed*. In our work, we will examine children's ability to use the syntax to hypothesize the meanings of words that refer to psychological events. This is quite different from the tasks present above, because of the lack of observability of psychological events. On one hand, this makes learning these words harder than the above cases. On the other hand, perhaps the learner must rely more on the syntactic information, precisely *because* the world is less helpful in these cases.

Adults are also sensitive to syntactic information. A classic study by Gillette et al. (1998) used the *human simulation* paradigm (HSP). This method asks adults to guess a novel word after receiving different sources of evidence for the word's meaning. Participants were provided three types of evidence:

contextual, lexical and syntactic. "Contextual" information was provided though silent video clips of mothers playing with their infants, syntactic information through jabberwocky sentence, and lexical information through a list of words used surrounding the target word. They found that syntactic information was extremely helpful to participants in guessing the novel word. Papafragou et al. (2007) use the HSP to look at attitude verbs learning. They explore the influence of syntax on adults' and children's hypotheses about the meanings of attitude verbs. Again, participants were asked to guess a novel word after receiving evidence. Participants were given "contextual" information through watching silent video clips. In the task, they were given contextual information, syntactic information, or both—and asked to guess a novel word's meaning. Papafragou and colleagues found that both adults and children were more likely to use attitude verbs in false belief contexts than in simple action context. They found that when participants (both children and adults), were given syntactic frame information, the number of attitude verbs guesses increased. They conclude that both contextual and linguistic information is important for children hypothesizing attitude verb meaning. This evidence suggests that is a reasonable possibility that children may be using syntactic distribution to learn attitude verb meanings.

2.5.2 Syntactic Bootstrapping for Attitudes

In order for a syntactic bootstrapping hypothesis for attitude verbs to hold, two facts must be true:

1. The link between attitude verb syntax and semantics must be principled. If the syntactic distribution is *not* informative about

the semantics, tracking the syntax is not a productive strategy for learners.

2. Children must be sensitive to this link in the case of attitude verbs. Even if we see principled links, if children are not sensitive to the syntactic distributions in this case, then bootstrapping is not a likely learning account.

In this section, we will address #1, citing the work of many syntacticians and semanticists who have argued that the mappings between syntactic frame and semantic features are principled. We will also demonstrate that this may hold up cross-linguistically, as long as the observation is made at the right level of abstraction.

The plausibility of the hypothesis hinges on point #2. Even if the mappings are principled, if children are not sensitive to the mappings, then this is not a feasible learning strategy. The work presented in this dissertation will address point #2, and we will ultimately demonstrate that children *are* in fact able to categorize verbs with different syntactic semanticc features differently very early on, even after controlling for methodological factors (experiments 1-4); and that children *are* using syntactic information when hypothesizing meanings for unknown attitude verbs (experiments 5-6).

1.5.2.1 A Syntax-Semantics Link?

Attitude verbs connect a proposition *P* with an individual, namely the attitude-holder. Many semanticists have observed that attitude verbs fall into two

main semantic subclasses: “representational attitudes”, such as *think* or *believe*, which express a judgment of truth (34); and non-representational, or “preferential” attitudes, such as *want* or *wish*, which do not express a judgment of truth (35), but a preference (Bolinger 1968, Farkas 1985, Heim 1992, Hooper 1975, Searle & Vanderveken 1985, Stalnaker 1984, Villalta 2000, 2008).

(8) *Mike thinks Aaron is at Qualia and it’s true.*

(9) *#Mike wants Aaron to be at Qualia and it’s true.*

There are several different proposals about the semantics of attitude verbs, specifically with respect to how the semantics of representational verbs (*think, believe*) compares to the semantics of preferentials (*want, wish*).

The classic view of attitude verb semantics comes from Hintikka (1969). Hintikka proposed attitude verbs as quantifiers over worlds. This proposal divides up the set of all possible worlds into 1) worlds that are compatible with the attitude of the subject, and 2) those that are not. The set of worlds that a given attitude verb quantified over is determined by an *accessibility relation*. He proposed that different verbs have different types of accessibility relations; according to the attitude that the verb expresses. Belief verbs, like *think*, are doxastic, and thus pick out belief worlds. Desire verbs, such as *want,* are bouletic, and thus pick out desire worlds. For example, a sentence like in (36) is true in a world *w* if it is raining in every world *w’* that is doxastically accessible (compatible with the belief worlds of the subject) for Dustin to *w*.

(10) *Dustin believes it is raining.*

This account suggests that all attitude verbs, both representational and preferential, share a semantic template.

More recent proposals have suggested that representational attitude verbs have a classic Hintikkan semantics, but preferentials are inherently comparative (Bolinger 1968, Farkas 1985, Heim 1992, Hooper 1975, Searle & Vanderveken 1985, Stalnaker 1984, Villalta 2000, 2008). A recent proposal by Villalta (2000, 2008) demonstrates one way to implement this. Villalta proposes that desire verbs (and all verbs that take subjunctive complements) introduce a gradable scale or ordering relation, which require comparison of contextually alternative propositions. In this kind of analysis, *think* and *want* have different semantics. In order for these semantic subclasses to be transparent to the child via the syntax, we expect that the links between these subclasses and syntactic complement should be principled.

In English, we have seen that *want* and *think* have different syntactic distributions; *want* takes a non-finite complement, and *think* takes a finite complement. This distributional observation does not apply only to *think* and *want,* however; it appears to apply to the broader subclasses of attitude verbs. representational and preferential attitudes. Representational attitudes tend to be allowed with finite complements, while preferentials do not (43)-(47) (Dayal & Grimshaw 2009, Hacquard 2014, White 2015).

(11) *Mike believes that Aaron is at Qualia (and it's true).*

(12) *Mike says that Aaron is at Qualia (and it's true).*

(13) *Mike knows that Aaron is at Qualia (#and it's true)*[1].

(14) *#Mike wishes that Aaron is at Qualia (and it's true).*

(15) *#Mike desires that Aaron is at Qualia (and it's true).*

This suggests, that at least in English, the syntactic distribution may serve as a cue to the learner for what subclass a given attitude verb falls into: representational or preferential. For this to be a useful learning strategy, however, it needs to apply cross-linguistically, as learners cannot anticipate the particular features specific to their language. We have already seen, however, that finiteness cannot be the syntactic cue available to children cross-linguistically, given that German allows for *want* with a finite complement (48)-(49).

(16) *Was will die Mutter, dass Andreas tut?*

What wants the Mom that Andy does?

'What does Mom want Andy to do?'

(17) *Was glaubt die Mutter, dass Andreas tut?*

What thinks the Mom that Andy does?

'What does Mom think that Andy is doing?'

However, upon further investigation, we see that *want* and *think* still have different syntactic distributions in German. In sentences with *think*, the verb in the complement clause can optionally appear in second position, rather than finally, which is the typical word order for embedded clauses in German. *Want* does not allow this, as shown in (50) and (51) (Meinunger 2006 Truckenbrodt 2006; Scheffler 2008, Hacquard 2014).

[1] While *know* is a representational attitude verb, the endorsement of the judgment

(18) *Maria denkt, Peter kommt heute.*

Maria thinks, Peter comes today.

'*Maria thinks that Peter is coming today.'*

(19) **Maria will, Peter kommt heute.*

Maria wants, Peter comes today.

'*Maria wants Peter to come today.'*

Other languages, such as Romance languages, also distinguish verbs like *think* from verbs like *want* syntactically. In these languages, it shows up in the mood selection of the embedded clause. Verbs like *think* select for indicative mood, while verbs like *want* select for subjunctive mood, as shown in the examples in (52) and (53) in French (Bolinger 1968, Farkas 1985 Giannakidou 1997, Hacquard 2014, Hooper 1975, Villalta 2008, and others).

(20) *Jean veut que Marie soit á Boston.*

Jean wants that Marie be-SUBJ in Boston.

'Jean wants Marie to be in Boston.'

(21) *Jean pense que Marie est á Boston.*

Jean thinks that Marie be-IND in Boston.

'Jean thinks that Marie is in Boston.'

Although in each of these cases, the specific syntactic frames associated with each of the semantic classes differ, there is something that is consistent across all of these cases: the complements that representational attitudes take allow syntactic features found in main clauses in that language (indicative mood for Romance, V2 complements for German, finiteness for English). The complements that

preferential verbs take take do not allow main clause features in their complement (Dayal & Grimshaw 2009, Hacquard 2014). So, while not all languages make the same syntactic distinctions that English does, we do find within a language, these different subclasses of attitude verbs often have different subcategorization frames that they allow; and if we look at the right level of abstraction—main clause syntax in embedded clauses, it looks like there may be a pattern that is potentially informative to the learner.

1.5.2.2 Children's Sensitivity to the Syntax-Semantics link?

A second requirement for our syntactic bootstrapping hypothesis to be feasible is that children are sensitive to these links. Syntacticians and semanticists have done the important work of noticing these connections, and we have proposed a specific hypothesis for how this might translate to acquisition; but none of this is useful as an explanatory learning story if we do not see evidence that children are both in fact, categorizing verbs like *want* and *think* differently, and using syntactic information to do so. This is where our experimental results will be informative.

Experiments 1-4 will explore very thoroughly whether there is actually an asymmetry between the acquisition of *think* and *want.* We test interpretation of sentences using these verbs in a number of critically controlled ways. We will show that even under a stringent comparison of the two, the asymmetry holds. Experiments 5-6 will explore whether children are sensitive to syntactic information when hypothesizing meanings for an unknown attitude verb. We will show that children are, in fact, sensitive to syntactic information.

2.5 Conclusion

It has been observed in previous literature that children are adult-like in interpretation of sentences containing *want* before they are adult-like in interpretation of sentences with *think* (Wellman & Wooley 1990, Stein & Levine 1989, Wellman & Bartsch 1988, Yuill 1984, Hadwin & Perner 1991, Wellman & Banerjee 1991, Bartsch & Wellman 1995, Repacholi & Gopnik 1997, Wimmer & Perner 1983, Wellman et al. 2000). Specifically, they have been shown to make errors in interpreting sentences about someone's false beliefs, responding based on reality, or their own knowledge, and not taking into account the mental state of the subject of the sentence (de Villiers 1995, 2005, 2007, de Villiers & de Villiers 2000, de Villiers & Pyers 2002, Perner et al. 2003, Lewis 2013). Regardless of the cause of children's errors in interpreting *think*, many studies have shown differences in acquisition trajectories for *want* and *think;* suggesting that whatever the cause of *think*-errors, children are susceptible to reality-errors in one case, but not the other by their preschool years.

This dissertation will fill in some missing pieces in the landscape of our understanding of children's knowledge of *want* and *think*. Additionally, we will ask whether syntactic distribution plays a role in children's acquisition of attitude verbs. I will present 6 studies looking at preschoolers' knowledge of *want* and *think*; as well as the verb *hope*, which we will use to test children's sensitivity to syntactic frame in their acquisition of attitude verbs. This dissertation addresses two specific topics related to attitude verb acquisition:

1. Is the performance asymmetry observed between *want* and *think* due to an acquisition difference? Or have differences in tasks demands inflated children's knowledge of *want* or masked understanding of *think*?
2. If the observed asymmetry reflects an acquisition difference, is the syntax of these verbs cuing them in to semantic class?

In chapter 2 I review the literature on children's interpretation of sentences with *think* and *want*, as well as their performance on related belief- and desire-tracking tasks. I briefly review several proposals explaining children's difficulty with *think,* summarizing how they fit in with the observed data. I then point out several specific methodological differences in the conditions under which *think* and *want* have been tested, which may have made tests of *think* more difficult than tests of *want.* These factors include setting up a conflict with reality, and a conflict with the child's own mental state. We conclude that these task difference may have contributed to the observed difficulty with *think* and ease with *want*, and experiments designed to control for these lingering unresolved factors are necessary. These manipulations are particularly critical for some accounts that blame the difficulty with *think* with on task demands. If this is the case, we expect to see the same difficulty in interpreting *want* when the same task demands are introduced.

In chapter 3, we present 4 original experiments addressing the concerns raised in chapter 2. In Experiments 1-3, we test the verb *want* under conditions more analogous to the way *think* has traditionally been tested, increasing the task demands of interpreting sentences with *want* as compared to previous studies. In

experiment 1, we introduce a conflict with reality. In experiments 2 and 3, we introduce a conflict between a character's mental state and the participant's mental state. We show that children are still adult-like in their interpretation of *want*, and it has not been the conditions under which *think* has been tested that are the cause of children's reality errors. In Experiment 4, we test *want* and *think* directly, comparing them under the same experimental conditions. Again, we find success in interpreting *want,* and see the influence of reality on children's interpretations of sentences with *think*. This suggests that the difficulty with *think* cannot entirely be due to task demands created in explicit belief-reasoning tasks.

In chapter 4, we will further explore the role of linguistic features that may contribute to children's acquisition trajectories for each of these verbs. We explore the relation between the syntactic distributions of attitude verbs, their semantic features and pragmatic uses. We review our bootstrapping account of attitude verb acquisition (following Gleitman 1990, Landau & Gleitman 1895, and others). Given that we do replicate the asymmetry between *think* and *want*, we will explore whether syntactic distribution serves as a cue to learners. We introduce the verb *hope* as a test case. *Hope* shares syntactic and semantic features with both *think* and *want*, making it an ideal probe for sensitivity to syntactic frame. In experiments 5 and 6, we test interpretation of sentences with the verb *hope*, manipulating syntactic frame both between (experiment 5) and within (experiment 6) subjects. We show that children are in fact sensitive to the syntax when interpreting a potentially unknown attitude verb.

In chapter 5 I will summarize the findings in this dissertation, and further discuss the proposals for difficulty with *think*, reviewing how each of them fit with the findings presented in this dissertation. I then discuss future directions, which will focus on better understanding the mechanism for learning attitude verbs. The 6 experiments in this dissertation address questions left open in the literature. Each experiment addresses predictions made by accounts of the delay in interpretation of *think* sentences. Experiments 1-4 address differences in task demands that may have contributed to the observed asymmetry between acquisition of *think* and *want*, and show that even under the most stringent comparison, children are adult-like in interpreting sentences with *want* before *think.* Experiments 5-6 further explore the role of linguistic features in the acquisition trajectories of *think* and *want*. We demonstrate that children are sensitive to syntactic distribution in interpreting attitude verbs, and propose that children are using the syntactic and pragmatic features to access information about attitude semantics; and that differential pragmatic uses for *think* and *want* are ultimately responsible for the asymmetry.

Chapter 3: Testing *want* and *think*

Previous literature suggests that children show differential sensitivity to reality when interpreting *think* and *want* in their preschool years (Perner et al. 2003, Moore et al. 2005, de Villiers 2005, Rakoczy et al. 2007). The fact that children make errors with *think* but not *want*, shows that although they may not have completely figured out the semantics or appropriate pragmatic uses of both verbs, they categorizing these verbs differently. Although differential sensitivity to reality in interpreting these two verbs is taken as fact in the literature, we have pointed out several differences in the conditions under which each of these verbs have been tested. In order to further explore what the acquisition paths look like for attitude verbs, it is necessary to confirm that children are actually showing differential sensitivity to reality in interpreting *think* and *want* at this point in development.

Our syntactic bootstrapping hypothesis predicts differential categorization of these two verb classes. In this chapter, I will present 4 original experiments testing whether or not there is actually an asymmetry between *think* and *want.* We conclude that even after attempting to control for every possible difference between the conditions under which *think* and *want* have been tested; we still find differential sensitivity to reality in interpretation of these two verbs by 4 year olds. The first three experiments will test 3-year-olds understanding of sentences with *want*, attempting to make a better comparison of desire situations to previous tests of belief. Experiment 4 will look at 4-year-olds interpretation of *think* and *want* in

the same task. The studies in this chapter will address two specific hypotheses, shown in table 3-1 below.

TABLE 3-1: Experiment 1: Hypotheses

HYPOTHESIS 1	NO *THINK*-*WANT* ASYMMETRY: The *think*-*want* asymmetry that has previously been observed is due to unequal task demands; testing these verbs under more similar conditions will reveal no asymmetry.
HYPOTHESIS 2	DIFFERENTIAL SENSITIVITY TO REALITY IN INTERPRETING *WANT* AND *THINK:* Children are able to differentiate *want* and *think* by four years of age (as the literature has previously suggested).

Each study presented in this chapter will test whether there is actually an asymmetry in acquisition of *want* and *think*, or whether the observed asymmetry is an experimental artifact. Each study will address different possible tasks demands that may have contributed to the appearance of an asymmetry.

3.1 Experiment 1: Conflict with Reality

One difference in the way *think* and *want* have previously been tested is related to the temporal orientation of sentences with these verbs. Sentences with *want* often get a future-oriented reading, and thus do not necessarily report a desire that *conflicts* with reality. This happens when the embedded predicate is a bare eventive (e.g., "*Mom wants Max to go to bed"*). Think, on the other hand, takes a finite complement, and when this complement is in present tense, a false belief report sets up a conflict with reality. Even in the study reported in Perner et al. 2003, in which the syntax of the complements of *want* and *think* were matched, the *want* sentence still allows a future-oriented interpretation, whereas the *think* sentence does not. Experiment 1 tests *want* in sentences that force a present-

orientation, and thus describe desires that potentially conflict with reality. This will make for a better comparison, as it requires children to process a desire that is in direct conflict with the current reality in the story. This will be informative about whether processing a conflict with reality has previously made tests of *think* more difficult than *want*, and is ultimately driving the errors in interpreting *think*.

3.1.1 Experiment 1: Subjects

Participants were 44 children aged 3;0 to 4;0 (mean = 3;8). 16 additional children were excluded from the task, either due to *yes* or *no* biased responses on the task, or parental interference. Children in all three studies were recruited from the College Park, Maryland area, and were reported by their parents to be monolingual speakers of English. Participants were recruited via telephone or email from the University of Maryland Infant Studies Database.

3.1.2 Experiment 1: Design and Materials

Experiment 1 was a *Truth Value Judgment Task* (TVJT), which requires children to correct sentences uttered by a "silly" puppet (Crain & Thornton 1998; Crain & McKee 1985). TVJT tasks gauge whether children at a given age pair certain linguistic stimuli to a given situation in an adult-like way, or whether their interpretation of the stimuli differs in some way from adult judgments. In this task, children listened to stories with pictures. They were told that a puppet who was "very silly and sometimes gets things wrong" was listening to the stories as well, and asked to tell the puppet whether he was right or wrong after every utterance. Each child saw eight stories. After each story the puppet uttered two sentences: a filler sentence and a test sentence. The fillers were intended to ensure

that the child was paying attention and had a basic understanding about what happened in the story. Test sentences had a sentential complement which forced a present orientation by using a progressive ('be ___ING'), and the temporal modifier 'right now' (see (87)).

(22) *Mom wants Megan to be sitting in the grocery cart right now.*

There were a total of 8 stories, each with two different versions. Between subjects we manipulated whether the stories contained a desire that conflicted with reality (CONFLICT condition) or not (NO CONFLICT condition). Each of the stories described a situation in which a child starts out doing a given activity, and then an adult asks the child to either continue doing the same activity (STAY condition) or switch to a new activity (SWITCH condition). This manipulation was within subjects. Half of the conflict stories were STAY stories, and the other half were SWITCH stories. For the participants in the NO CONFLICT condition, the stories that were STAY stories in the CONFLICT condition were SWITCH stories, and the stories that were SWITCH stories in the CONFLICT condition were SWITCH stories. This ensured that each story was equally plausible as a conflict or no conflict situation, as well as a switch or stay scenario. Additionally, it ensured that in both the CONFLICT and NO CONFLICT conditions, the character did not always start and end doing the same activity. We also manipulated the truth-value of the test sentences within subjects. Table 3-2 illustrates the within and between-subjects factors in Experiment 1.

TABLE 3-2: Experiment 1: Within and Between-Subjects Factors

CONFLICT/NO CONFLICT (between subjects)	SWITCH/STAY (within subjects)	Truth Value (within subjects)
CONFLICT	SWITCH	*True*
		False
CONFLICT	STAY	*True*
		False
NO CONFLICT	SWITCH	*True*
		False
NO CONFLICT	STAY	*True*
		False

3.1.2.1 Sample Story

The stories consisted of four pictures each. Each picture represented about one sentence of a story. A sample of the text of one story is laid out in Figure 3-1.

FIGURE 3-1: Experiment 1: Sample Story

Introduction Phase 	Megan is at the grocery store with her mom. She's sitting in the cart while her mom shops.	
STAY/SWITCH Phase 	STAY: Megan's mom says, "Megan, I have to run and get something in the next aisle, stay right there in the cart until I get back. And Megan says, "No problem, mom!"	SWITCH: Megan's mom says, "Megan, I have to run and get something in the next aisle, can you climb out of the cart and go get some cereal? And Megan says, "No problem, mom!"

CONFLICT/ NO CONFLICT Phase 	STAY/CONFLICT: Mom leaves, and Megan says to herself, "I know my mom said I should stay in the cart, but I'd like to get out and go get some cereal, so I will!"	SWITCH/NO CONFLICT: Mom leaves, and Megan says to herself, "I'd like to stay right here in the cart, but my mom said to get out of the cart and go get some cereal, so I will!"
	STAY/NO CONFLICT: Mom leaves, and Megan says to herself, "I'd like to get out of the cart and go get some cereal, but my mom said to stay in the cart, so I will!"	SWITCH/CONFLICT: Mom leaves, and Megan says to herself, "I know my mom said to get out of the cart and go get some cereal, but I'd like to stay right here in the cart, so I will!"

Outcome Phase 	STAY/CONFLICT: So she climbs out of the cart to go get some cereal.	SWITCH/NO CONFLICT: So she climbs out of the cart to go get some cereal.
	STAY/NO CONFLICT: So she stays right there in the cart.	SWITCH/CONFLICT: So she stays right there in the cart.

Test Question		STAY/CONFLICT	SWITCH/NO CONFLICT
	Yes-target	*Mom wants Megan to be sitting in the cart right now!*	*Mom wants Megan to be getting cereal right now!*
	No-target	*Mom wants Megan to be getting cereal right now!*	*Mom wants Megan to be sitting in the cart right now!*
		STAY/NO CONFLICT	SWITCH/CONFLICT
	Yes-target	*Mom wants Megan to be sitting in the cart right now!*	*Mom wants Megan to be getting cereal right now!*
	No-target	*Mom wants Megan to be getting cereal right now!*	*Mom wants Megan to be sitting in the cart right now!*

3.1.3 Experiment 1: Procedure

Each child was tested in a quiet room with two experimenters. One experimenter told the child the stories and showed her the pictures, while a second experimenter controlled the puppet and uttered the filler and test sentences. The second experimenter also coded the child's responses. Permission was obtained from parents to video record each subject for an additional round of coding off-line.

The experiment began with the child being introduced to a silly puppet, "Froggy." The experimenters were somewhat flexible with the script, adjusting to each child's level of attention, but followed the following script fairly closely:

> *"We're going to be looking at some pictures and hearing some stories that go along with them. And our friend Froggy is going to listen to the stories with us, ok? And after we hear a story, Froggy's gonna try to tell us what happened in the story. But sometimes, he's not a very good listener. And so sometimes when he tells us, he might get it wrong, ok? And you get to tell us whether Froggy was right or wrong. Does that sound like a good plan? OK, so listen carefully, because he says silly stuff sometimes!"*

The child then practiced interacting with Froggy. First Froggy named a few items, and the child practiced telling him *yes* and *no*. The child was corrected during this

practice phase if they did not correctly tell Froggy *yes* and *no*. Then the child was told two very simple stories, and practiced responding to sentences Froggy said about the stories. Froggy was correct once and incorrect once. Again, the child was corrected if she did not respond correctly to Froggy's sentences.

During each test trial, experimenter 1 read the story and showed the child the pictures. After each story, experimenter 1 turned to Froggy and asked "*what happened in that story, Froggy?*" Then Froggy uttered the filler sentence, after which the experimenter turned to the child and asked "*did Froggy get it right?*". Then the child either responded *yes* or *no*. After the filler, Froggy uttered the test sentence, and the child was again asked whether or not he was right and given the chance to respond *yes* or *no*. Experimenter 1 gave feedback to Froggy that was in accordance with how the child had responded—"*good job, Froggy!*" when the child said that Froggy was correct, and—"*oh, silly Froggy! Try again next time!*" when the child said that Froggy was incorrect. The entire experiment took around 8-10 minutes per child.

3.1.4 Experiment 1: Hypotheses and Predictions

This experiment tests whether or not children have more difficulty with *want* than in previous studies, when interpreting sentences with *want* requires processing a desire state that conflicts with reality. This hypothesis is spelled out in Table 3-3 below, as Hypothesis 1A.

TABLE 3-3: Experiment 1: Hypotheses

HYPOTHESIS 1	NO *THINK*-*WANT* ASYMMETRY: The *think*-*want* asymmetry that has previously been observed is due to unequal task demands; testing these verbs under more similar conditions will reveal no asymmetry.
	HYPOTHESIS 1A: *Think* has been harder than *want* in previous tasks because the present temporal orientation of *think*-sentences sets up a conflict with reality that children have difficulty processing.
HYPOTHESIS 2	DIFFERENTIAL SENSITIVITY TO REALITY IN INTERPRETING *WANT* AND *THINK:* Children are able to differentiate *want* and *think* by four years of age (as the literature has previously suggested).

If this conflict is responsible for the difficulty with *think*, then we expect children to have more difficulty with the conflict condition than the no-conflict condition in this task. If this conflict is not responsible for the observed difficulty with *think*, then we expect to see no difference between conditions in this task.

3.1.5 Experiment 1: Results

3.1.5.1 Coding

Children's responses were coded online by the second experimenter. Four out of the sixty videos were coded by a second experimenter offline, because coding did not happen online. Responses were coded as *yes*, or *no*. One response (out of 1,080 total responses) was unintelligible. An additional 25% (11 videos) were coded offline by an additional coder. We found 99.4 percentage of agreement between coders (Cohen's Kappa = .989).

3.1.5.2 Filler Accuracy

The fillers were designed to ensure that children were listening to the story. They did not rely on understanding *want*. Children who answered either all *yes* or all *no* to 15 out of 16 total items were excluded from analysis. Twelve

children were excluded due to *yes*-biased responses (20%). Three children were excluded due to *no*-biased responses (5%). One additional child was rejected due to parental interference. The age range that we were testing for this study is quite young for the TVJT paradigm, which likely contributed to the high number of children with *yes*- or *no-biases.*

3.1.5.3 Experiment 1: Truth-Value Judgments

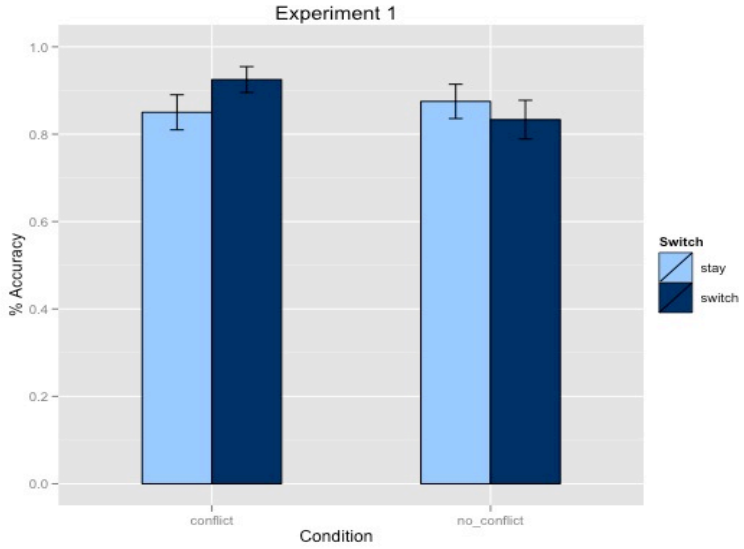
The results for each condition are shown in Table 3-4.

TABLE 3-4: Experiment 1: Percent accuracy by condition

CONFLICT/NO CONFLICT (between subjects)	SWITCH/STAY (within subjects)	Truth Value (within subjects)	% Yes Responses children 3;0-4;0
CONFLICT	SWITCH	*True*	93.2%
		False	13.6%
CONFLICT	STAY	*True*	79.1%
		False	17.8%
NO CONFLICT	SWITCH	*True*	79.5%
		False	11.4%
NO CONFLICT	STAY	*True*	93.2%
		False	15.9%

A 2x2x2 ANOVA with percent *yes* responses as the dependent measure revealed a significant main effect of Target response ($F(1,166) = 301.9$, $p < .0001$), but no significant effects of CONFLICT ($F(1,166) = 0.006$, $p = 0.94$) or SWITCH ($F(1,166) = 0.209$, $p = 0.65$). There were no significant interactions. Children were significantly more likely to respond *yes* to the *yes*-target items, and *no* to the *no*-target items, regardless of whether the item was a CONFLICT or a NO CONFLICT item, or whether it was a SWITCH or STAY item. Results from Experiment 1 indicate that three years olds understand *want* correctly, even when it is present-oriented and describes a desire that conflicts with reality. Data for all conditions is shown in Figure 3-2 below.

FIGURE 3-2: Experiment 1: Percent Accuracy



3.1.6 Experiment 1: Discussion

This study shows that three year olds are correct in their interpretation of *want*, even when there is a conflict with reality, and there is no chance of interpreting the test sentence as describing a desire about a future time. This is much younger than children have been shown to be reliably adult-like in interpreting *think*. This suggests that children's difficulty with *think* is not soley due to an inability to process a mental state which conflicts with reality.

3.2 Experiment 2: Conflict with Child's Mental State 1

Previous results looking at three-year-olds' ability to understand reports of desires that conflict with their own are inconsistent, and raise several methodological concerns. One study (Moore et al. 2005) found conflicting desires

to be just as difficult for children as false beliefs; another (Rakoczy et al. 2007) claim that conflicting desires are easier than false beliefs. Furthermore, both studies raised methodological concerns. In both tasks, there were few critical trials, and no reported training. Experiment 2 remedies these concerns. We set up a task where the child plays a game with a puppet, in which their desires sometimes conflict, and then the child is asked about those conflicting desires. This task requires children to maintain in memory both their own desire and the puppet's desire, and is therefore a much more comparable task to the previous tests of *think*, which require children to maintain in memory both a character's (false) belief as well as their own belief. We additionally improved on several methodological concerns raised with respect to previous tasks: children had sufficient practice with the task, and were excluded after practice trials if they were not successful in learning how the task worked.

3.2.1 Experiment 2: Subjects

Participants were 40 children aged 3;0 to 4;0 (mean = 3;8). 23 additional children were excluded from the task. 16 did not pass the practice, three due to *yes*-biased responses, two due to *no*-biased responses, and two who did not finish the task.

3.2.2 Experiment 2: Design and Materials

Experiment 2 was set up like a game. The child played with a puppet, *Froggy*, while another puppet, *Booboo*, was "learning" and said things about the game. The child's job was to tell Booboo whether he was right or wrong. The experimenter flipped colored cards, and depending on the color of the card, the

outcome was either positive for Froggy, the child, both of them, or neither of them (the positive outcome being that someone gets to stamp). This set-up induced desires in the child, which sometimes conflicted with the puppet's. Booboo then uttered test sentences. The child was told that *Booboo* is "not very good at colors and sometimes gets things mixed up", and was asked to tell Booboo whether he was right or wrong after every utterance. Each child participated in four, eight or twelve practice trials and sixteen test trials. The purpose of the practice trials was to teach the child how the game is played, and to have a measure to exclude children who did not understand how the game worked. The practice trials involved Booboo uttering a sentence that the child had to correct, just like the test trials, but the sentences were about the structure of the game, not a desire. An example of a practice question is shown in (88).

(23) *Oh, I see how the game works! When it's green, Froggy gets to stamp!*

After the child corrected Booboo, the experimenter flipped the card, and asked the child to tell everyone who got to stamp based on the color of the card. This ensured that participants understood the rules of the game and were comfortable playing before the test trials started. Each child had at least four and at most twelve practice trials. We continued with the practice until the child got four in a row correct, and then we moved on to the test trials. If the child did twelve practice items and did not learn how the game worked, they did not move on to the test trials and were excluded from analysis.

Each test trial consisted of two test sentences (examples in (89) and (90)), one about Froggy's desire and one about the child's desire.

(24) *Froggy wants the card to be green!*

(25) *You want the card to be green!*

After Booboo uttered the test sentences and the child said whether he was right or wrong, the experimenter flipped the next card on the pile. The experimenter then asked the child the filler question, which was about the outcome based on color (example in (91)), and then the appropriate player(s) stamped their paper.

(26) *Oh! We got green! Who gets to stamp when we get a green card?*

The fillers were intended to ensure that the child was paying attention and understood how the game worked. Children were encouraged to try again if they got the fillers incorrect. This happened very rarely during the game.

This study was a 2x2x2 design, and all manipulations were within subjects. We manipulated whether we were asking about a desire with a conflict (CONFLICT condition) or not (NO CONFLICT condition). Additionally, we manipulated whether we were asking about a positive outcome from the child's perspective (POSITIVE condition) or not (NEGATIVE condition). We also manipulated whose desire we were asking about, the child's (CHILD DESIRE condition) or Froggy's (FROGGY DESIRE condition). We counterbalanced order between subjects. Table 3-5 illustrates the within-subjects factors in experiment 2.

TABLE 3-5: Experiment 2: Within-subjects factors

CONFLICT/NO CONFLICT	POSITIVE/NEGATIVE	SENTENCE (Froggy v. Child desire)	Truth Value
CONFLICT	POSITIVE (child stamps)	"FROGGY WANTS"	False
		"YOU WANT"	True
CONFLICT	NEGATIVE (Froggy stamps)	"FROGGY WANTS"	True
		"YOU WANT"	False
NO CONFLICT	POSITIVE (Child & Froggy stamp)	"FROGGY WANTS"	True?
		"YOU WANT"	True?
NO CONFLICT	NEGATIVE (No one stamps)	"FROGGY WANTS"	False
		"YOU WANT"	False

Color and outcome were counterbalanced within subjects, so that every color and every outcome occurred an equal amount of times during the game. We also rotated which colors were paired with which outcomes throughout the game, to ensure that a color bias would not affect the results. We rotated a total of four times during the game, after every four sets of test questions. Within each of the four blocks, each color and each outcome occurred one time. A schematic of a trial is shown in table 3-6.

TABLE 3-6: Experiment 2: Sample trial

Booboo: Froggy wants the card to be blue!
E1: Did Booboo get it right?
Child: yes/no
E1: Good job/try again, Booboo!
Booboo: You want the card to be green!
E1: Did Booboo get it right?
Child: yes/no
E1: Good job/try again, Booboo! OK, let's flip! [**E1 flips card]** Oh! we got green! What happens when we get a green card?
Child: ____ gets to stamp!
E1: Good job! Let's stamp! … ok, Booboo, tell us something about the game …

3.2.3 Experiment 2: Procedure

The procedure for Experiment 2 was the same as for Experiment 1. Experiment 2 began with the child being introduced to "Froggy," with whom they would be playing the game. The experimenters were somewhat flexible with the script, adjusting to each child's level of attention, but the experimenters followed the following script fairly closely:

> *"We're going to play a game with Froggy today where we get to flip cards! And every time that we flip a card, someone gets to put a stamp on their paper. Froggy loves stamps… do you like stamps? OK, so every card that we flip has a color, and we can look at the board (point) to see who gets to stamp when we flip that color. OK, so when we flip a green card, you and Froggy both get to stamp. When we flip a brown[2] card just Froggy gets to stamp. When we flip a blue card just you get to stamp. And when we flip a pink card no one gets to stamp."*

Then the child was introduced to the silly puppet, Booboo:

> *"OK, one more thing! Froggy's friend Booboo the baboon wants to learn how to play the game, so he's going to watch us play. But*

[2] The brown card was occasionally named by the child as a different color, e.g., *tan*. In these cases we adapted the name of the color based on what the child said. Children had no difficulty with any other colors used in the game.

he's not very good at colors, so sometimes he gets things mixed up! Sometimes he's going to try to tell us something about how the game works, but he might get it wrong, and your job is going to be to help him out and tell him whether he's right or wrong so he can learn how to play the game. How does that sound?"

The child then practiced interacting with Booboo. First Booboo practiced naming colors, half of which he got right and half of which he got wrong, and the child practiced telling him *yes* and *no*. The child was corrected during this color practice phase if they did not correctly tell Booboo *yes* and *no*. Then we moved on to the practice phase, where the child saw between four and twelve practice trials. Again, during this phase the child was corrected when they made an error.

After sufficient practice, we moved on to the test phase. During each test trial, Booboo uttered each test sentence, and experimenter 1 asked the child if Booboo was right. Then the child gave her response. Experimenter 1 gave feedback to Booboo that was in accordance with how the child had responded, as in the previous experiment. After both test sentences, experimenter 1 flipped the next card on the pile and asked the child the filler question. After the child responded, the appropriate player(s) stamped their paper, and we moved on to the next test trial. The entire experiment took around 20 minutes per child.

3.2.4 Experiment 2: Hypotheses and Predictions

This experiment tests whether children have more difficulty interpreting sentences with *want* than in previous studies, when interpreting it requires

processing a desire state that conflicts with the child's own. This hypothesis is spelled out in table 3-7 below, as Hypothesis 1B.

TABLE 3-7: Experiment 2: Hypotheses

HYPOTHESIS 1	NO *THINK*-*WANT* ASYMMETRY: The *think*-*want* asymmetry that has previously been observed is due to unequal task demands; testing these verbs under more similar conditions will reveal no asymmetry.
	HYPOTHESIS 1A: *Think* has been harder than *want* in previous tasks because the present temporal orientation of *think*-sentences sets up a conflict with reality that children have difficulty processing.
	HYPOTHESIS 1B: *Think* has been harder than *want* in previous tasks because interpreting *think*-sentences requires processing a conflict with the participant's own mental state.
HYPOTHESIS 2	DIFFERENTIAL SENSITIVITY TO REALITY IN INTERPRETING *WANT* AND *THINK:* Children are able to differentiate *want* and *think* by four years of age (as the literature has previously suggested).

If this conflict is responsible for the difficulty with *think*, then we expect children to have more difficulty with the conflict conditions than the no-conflict conditions in this task. If this conflict is not responsible for the observed difficulty with *think*, then we expect to see no difference between conditions in this task.

3.2.5 Experiment 2: Results

3.2.5.1 Coding

Children's responses were coded online by the second experimenter. Four out of the 60 videos were coded by a second experimenter offline, because coding did not happen online. Responses were coded as *yes*, or *no*. An additional 25% (15 videos) were coded offline by an additional coder. We found 97.9 percent agreement (Cohen's Kappa = .952.)

3.2.5.2 Practice and Filler Accuracy

This experiment included an extensive training and practice section. There were four practice items. Children had to get all four in a row right to be included. We went through all the items either once (four items), twice (eight items) or three times (12 items). This means that children had a minimum of four practice items, and a maximum of 12. 16 out of the total of 63 children tested (25%) did not pass the practice after three rounds and were thus excluded from the rest of the experiment and analysis. Of the 40 included subjects, 20 of them went through the practice items once, 11 went through the practice items twice, and 2 went through the practice items three times. Overall accuracy was not different for the groups of children who did the practice items once or twice. The two children who did the practice items three times had lower accuracy (table 3-8). This may be related to an overall difficulty to perform on this task, or it may be due to the fact that for these children the task took a longer amount of time, thus, they may have been more fatigued by the time they got to the test questions, which may have contributed to their overall accuracy. It is also possible that children with lower executive function abilities performed worse on this task. Perhaps children with lower executive functioning abilities were less likely to pass the practice, or more likely to give *yes*- or *no*-biased responses on the test items. For the additional six children, the practice session was not recorded due to experimenter error.

TABLE 3-8: Experiment 2: Accuracy by Number of Practice Items

Number of practice items	% Accuracy overall
4	75%

8	74.4%
12	56%
no data	72.3%

The fillers were designed as a control to ensure that children were paying attention during the game as well as to keep them engaged. Once children were included after the practice phase, they rarely had any difficulty correctly saying who got to stamp after each card flip, and asking the child after each card flip was an extremely natural question during the game. If they incorrectly answered the filler, they were directed to try again. Some children passed the practice phase, but then responded either *yes* or *no* to all (or all but one) of the test items. These children were excluded from analysis. Three children had *yes*-biases (3%), and two children had *no*-biases (3%).

3.2.5.3 Experiment 2: Truth-Value Judgments

The results for each condition are shown in Table 3-9.

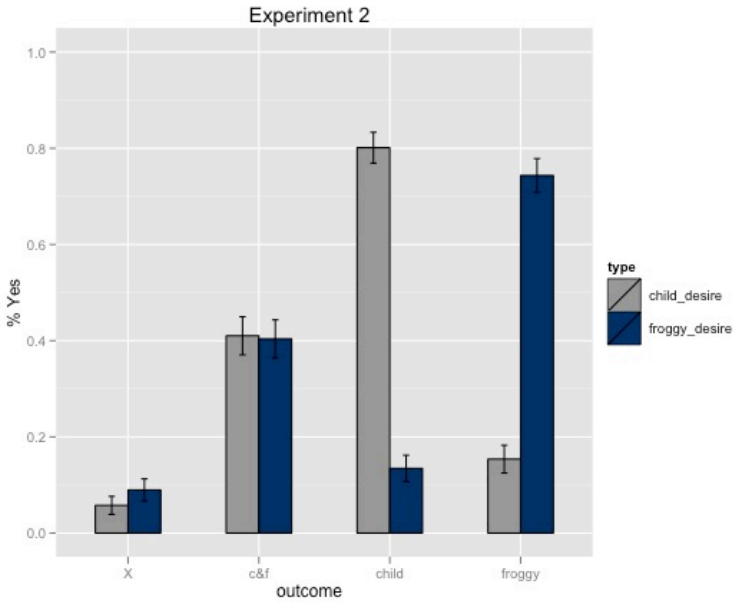
TABLE 3-9: Experiment 2: Percent *yes*-responses by condition

CONFLICT/NO CONFLICT (within subjects)	OUTCOME (within subjects)	SENTENCE (Froggy v. Child desire)	Target	% Yes
CONFLICT	POSITIVE (child stamps)	"FROGGY WANTS"	No	13%
		"YOU WANT"	Yes	80%
CONFLICT	NEGATIVE (Froggy stamps)	"FROGGY WANTS"	Yes	74%
		"YOU WANT"	No	15%
NO CONFLICT	POSITIVE (Child & Froggy stamp)	"FROGGY WANTS"	Yes?	40%
		"YOU WANT"	Yes?	41%
NO CONFLICT	NEGATIVE (No one stamps)	"FROGGY WANTS"	No	9%
		"YOU WANT"	No	6%

We ran a 2x2x2 ANOVA with percent *yes* responses as the dependent measure. The analysis revealed an interaction between SENTENCE type and

OUTCOME (F(1,38) = 127.5, p <.0001), but no interaction between SENTENCE type and CONFLICT (F(1,38) = 2.61, p = 0.11). Children responded significantly differently based on whose desire was reported and whether that outcome was positive or negative. They were not significantly influenced in answering questions about their own or Froggy's desires by whether a conflict was present.[3] Results for all conditions are shown in Figure 3-3.

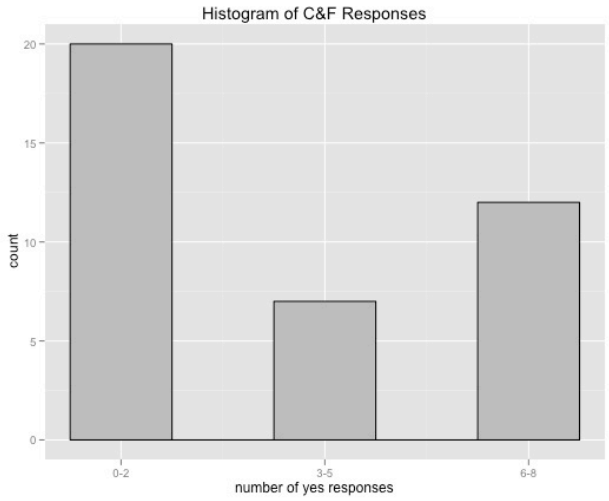
FIGURE 3-3: Experiment 2: Percent *yes*-responses



[3] We also ran the same analyses including the children who were excluded due to *yes*- or *no*-biases. We still find a significant interaction between SENTENCE type and OUTCOME (F(1,42) = 101.6, p <.0001); but also a marginally significant interaction between SENTENCE type and CONFLICT (F(1,42) = 3.96, p = 0.053). This is due to the fact that these additional 5 children were responding *yes* or *no* to all test questions—including questions about their own desires. This makes it appear as though (as a group) children were responding in a manner more similar on CONFLICT and NO CONFLICT trials. We argue that excluding these children is appropriate in this case, given that they did not respond differently to any test items during the task, including trials referencing their own desires. This demonstrates that they either did not understand the game, or did not have any of their own desires for the outcome of the card flips. In either case, the "conflict" trials for this group of 5 children do not represent any real conflicting desires.

Children were adult-like in the conflict cases, whether they were being asked about either positive or negative outcomes. In the NEGATIVE NO CONFLICT condition, children had no trouble saying that neither they nor Froggy wanted an outcome where no one got to stamp. In the POSITIVE NO CONFLICT condition, where both the child and Froggy got to stamp, some children played the game in a more competitive way, responding that neither they nor Froggy wanted the outcome where both players got to stamp, while other participants responded that both they and Froggy wanted this outcome. The histogram in Figure 3-4 shows that children were normally choosing either a strategy of responding *yes* to this condition all the time, or *no* to this condition all the time. This indicates that they were not confused by this condition, but that different children simply differed in how competitive they chose to be with Froggy. This however does not affect whether a conflict with someone else's desires impacts performance on interpreting *want*.

FIGURE 3-4: Experiment 2: Histogram of responses to Child & Froggy condition



Our results indicate that three year olds are adult-like in interpreting *want* even when they are asked to assess a character's desire that conflicts with their own, as long as they are given adequate training and opportunity to understand the rules of the "game" used to test this ability.

3.2.6 Experiment 2: Discussion

In studies testing *think* in false belief situations, the reported false belief is in direct conflict with the participant's belief. Previous tests of *want* either did not require the child to evaluate desires that directly conflicted with their own, or the methodology was problematic and results were inconclusive. Experiment 2 improved on previous methodology, and looked at three year olds' ability to interpret sentences with *want* in situations where the reported desires conflicted with their own, and showed that three year olds responded in adult-like fashion. This suggests that children's difficulty with *think* is not solely due to processing demands evaluating a mental state that conflicts with one's own.

One potential problem with this study is the possibility that the "desire" that we induced in the child in the game is not a real one. During the game, the child has to keep track of which color is paired with which outcome at that point in the game. The pairings are only consistent for four trials before switching again. The rotation of colors and outcomes was an important manipulation to ensure that the results were not affected by color biases, but it's possible that keeping track of this requires a lot of effort for the child, and that this effort is interfering with their interpretation of the desire sentences. In this context, they may have been so focused on the online computation of the color/outcome pairs that they do not form a true desire.

3.3 Experiment 3: Conflict with Child's Mental State 2

The results of Experiment 2 suggest that given the right context and an age-appropriate game with enough training and practice, children are able to correctly interpret sentences with *want*, even in cases where the sentences are about another character's desires, and those desires conflict with the child's own. In order to control for this possibility, we designed a slightly modified version of experiment 2, designed to induce a more deeply rooted desire in children. In this manipulation, the child picked the color/outcome, and the color/outcome pairings did not change during the course of the game. This allowed the child to have a deeper-rooted desire, because after several rounds they no longer had to calculate online which outcome a particular color led to on a given trial.

3.3.1 Experiment 3: Subjects

Participants were 8 children aged 3;0 to 4;0 (mean = 3;8). 1 additional child was excluded due to *no*-biased responses on the task. All children were recruited from the College Park, Maryland area, and were reported by their parents to be monolingual speakers of English. Participants were recruited via telephone or email from the University of Maryland Infant Studies Database.

3.3.2 Experiment 3: Design and Materials

The design and materials for this experiment were exactly the same as Experiment 2, except that the color/outcome pairings did not change throughout the game. In this experiment, the child was asked to choose at the beginning of the session which colors were paired with which outcomes, and these pairings stayed stable throughout the game.

3.3.3 Experiment 3: Procedure

The procedure was almost exactly the same as the procedure in Experiment 2, except the initial instructions were slightly different. Again, the experimenters were somewhat flexible with the script, adjusting to each child's level of attention, but the experimenters followed the following script fairly closely:

> *"... OK, so let's decide what happens when we get each color. Which color is your favorite? OK, so when we get a __ card, you get to stamp. Which color is your next favorite? OK, so when we get a __ card, you and Froggy get to stamp. Which color is Froggy's favorite color? OK, so when we get a __ card, Froggy*

gets to stamp. OK, and we have __ left, so when we get a __ card, no one gets to stamp."

3.3.4 Experiment 3: Hypotheses and Predictions

This experiment tests the same hypotheses as the previous study, shown again below in Table 3-10. This experiment has been modified slightly to ensure that the desire that the participant has is, in fact, a real desire.

TABLE 3-10: Experiment 3: Hypotheses

HYPOTHESIS 1	NO *THINK*-*WANT* ASYMMETRY: The *think*-*want* asymmetry that has previously been observed is due to unequal task demands; testing these verbs under more similar conditions will reveal no asymmetry.
	HYPOTHESIS 1A: *Think* has been harder than *want* in previous tasks because the present temporal orientation of *think*-sentences sets up a conflict with reality that children have difficulty processing.
	HYPOTHESIS 1B: *Think* has been harder than *want* in previous tasks because interpreting *think*-sentences requires processing a conflict with the participant's own mental state.
HYPOTHESIS 2	DIFFERENTIAL SENSITIVITY TO REALITY IN INTERPRETING *WANT* AND *THINK:* Children are able to differentiate *want* and *think* by four years of age (as the literature has previously suggested).

Again, we expect that if this conflict is responsible for the difficulty with *think*, then children should have more difficulty with the conflict conditions than the no-conflict conditions in this task. If this conflict is not the responsible for the

observed difficulty with *think*, then we expect to see no difference between conditions in this task.

3.3.5 Experiment 3: Results

3.3.5.1 Coding

Children's responses were coded online by the second experimenter. Responses were coded as *yes*, or *no*. We are in the process of coding the videos offline to ensure good intercoder reliability and correct delivery of all items.

3.3.5.2 Practice and Filler Accuracy

Like Experiment 2, this experiment included an extensive training and practice section. There were four practice items. Children had to get all four in a row right to be included. We went through all the items either once (four items), twice (eight items) or three times (12 items). This means that children had a minimum of four practice items, and a maximum of 12. All children in this sample passed the practice. Of the 7 included subjects, two of them went through the practice items once, and three went through the practice items twice. For the additional two children, the practice session was not recorded due to experimenter error.

The fillers were designed to be a control to ensure that children were paying attention during the game as well as to keep them engaged. Once children were included after the practice phase, they very rarely had difficulty correctly saying who got to stamp after each card flip, and asking the child after each card flip was an extremely natural question during the game. If they incorrectly answered the filler, they were directed to try again. This occurred very few times.

One child passed the practice phase, but then responded *no* to all of the test items (13%). This child was excluded from analysis.

3.3.5.3 Truth-Value Judgments

The results for each condition are shown in Table 3-11.

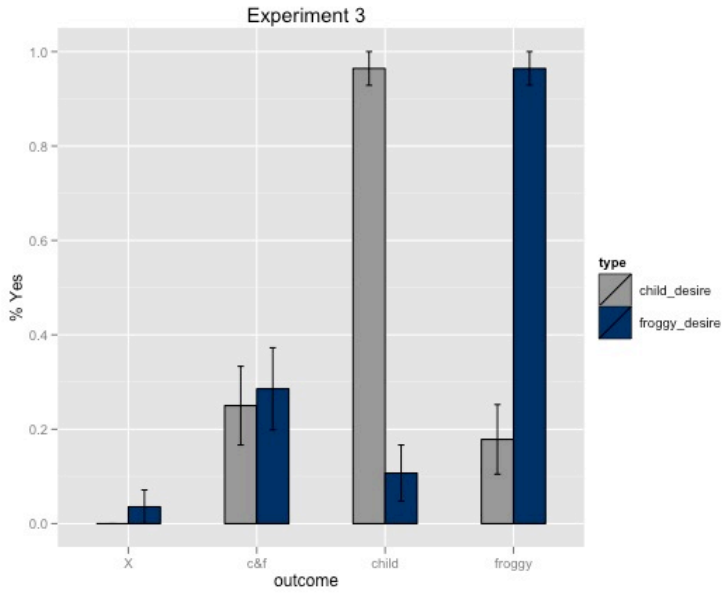
TABLE 3-11: Experiment 3: Percent *yes*-responses by condition =

CONFLICT/NO CONFLICT (within subjects)	POSITIVE/NEGATIVE (within subjects)	FROGGY/CHILD DESIRE (within subjects)	Target	% Yes
CONFLICT	POSITIVE (child stamps)	FROGGY DESIRE	No	11%
		CHILD DESIRE	Yes	96%
CONFLICT	NEGATIVE (Froggy stamps)	FROGGY DESIRE	Yes	96%
		CHILD DESIRE	No	18%
NO CONFLICT	POSITIVE (Child & Froggy stamp)	FROGGY DESIRE	Yes	29%
		CHILD DESIRE	Yes	25%
NO CONFLICT	NEGATIVE (No one stamps)	FROGGY DESIRE	No	4%
		CHILD DESIRE	No	0%

In a 2x2x2 ANOVA with percent yes responses as the dependent measure, we found an interaction between Sentence Type and Outcome ($F(1,6) = 45.67$, $p = .0005$); but no interaction between Sentence Type and conflict ($F(1,6) = 1.78$, $p = 0.23$).[4] Graphs for all conditions are shown in Figure 3-5.

FIGURE 3-5: Experiment 3: Percent *yes*-responses

[4] We also ran the same analyses including the child who were excluded due to a *no*-bias. We still find a significant interaction between SENTENCE type and OUTCOME ($F(1,6) = 45.7$, $p = .0005$); and no significant interaction between SENTENCE type and CONFLICT ($F(1,6) = 1.78$, $p = 0.23$). Excluding this child made no difference to the analyses.



Results of this study indicate that children are good at interpreting *want* even when they are asked to reason about a character's desires that conflict with their own, even when the desire is more deeply-rooted than in Experiment 2.

3.3.6 Experiment 3: Discussion

This study looked at children's ability to correctly interpret sentences with *want* in a situation where the subject's desires were different from their own, and when the desire does not require a lot of online calculation, which could distract children from the conflict. Previous results were inconclusive about whether or not children are able to do this kind of task. Two previous studies looked at children's ability to interpret sentences with *want* which reference an agent's desires that differed from the child's, however results are somewhat contradictory. One study (Moore et al. 2005) claim that their results show that conflicting desires

are just as hard as false beliefs; the other (Rakoczy et al. 2007) claim that conflicting desires are easier than false beliefs. Furthermore, both studies raised methodological concerns. In both tasks, there were few critical trials, and no reported training. Results from the two experiments that we have presented here show that given the right kind of task, children have no difficulty representing multiple conflicting desire states at once, even when one of those desire states is in conflict with their own. This supports HYPOTHESIS 2, which stated that the asymmetry previously observed between *think* and *want* is robust, and that the asymmetry is being caused by a real difference between these two subclasses of attitude verbs, and not differences in processing demands on previous experiments.

3.4 Experiment 4: Comparing *want* and *think* directly

The first three studies look at children's interpretation of *want* in experimental contexts more similar to the way *think* has previously been tested. While these studies provide evidence that it is not experimental factors influencing children's interpretation of *think,* studies 1-3 do not provide a direct comparison of children's interpretation of these two verbs. Therefore, it is still possible that compared in the exact same experimental task, we would see performance errors in interpreting *want* in the same way we see errors interpreting *think*. Few studies have directly compared interpretation of these verbs. Perner (2003) looked at interpretation of both verbs using stories, but the stories were not exactly matched, thus the experimental conditions were not the same for both

verbs. Experiment 4 remedies this problem. In this study, we test *want* and *think* in the same task, in order to directly compare children's interpretation of these two attitude verbs.

3.4.1 Experiment 4: Subjects

Participants were 48 children aged 4;0 to 5;0 (mean = 4;6). 6 additional children were excluded from the task; 4 due to getting too many controls incorrect, 1 due to parental report of hearing below 80% English, and 1 due to experimenter error.

3.4.2 Experiment 4: Design and Materials

Experiment 4 was a game task, in the style of experiments 2 and 3. In order to manipulate verb (*want* v. *think*), we set up a context in which both the beliefs and desires of a character were relevant. In order to do this, we set up a "game" for the child to play with a puppet, *Froggy.* The child and one experimenter are behind an occluder, while Froggy is on the other side. In front of the child and experimenter is a box with 40 wooden shapes in it. The shapes, which are hearts and stars, are either red or yellow. Color is predictive of shape; 15 of the hearts are red and 5 are yellow, and 15 of the stars are yellow and 5 are red. In the game, the child and the experimenter pull shapes out of the box to show Froggy, and every time the shape is a heart, the child gives Froggy a sticker. We establish that Froggy likes getting stickers; therefore his desire is that on every trial, it will be a heart that is pulled out of the box. On each trial, before Froggy sees what the shape is, the child and the experimenter show him a "clue," which is ambiguous in shape. There is an opening in the occluder that is the right

shape for a point—either the point of the heart or one of the points of the star (see figure 3-6).

FIGURE 3-6: Experiment 4: Shapes

This way, on every trial, Froggy has both a *desire* about what the shape will be—because he always wants the shape to be a heart; and also a *belief* about what the shape will be—because when it is red, he thinks it's a heart and when it's yellow he thinks it's a star. This set-up allows another puppet, *Booboo*, whom the child is told is "silly and wants to learn how to play the game, but often gets things mixed up," to utter test sentences either about what Froggy *wants* (92) or what he *thinks* (93).

(27) *Froggy wants it to be a heart/star!*

(28) *Froggy thinks that it's a heart/star!*

The child's job in the task is then to say whether Booboo is correct or incorrect.

In a 2x4 design, we tested sentence type as a between-subjects factor (*want* (n=24)*, think* (n=24), and "realization of mental state" as a within-subjects factor and the child's response of *yes* or *no* as the dependent measure. On every trial, Froggy has both a belief and a desire about what the next shape to be pulled out of the box is. Sometimes, he has a true belief (red heart, yellow star conditions), which we call "realized belief" situations. Sometimes, he has a false

belief (red star, yellow heart conditions), which we call "non-realized belief" situations. Similarly, sometimes his desire for a heart is fulfilled (red/yellow heart conditions), which we call "realized desire" situations. Sometimes his desire for a heart goes unfulfilled (red/yellow star conditions), which we call "non-realized desire" situations. In the study, the participant encounters every possible combination of realized and non-realized beliefs and desires. Table 3-12 shows each of the within-subjects conditions.

TABLE 3-12: Experiment 4: Within-Subjects Conditions

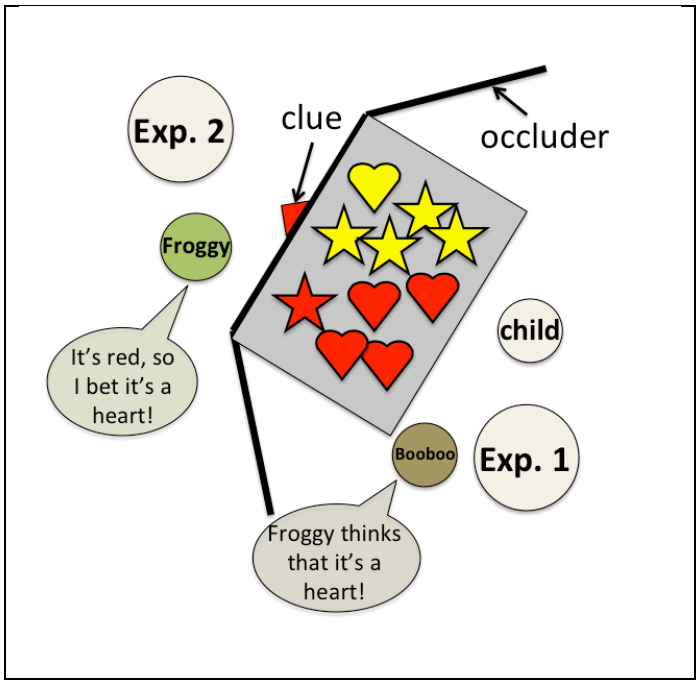
Shape	Desire	Belief
Red Heart	Realized	Realized
Red Star	Non-Realized	Non-Realized
Yellow Heart	Realized	Non-Realized
Yellow Star	Non-Realized	Realized

The experiment includes 8 items of each type—4 yes-target sentences and 4 no-target sentences, for a total of 32 test items per child.

3.4.3 Experiment 4: Procedure

Each child was tested in a quiet room with two experimenters. One experimenter sat next to the child and gave the child instructions about the game. The first experimenter also controlled the silly puppet, "Booboo," and read the filler and test sentences. Another experimenter sat on the other side of the occluder (across the table from the child and the first experimenter), and played Froggy (see figure 3-7).

FIGURE 3-7: Experiment 4: Set-up



The second experimenter also coded the child's responses. Permission was obtained from parents to video record each subject for an additional round of coding off-line. The experiment began by the child being introduced to a puppet, "Froggy," with whom they would be playing the game. The first experimenter says the following to introduce the child to the puppet:

> *"Hi, [child's name]. This is Froggy! We're going to play a game with Froggy today!"*

Next, the child goes through several practice sections in order to ensure that they understand all the necessary elements of the game, including an understanding of Froggy's desires and beliefs in this context. The practice sections are detailed below.

3.4.3.1 Practice Sections

Practice Section #1: Practice with distribution. The first warm-up involves directing the child's attention to the distribution of colors and shapes. The shapes are already divided up on the table in front of the child,

> *"Froggy has a whole bunch of different shapes. Let's look at what shapes he has! Can you tell me about the shapes? Some of them are red! Can you tell me what kinds of red shapes we have?"*
> *[Child responds 'hearts and stars'.]*
> *"That's right! Hearts and stars! Do we have a lot of the red hearts or just a few? And what about red stars?"*

The point of this warm-up is for the child to notice the distribution of colors and shapes. We have them tell us about each type—lots of red hearts and yellow stars, few red stars and yellow hearts. This helps them get the intuition that a red clue is more likely to be a heart and a yellow clue is more likely to be a star—and that Froggy's guesses will reflect this.

Practice Section #2: Child and Froggy guessing game. During the next warm-up section, we put all the shapes in the box, and the experimenter turns the occluder so that the child can no longer see the box of shapes. She then shows Froggy and the child clues—which are in the form of a point sticking through a slot in the occluder. The point is ambiguous—one of the points on the star shapes is the exact same size and shape as the point on the heart shapes. This means that

neither the child, nor Froggy can see what the shape is. The child is told that they will be able to guess what the shape is, and then Froggy will guess, and then the experimenter will take the shape out so everyone can see. If the shape is a heart, the child gives Froggy a sticker. The shapes pulled out during this section reflect the distribution in the box. The point of this practice section is for the child to experience seeing the ambiguous clues, so that they truly understand that from the other side of the occluder, it is impossible to tell. They sometimes have the experience of guessing incorrectly and then being surprised when the clue is taken out. This section also demonstrates to the child what Froggy's default guesses are—namely that when the clue is red, Froggy thinks it's a heart, and when it's yellow he thinks it's a star.

Practice Section #3: Froggy's default guess check. The next practice section ensures that children understand Froggy's belief (or default guess) given each clue type. The experimenter checks this by asking the following questions:

> *"So when Froggy sees a red clue, what kind of shape does he guess? Right, a heart! And when Froggy sees a yellow clue, what kind of shape does he guess? Right, a star!"*

This ensures that the child understands what Froggy's beliefs are, given the clue that he sees.

Practice Section #4: Practice with Booboo. In the final warm-up section of this task, children are introduced to the silly puppet, Booboo, who is going to

watch them play the game with Froggy. The child is told the following about Booboo:

> *"OK, one more thing! This is Froggy's friend, Booboo! Booboo really wants to learn how to play the game, but he's really silly and he always gets things mixed up! He always forgets what kind of shapes Froggy likes, and what kind of stuff Froggy guesses when he sees clues. But you're super good at that, right? So maybe you could help Booboo learn, could you do that? OK, good! So Booboo is going to watch us play, and sometimes he's going to try to tell us something about Froggy, but he might get it wrong, and your job is going to be to help him out and tell him whether he's right or wrong so he can learn how to play the game. How does that sound?"*

After Booboo is introduced, the child is told that we are going to show Booboo some clues, and see what he says about Froggy. Then Booboo is shown four clues—one of each type—and says sentences about what Froggy will guess, and whether he likes that shape or not. While only the clue is visible to the child, Booboo says a sentence about what Froggy will guess given the color (94), and after the shape is taken out, Booboo says a sentence about whether Froggy likes that shape or not (95).

(29) *This one is red/yellow… so Froggy is going to guess heart/star!*

(30) *Oh! Froggy likes/doesn't like that kind!*

The child's job is to tell Booboo whether he said each of the sentences correctly. This gives the child a chance to observe that Booboo is bad at remembering Froggy's mental states, and practice telling him when he is right and wrong when he says things about Froggy. This section also serves as a reminder of Froggy's desires and beliefs. If the child has any trouble correcting Booboo on this section, they are given help from the experimenter. We are currently in the process of coding the practice sections to look at rates of errors on these questions, and look for correlations between performance on these sections and performance on the test questions.

3.4.3.2 Test Sentences

After all of the warm-up sections are finished, the box of shapes and the occluder are turned so that now that child can again see which shape is under discussion. They are told that now they are going to be able to "peek" while we show Froggy some more clues, and Booboo is still going to say something about "what Froggy likes, or what he might guess." Then we begin showing Froggy clues, and uttering test sentences. The whole game takes about 25 minutes.

3.4.4 Experiment 4: Hypotheses and Predictions

This experiment tests whether or not children have more difficulty interpreting sentences with *want* than in previous studies, when interpreting sentences with *want* requires processing a desire state that conflicts with the child's own. This hypothesis is spelled out in Table 3-13 below, as Hypothesis 1C.

TABLE 3-13: Experiment 4: Hypotheses

HYPOTHESIS 1	NO *THINK*-*WANT* ASYMMETRY: The *think*-*want* asymmetry that has previously been observed is due to unequal task demands; testing these verbs under more similar conditions will reveal no asymmetry.
	HYPOTHESIS 1A: *Think* has been harder than *want* in previous tasks because the present temporal orientation of *think*-sentences sets up a conflict with reality that children have difficulty processing.
	HYPOTHESIS 1B: *Think* has been harder than *want* in previous tasks because interpreting *think*-sentences requires processing a conflict with the participant's own mental state.
	HYPOTHESIS 1C: *Think* has been harder than *want* in previous tasks because of some other difference in tasks demands between tests of the two verbs.
HYPOTHESIS 2	DIFFERENTIAL SENSITIVITY TO REALITY IN INTERPRETING *WANT* AND *THINK:* Children are able to differentiate *want* and *think* by four years of age (as the literature has previously suggested).

If there is some other difference in task demands between previous tests of *think* and tests of *want,* then we expect children to treat the two verbs the same when we compare them in the same task. If task demands are not responsible for the observed difficulty with *think*, then we expect to replicate the previously observed asymmetry in this task: children should still have difficulty interpreting sentences with *think*, while being adult-like in interpreting sentences with *want.*

3.4.5 Experiment 4: Results

3.4.5.1 Coding

Children's responses were coded online by the second experimenter. We are in the process of coding 25% of the videos offline by another coder to check for accuracy and reliability of the online coders.

3.4.5.2 Responses to test questions

There are three possible response patterns that we might expect to see

given the experimental setup. The first expected pattern is one based on desires. Children behaving this way should assent to sentences that mention "heart," regardless of what shape and color the shape actually is. The second possibility is that children will give responses based on Froggy's beliefs. In this case, children should assent to sentences that mention a heart whenever the clue is red, and to sentences that mention a star whenever the clue is yellow. Finally, we may see responses based on reality. In this case, children should assent to sentences that mention the shape corresponding to the actual shape (regardless of color, nor desire or belief). In the *think* condition, we expect belief-based responses if children are adult-like in interpreting sentences with *think*; and reality-based responses if children show the same difficulty with *think* as they do in typical false belief tasks. In the *want* condition, we expect desire-based responses if children are adult-like in interpreting sentences with *want*; but if using the same experimental context for *think* and *want* introduces further difficulty, we might expect children to also give reality based responses to *want*-sentences. Both hypotheses 1 and 2 predict reality-responses in the *think* condition. For the *want* condition, hypothesis 1 predicts reality-responses, and hypothesis 2 predicts desire-responses. Children's responses were measured in percent *yes*-responses. Red heart items were counted as controls—because this is a realized belief and realized desire case, whether the participant is responding based on desire, belief *or* reality; we predict the same pattern of responses. We predict that they will say *yes* when a heart is mentioned (96) and *no* when "star" is mentioned (97), regardless of verb condition.

(31) *Froggy wants it to be/thinks that it's a heart!*

(32) *Froggy wants it to be/thinks that it's a star!*

For this reason, we excluded participants who got fewer than 6 out of the 8 red heart items correct. We excluded 4 children for this reason. For the remaining children, we ran a 2x4 ANOVA with percent *yes* responses as the dependent measure. We find a significant main effect of verb ((F(1,344) = 4.67, p =.03)), a significant main effect of sentence type ((F(1,344) = 104.7, p <.0001)), and an interaction between sentence type and realization of mental state ((F(1,344) = 301.9, p <.0001)). Children are adult-like in interpreting *want*, but influenced by reality when there is a conflict in the *think* case. Data for all conditions are shown in Table 3-14.

TABLE 3-14: Experiment 4: Between- and Within-Subjects Conditions

VERB (BETWEEN SUBJECTS)	CONDITION (within subjects)	REALIZATION OF MENTAL STATE	Mentioned Shape	Target	% Yes Responses
THINK	RED HEART	REALIZED DESIRE REALIZED BELIEF	Heart	Yes	100%
			Star	No	3%
	RED STAR	NON-REALIZED BELIEF NON-REALIZED DESIRE	Heart	Yes	14%
			Star	No	85%
	YELLOW HEART	NON-REALIZED BELIEF REALIZED DESIRE	Heart	No	87%
			Star	Yes	22%
	YELLOW STAR	REALIZED BELIEF NON-REALIZED DESIRE	Heart	No	5%
			Star	Yes	91%
WANT	RED HEART	REALIZED DESIRE REALIZED BELIEF	Heart	Yes	98%
			Star	No	0%
	RED STAR	NON-REALIZED BELIEF NON-REALIZED DESIRE	Heart	Yes	69%
			Star	No	14%
	YELLOW HEART	NON-REALIZED BELIEF	Heart	Yes	100%

		REALIZED DESIRE	Star	No	2%
	YELLOW STAR	REALIZED BELIEF	Heart	Yes	74%
		NON-REALIZED DESIRE	Star	No	13%

Graphs for each of the conditions are shown below. The red heart condition (the control condition) is shown in Figure 3-8. As mentioned above, all three predicted interpretation types predict the same patterns of response in this condition. Children should say 'yes' to a mentioned heart (96) and 'no' to a mentioned star (97). As shown below in the graph, the remaining children have no difficulty in this condition (after 6 of the total 54 were excluded).

FIGURE 3-8: Experiment 4: Red Heart Condition

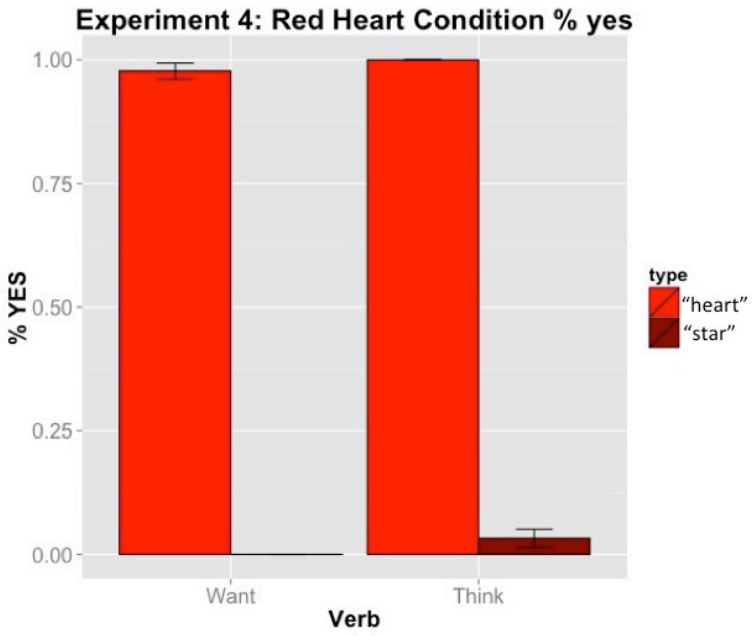


Figure 3-9 shows the yellow heart condition. In this case, if children are responding based on desire or reality, they should say 'yes' to a mentioned heart (96) and 'no' to a mentioned star (97). Children who are able to accurately respond based on Froggy's beliefs should have the opposite pattern of responses. As shown in the graph, very few participants in this study were adult-like in responding based on Froggy's beliefs. This condition does not demonstrate (or predict) differential treatment of *think* and *want*, but does provide evidence of children making the traditional false belief error with *think*.

FIGURE 3-9: Experiment 4: Yellow Heart Condition

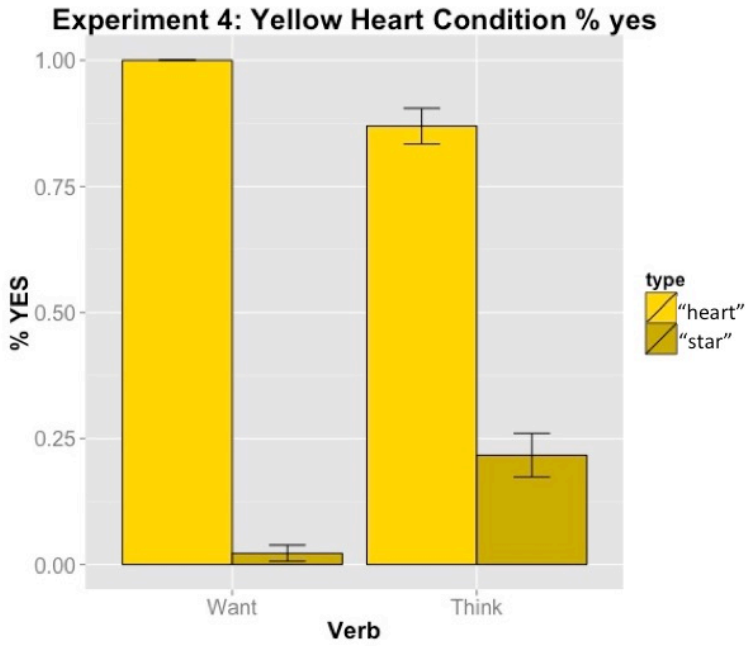


Figure 3-10 shows the red star condition. This condition is a non-realized belief and desire; therefore, reality patterns differently from both of these. This condition allows us to compare the influence of reality in the *think* and *want* conditions. In this case, if children are responding based on Froggy's beliefs or desires, they should say 'yes' to heart (96) and 'no' to star (97). Reality responses will show the opposite pattern of responses. As evident in the graph, children are able to overcome the lure of reality in interpreting sentences with *want*, but are influenced by reality in interpreting *think*. This condition shows both differential treatment of *think* and *want*, as well as showing children making the traditional false belief error in the *think* case.

FIGURE 3-10: Experiment 4: Red Star Condition

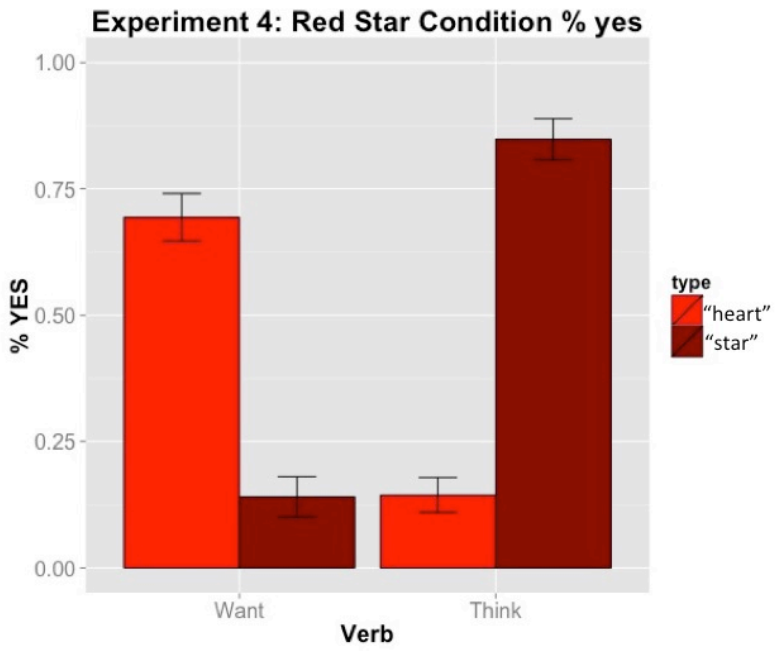
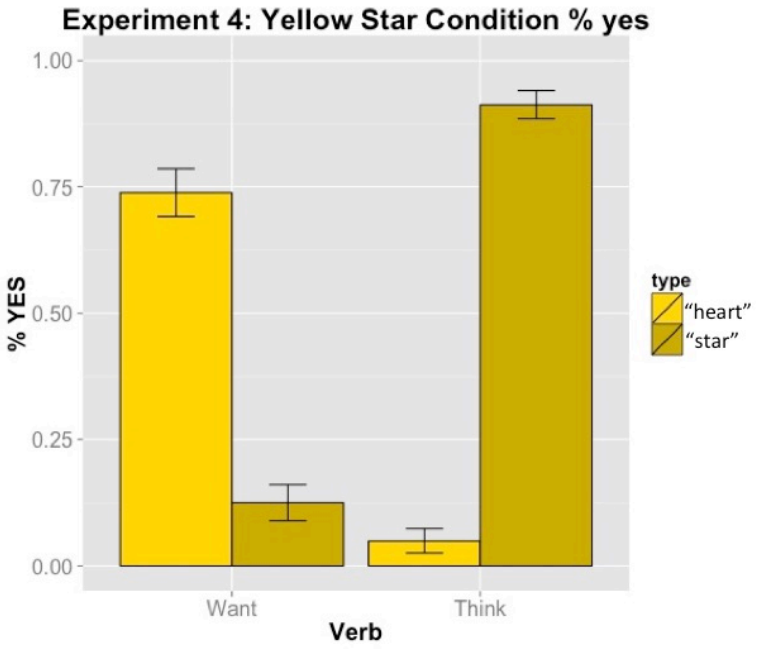


Figure 3-11 shows the yellow star condition. In this condition, Froggy's desire is unrealized, but his belief is realized (belief and reality pattern together). If children are responding based on Froggy's beliefs or based on reality, they will say 'no' to heart (96) and 'yes' to star (97); while desire responses will show the opposite pattern. Again, we see that children are giving desire responses in the *want* condition, but responding based on reality/belief in the *think* condition. This condition shows differential treatment of sentences with *think* and *want*, although does not demonstrate the traditional false belief error.

FIGURE 3-11: Experiment 4: Yellow Star Condition



3.4.6 Experiment 4: Discussion

In experiment 4, we have seen that even when children are tested under the same experimental conditions for both verbs, 4-year-olds are still much better at interpreting sentences with *want* than sentences with *think*. As previous studies have suggested, and was replicated here, when children interpret sentences with *think* about someone's false belief, they are influenced by what they know reality to be; whereas when they interpret sentences with *want*, they are able to override reality and respond based on the actual desires of the subject of the sentence, even when those desires differ from reality.

3.5 Chapter 3: Discussion

Previous literature has suggested there is an asymmetry between when *think* and *want* are acquired. We had concerns that the previous tests looking at children's knowledge of *want* and *think* were actually not comparable, and that there were many differences in the conditions under which these verbs had been tested. We were particularly concerned that tests of *think* often set up a conflict with reality, and a conflict with the child's own mental state, while tests of *want* did not include situations with these conflicts. Experiments 1-3 looked at whether adding these conflicts in to desire situations made interpreting *want* harder for 3-year-olds. We found that even when these conflicts were present, 3-year-olds had no difficulty interpreting sentences with *want.* This suggests that children are, in fact, treating these two verbs differently, and that the errors observed with *think* sentences cannot be solely due to difficulty processing a mental state that conflicts with reality or with the child's own mental state. In the final experiment presented in this chapter, we have controlled for other possible experimental factors by testing *think* and *want* in the same experimental context. Again, we find that children (4-year-olds) are influenced by reality when interpreting sentences with *think*, but not influenced by reality when interpreting sentences with *want.* In this chapter, I have presented 4 original experiments demonstrating that children are actually able to differentiate between *think* and *want*, even after controlling for possible differences between the conditions under which *think* and *want* have been tested.

The studies in this chapter addressed the hypotheses shown in table 3-15 below.

TABLE 3-15: Experiment 4: Hypotheses

HYPOTHESIS 1	NO *THINK*-*WANT* ASYMMETRY: The *think*-*want* asymmetry that has previously been observed is due to unequal task demands; testing these verbs under more similar conditions will reveal no asymmetry.
HYPOTHESIS 2	DIFFERENTIAL SENSITIVITY TO REALITY IN INTERPRETING *WANT* AND *THINK:* Children are able to differentiate *want* and *think* by four years of age (as the literature has previously suggested).

We found that Hypothesis 2 was confirmed—even when we control for experimental factors, we still find an asymmetry between interpretation of *want* and *think*. Now that it is clear that the observed asymmetry holds, we will explore what is cueing children in to semantic information about these verbs, especially considering how difficult psychological acts are to observe in the world. The next chapter will explore what might be guiding children's hypotheses about meanings, and specifically the role of syntax in learning attitude verbs.

Chapter 4: Syntactic Bootstrapping & Testing *hope*

4.1 A Bootstrapping Account

In this dissertation, I am addressing two main questions:

1. Is the performance asymmetry observed between *want* and *think* due to an acquisition difference? Or have differences in tasks demands inflated children's knowledge of *want* or masked understanding of *think*?
2. If the observed asymmetry reflects an acquisition difference, does the syntax of these verbs cue children in to semantic class?

Chapter 3 addressed the observed asymmetry between *want* and *think*, testing the two verbs under more equivalent conditions. The studies in this chapter demonstrate that even under very stringent comparisons, children are sensitive to reality in interpreting *think* but not *want.* In the next set of studies, we will explore a hypothesis about how children are getting to the relevant semantic or pragmatic information to be categorizing *think* and *want* differently. Specifically, as discussed in chapter I, we will explore a *syntactic bootstrapping for attitudes* hypothesis, which states that children use the syntactic distribution of different attitude verbs to access semantic and pragmatic information, contributing to their ability to categorize these verbs differently. In order for a syntactic bootstrapping hypothesis for attitude verbs hypothesis to hold, two facts must be true:

1. The link between attitude verb syntax and semantics must be principled.
2. Children must be sensitive to this link in the case of attitude verbs.

In the first chapter, we addressed #1, providing an overview of the work of many syntacticians and semanticists who have observed that the mappings between syntactic frame and semantic features do appear to be principled. Given the right level of abstraction, this linking even seems to hold cross-linguistically. We cited work proposing that representational attitude verbs, like *think*, embed clauses with syntactic features matching those of main clauses in their language, while preferential attitude verbs, such as *want,* embed clauses without main clause features. The work in this chapter will focus on point #2. We will test children's sensitivity to syntactic frame in interpreting an attitude verb, and ultimately demonstrate that children are sensitive to the syntactic form of the complement of attitudes when interpreting attitudes in experiment 5. In experiment 6, we show that in addition to using a syntactic complement for interpretation of individual sentences, children are able to carry over the information gleaned from the syntactic complement to future sentences using the same verb, even if the syntactic complement changes. This demonstrates that they seem to be using syntactic information not only to interpret sentences, but also learn attitude verb meanings. This link between syntax and semantics seems productive in explaining prototypical belief or desire verbs, like *want* and *think*.

The syntactic distribution facts for *want* and *think* provide a possible explanation as to how children might categorize these verbs by 4. These verbs are very clear examples, syntactically and semantically, of each of these categories. *Want* expresses only a desire, while *think* expresses only a belief. Additionally, their syntactic distributions are exactly complementary. This straightforward syntax-semantics connection provides an ideal opportunity for children to gain access to difficult-to-observe semantic facts through the syntactic distribution. However, in order to fully understand the nature of the syntax-semantics relation here, and how it might be useful for learning, it is necessary to consider other examples. In particular, cases which are less straightforward.

There are many different attitude verbs, each with its own particular semantic features and distributional facts. So far, we have pointed out that representational attitude verbs embed sentences with main clause features, while non-representational attitude verbs do not. While this connection may be informative for very early categorization by learners, it is possible that the syntax actually informs leaners of even more specific semantic features. If this is the case, we expect to see fine-grained syntactic features predicting specific semantic features (see White 2015 for a discussion of this using adult judgment data and computational modeling methods). We also hope to find that children will be sensitive to the distributional facts and this will lead them to the adult semantic representation for each attitude verb. We will start by looking at this at a fairly broad level, but in the future it will be interesting to explore not only how fine-

grained the links between syntax and semantics are (as White discusses), but also how sensitive children are to the syntactic distributions.

4.2 *Hope*

For the remainder of this dissertation, we will focus on one particular attitude verb, *hope*, that shares properties with both representational and preferential semantic classes. I will first lay out the facts about the meaning and syntactic distribution of *hope*, and demonstrate why it is not only an interesting case, but also makes an ideal test case for our syntactic bootstrapping hypothesis. The verb *hope* has an obvious desire component. Sentences with *hope* always express a preference (98)-(101)

(33) *Jeff hopes this dissertation will be done soon.*

(34) *Mike hopes for Kate to listen to him talk about wrestling.*

(35) *Kate hopes to be finished with her PhD soon.*

(36) *Mom hopes that Andy is in bed.*

In each of the above sentences, it is very easy to get the intuition that the *hoper* desires the content of the embedded clause. It appears that regardless of the syntactic frame, or the context, there is a desire component which is very obvious in interpreting sentences with *hope.*

Interestingly, *hope* also seems to have a belief component (Portner 1992). Although sentences with *hope* express a desire, there seems to be restrictions on what that desire can be, based on the belief state of the subject. For example, imagine a scenario where Andy is playing outside, and mom knows this. She can

still *want* him to do something else, but it is infelicitous to say that she *hopes* he's doing something else (102)-(103).

(37) *Mom knows Andy is playing outside, but she wants him to be in bed.*

(38) *#Mom knows that Andy is playing outside, but she hopes he's in bed.*

This belief component has been formalized in different ways (Anand & Hacquard, 2013, Scheffler 2008, Portner 1992), but the basic intuition is that in order to *hope* for P, the subject has to believe that P is a live possibility. Additionally, although it is fine for the subject to *want* P when she knows P to be true, *hope* seems to be infelicitous if the subject *knows* that P is true (104)-(105).

(39) *Mom knows Andy is in bed and that's where she wants him to be.*

(40) *Mom knows that Andy is in bed and that's where she hopes he is.*

Although *hope* expresses a desire, it requires that that desire is compatible with the beliefs of the subject, but not certain. While verbs like *think* express a commitment to truth, *hope* expresses a commitment to the possibility of truth.

Despite its prominent desire meaning, *hope* patterns with representational attitude verbs on several pragmatic features. Because of their representational semantics, verbs like *think* can be used to make indirect assertions, while verbs like *want* cannot. Like representational attitude verbs, *hope* can be used to make an indirect assertion, or to answer a question about the truth of the complement (106).

(41) A: Is John coming to the meeting?

B: a: I think he's coming. (= he's probably coming)

b: #I want him to come. (= he's probably coming)

c: I hope he's coming. (= he's probably coming)

Interestingly, even in this case where *hope* is used to make an indirect assertion, we see evidence of the desire component of its meaning. While B's response *a* probably means something like 'John is probably coming to the meeting,' response *c* means that John is probably coming, and additionally, it better be true or else John may be in trouble. The desires of the speaker for whether John comes to the meeting are much more evident with response *c* than with response *a.*

In addition to having both desire and belief components in the meaning of *hope*, we also observe syntactic distributional facts that are consistent with both representational and preferential attitude verb classes. We observed in chapter 1 that representational attitudes allow embedded clauses in which main clause features show up, while preferential attitude verbs do not (107)-(108).

(42) *Mom wants Andy to be in bed/*that Andy is in bed.*

**Andy to be in bed.*

(43) *Mom thinks that Andy is in bed/*Andy to be in bed.*

Andy is in bed.

Hope can take both non-finite (109)-(110) and finite (111) complements.

(44) *Mom hopes to go to bed.*

(45) *Mom hopes for Andy to be in bed.*

(46) *Mom hopes that Andy is in bed.*

This suggests that the syntactic distribution might track the semantic features: both belief and desire meaning components are present; and *hope* can take both finite and non-finite complements. Additionally, slifting is allowed with representationals and *hope,* while preferentials do not allow slifting (112).

(47) John is coming to the meeting, I think.
#John is coming to the meeting, I want.
John is coming to the meeting, I hope.

Hope shares semantic (and therefore pragmatic) components with both preferential and representational classes of attitude verbs. This seems to be reflected in the syntactic distribution—*hope* occurs in some frames traditionally associated with desire verbs, and others traditionally associated with belief verbs.

The cluster of properties that we see associated with *hope* shows that it shares features with both representational and preferential classes of attitude verbs. This is interesting and relevant to this line of research for several reasons. It appears on the surface that a verb like *hope* may pose a problem for a syntactic bootstrapping hypothesis. One might initially assume that *hope* is a desire verb, given that the desire meaning is usually very prominent, and worry that the syntactic distribution that we see for *hope* would be a problem for the learner. If they are using main clause features in the complement to categorize verbs as representational, a verb like *hope,* which sometimes appears with a finite complement, could get miscategorized. But in fact, given a more careful probing of the meaning of *hope*, we see that it also has a belief component. This shows that although *hope* does not fit neatly into only the belief or desire category, it

seems like the syntactic distribution and the semantic features are, in fact, linked in a way that could help the learner figure out the adult semantics for this verb. This is evidence that the links between syntax and semantics might be principled at a more fine-grained level than just two basic categories and two types of syntax.

We have seen in the preceding section that even in a case that is less straightforward than *want* or *think*, the links between the syntax and the semantics appear to be principled. In order for our syntactic bootstrapping hypothesis to hold, it must also be the case that the learner is able to use the syntax to get to the semantics. In the next section, we will outline why *hope* is an ideal case to look at this question. One piece of evidence that the syntax may help children is their differential susceptibility to reality in interpreting *want* and *think*. Although the contextual input that children get about the meanings of attitude verbs may not be very helpful, we have seen that they are able to categorize them by age 4. But, of course, *think* and *want* are quite common in the input. Looking in the CHILDES database (MacWhinney 2000), we found that *want* occurs 22,012 times per million utterances, and *think* occurs 10,187 times per million utterances. We know that children have heard on average about 15 million utterances by the age of 4, which means that an average 4-year old has heard *want* about 330,180 times; and *think* about 152,805 times. Although there is no necessary physical correlates that go along with these psychological acts, it is possible that they are getting at least some help from the situational contexts (perhaps along with the syntax) to figure out the meanings of *want* and *think*.

In order to better understand the learning strategy, and whether syntax plays a role, we need a more neutral case, where children have had less real world exposure. This allows us to look more directly at the role of syntax. The distribution we have observed for *hope* provides evidence that semantic information may be extractable from syntactic distributions in a more fine-grained way than has been observed for *want* and *think*. But, in addition, *hope* is also an ideal test case to look at the influence of syntactic frame on attitude verb understanding. In learning *want* and *think*, we have hypothesized that children may initially categorize these verbs as either representational or preferential, because of the differing syntactic complements and pragmatic functions. If children do, in fact, use the syntax in this way, children may find input for *hope* conflicting, given that it can occur with both a finite and a non-finite complement. Looking at children's initial hypotheses about *hope*'s meaning could tell us about the relative informativity of different frame types. For example, if we find that children always assume that *hope* is representational, this is evidence that hearing an attitude verb with a finite complement is strong evidence to the child. If we find a lot of individual variation, this might suggest that children's initial hypotheses are linked directly to the particular exposure that they have had. If we find that children do not yet know what *hope* means, than this shows us that whatever input that have gotten is not yet enough for them to have a semantic representation. This case would set up an ideal probe to test sensitivity to syntactic frame. Ultimately, looking at understanding of *hope* will tell us about the initial hypotheses children make based on what might be conflicting syntactic

input, and the amount of input children need to get to the adult semantic representations.

In order to understand children's hypotheses about the meaning of *hope*, and how those may be affected by the input, it is necessary to better understand the nature of the input that children get for these attitude verbs. *Hope* is obviously a much less common attitude verb than *want* or *think*, and we know children still have difficulty with *think* at age 4. It is unclear whether children at this age will have exposure to *hope* at all, and if so, whether they have enough exposure to notice the potentially conflicting syntactic evidence. Again, looking in CHILDES (MacWhinney 2000), we find that children hear *hope* much less often than *want* or *think*. *Hope* occurs in child directed speech at a rate of 364 times per million utterances, which means the average 4 year old may have heard *hope* around 5,460 times. Additionally, we find that although the evidence may be "conflicting" in that *hope* is allowed to occur with a non-finite complement, the overwhelming majority of sentences with *hope* actually occur with a finite complement.

Given this information about the input for *hope*, it is unclear whether children have enough exposure to know what *hope* means by the age of 4, or even to realize that if they do use the syntactic frame to determine meaning, that *hope* can occur with different kinds of complements. Testing children's understanding of *hope* is still a worthwhile endeavor, however. If children do know the meaning of *hope*, we will learn that this amount of exposure is sufficient to learn it's meaning; and can get a better sense of what role the syntactic distribution might

play. If children do not yet know the meaning of *hope* by age 4, however, this is an ideal case for testing the influence of syntax experimentally. The fact that *hope* can occur with both a finite and a non-finite complement allows us to manipulate syntactic frame in a neutral context to observe whether this impacts children's interpretations. This is an improvement over the work of Lidz, Gleitman & Gleitman 2004, who used ungrammatical sentences to test for the contribution of syntactic frame, which introduces complications. Here, we use only grammatical sentences.

We will use *hope* to test the influence of syntax in two ways. In experiment 5, we set up a context that is neutral with respect to beliefs or desires, and then look at children's interpretation of sentences with *hope*, manipulating syntactic frame between subjects. We find that children are sensitive to syntactic frame in interpreting *hope*. In experiment 6, we look at what happens when we expose children to the conflicting evidence by giving them both frames in a blocked within-subjects study. This shows us that children use syntactic information to build a meaning which carries over to interpretation of future *hope* sentences. We also see an interesting effect based on which frame is presented to children first. The results from these studies ultimately support our syntactic bootstrapping hypothesis; showing that children are sensitive to syntactic frame both in interpreting a new attitude verb and also in building a meaning hypothesis.

4.3 Experiment 5: Hope-to v. Hope-that (between subjects)

In order to test whether children use syntactic environment as a cue to attitude verb meaning, we test children's interpretation of sentences with *hope*, manipulating syntactic frame. As discussed in the previous section, *hope* is an ideal test case for several reasons. *Hope* is a real verb in English which shares semantic features with both representational and preferential attitudes, and can occur in syntactic frames associated with both classes of verbs. Additionally, because children are not exposed to *hope* nearly as much as they are to *want* and *think*, it is reasonable to assume that although they may know that it is a word of their language, they may not know the semantics of this verb. This makes it an ideal test case to look at children's sensitivity to syntactic frame in attitude verb interpretation. In this study, we will look at children's interpretations of sentences with *hope* in different syntactic frames.

4.3.1 Experiment 5: Subjects

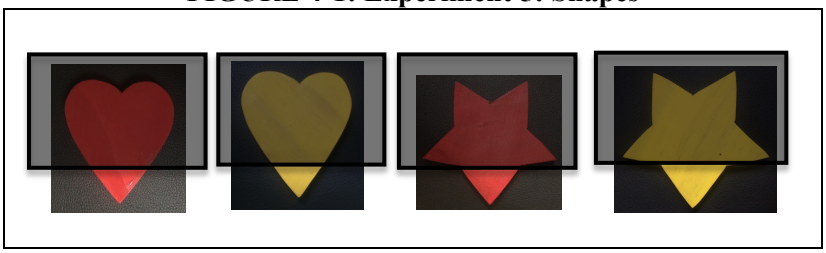
Participants were 48 children aged 4;0 to 5;0 (mean = 4;6). 6 additional children were excluded from the task; 4 due to getting too many controls incorrect, 1 due to parental report of the child's exposure to English as less than 80%, and 1 due to experimenter error.

4.3.2 Experiment 5: Design and Materials

Experiment 5 was a game task, set up exactly the same way as experiment 4. In order to manipulate verb in experiment 4 (*want* v. *think*), we set up a context in which both the beliefs and desires of a character were relevant. This same kind of context is necessary to test interpretation of *hope*: we want the context to

equally bias children toward interpretations based on desire, belief or reality, so that no matter what interpretation children get for sentences with *hope*, we can be sure that it is not due to the context of the task. Using the same design as experiment 4 is an ideal solution, since we have already seen that children are able to get desire, reality and belief interpretations (albeit very few of the last type), depending on the type of sentence that they hear. In experiment 5, we use the same "game" task as experiment 4, in which the child plays with a puppet, *Froggy.* Again, the premise of the game is that the child and the experimenter pull shapes out of a box and show them to Froggy. The child and one experimenter are behind an occluder, while Froggy is on the other side. In front of the child and the experimenter is a box with 40 wooden shapes in it. The shapes, which are hearts and stars, are either red or yellow. Color is predictive of shape; 15 of the hearts are red and 5 are yellow, and 15 of the stars are yellow and 5 are red. In the game, the child and the experimenter pull shapes out of the box to show Froggy, and every time the shape is a heart, the child gives Froggy a sticker. We establish that Froggy likes getting stickers; therefore his desire is that on every trial, it will be a heart that is pulled out of the box. On each trial, before Froggy sees what the shape is, the child and the experimenter show him a "clue," which is ambiguous in shape. There is an opening in the occluder that is the right shape for a point—either the point of the heart or one of the points of the star (see figure 4-1).

FIGURE 4-1: Experiment 5: Shapes



This way, on every trial, Froggy has both a *desire* about what the shape will be—because he always wants the shape to be a heart; and also a *belief* about what the shape will be—because when it is red, he thinks it's a heart and when it's yellow he thinks it's a star. This set-up allows another puppet, *Booboo*, whom the child is told is "silly and wants to learn how to play the game, but often gets things mixed up," to utter a test sentences either about what Froggy *hopes*, either with a non-finite complement (113) or with a finite complement (114).

(48) *Froggy hopes to get a heart/star!*

(49) *Froggy hopes that it's a heart/star!*

The child's job in the task is to say whether Booboo is correct or incorrect.

In a 2x4 design, we tested sentence type as a between-subjects factor (*hope-to* (n=24)*, hope-that* (n=24), and "realization of mental state" as a within-subjects factor and the child's response of *yes* or *no* as the dependent measure. On every trial, Froggy has both a belief and a desire about what the next shape to be pulled out of the box is. Sometimes, he has a true belief (red heart, yellow star conditions), which we call "realized belief" situations. Sometimes, he has a false belief (red star, yellow heart conditions), which we call "non-realized belief" situations. Similarly, sometimes his desire for a heart is fulfilled (red/yellow heart

conditions), which we call "realized desire" situations. Sometimes his desire for a heart goes unfulfilled (red/yellow star conditions), which we call "non-realized desire" situations. In the study, the participant encounters every possible combination of realized and non-realized beliefs and desires. Table 4-1 shows each of the within-subjects conditions.

TABLE 4-1: Experiment 5: Conditions

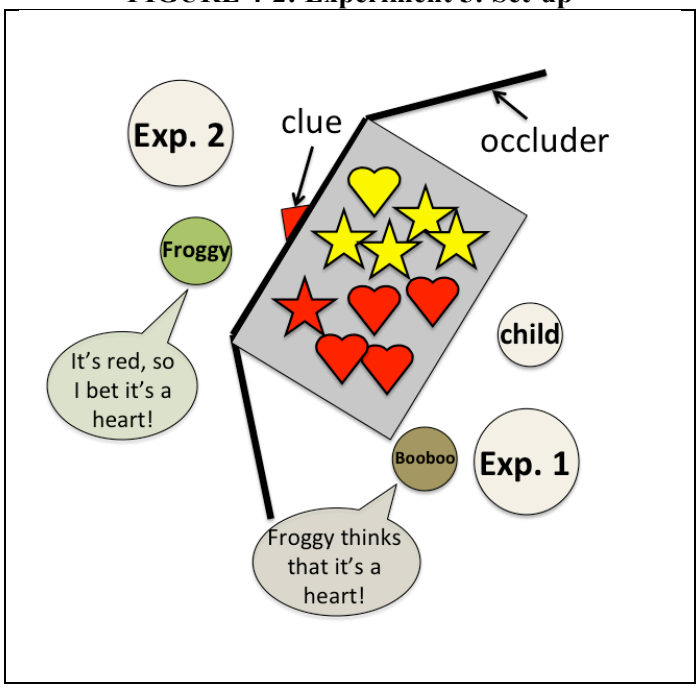
Shape	**Desire**	**Belief**
Red Heart	Realized	Realized
Red Star	Non-Realized	Non-Realized
Yellow Heart	Realized	Non-Realized
Yellow Star	Non-Realized	Realized

The experiment includes 8 items of each type—4 yes-target sentences and 4 no-target sentences, for a total of 32 test items per child.

4.3.3 Experiment 5: Procedure

Each child was tested in a quiet room with two experimenters. One experimenter sat next to the child and gave the child instructions about the game. The first experimenter also controlled the silly puppet, "Booboo," and read the filler and test sentences. Another experimenter sat on the other side of the occluder (across the table from the child and the first experimenter), and played Froggy (see figure 4-2).

FIGURE 4-2: Experiment 5: Set-up



The second experimenter also coded the child's responses. Permission was obtained from parents to video record each subject for an additional round of coding off-line. The experiment began by the child being introduced to a puppet, "Froggy," with whom they would be playing the game. The first experimenter says the following to introduce the child to the puppet:

> *"Hi, [child's name]. This is Froggy! We're going to play a game with Froggy today!"*

Next, the child goes through several practice sections in order to ensure that they understand all the necessary elements of the game, including an understanding of Froggy's desires and beliefs in this context. The practice sections are detailed below.

4.3.3.1 Practice Sections

Practice Section #1: Practice with distribution. The first warm-up we involves directing the child's attention to the distribution of colors and shapes. The shapes are already divided up on the table in front of the child.

> *"Froggy has a whole bunch of different shapes. Let's look at what shapes he has! Can you tell me about the shapes? Some of them are red! Can you tell me what kinds of red shapes we have?"*
> *[Child responds 'hearts and stars'.]*
> *"That's right! Hearts and stars! Do we have a lot of the red hearts or just a few? And what about red stars?"*

The point of this warm-up is for the child to notice the distribution of colors and shapes. We have them tell us about each type—lots of red hearts and yellow stars, few red stars and yellow hearts. This helps them get the intuition that a red clue is more likely to be a heart and a yellow clue is more likely to be a star—and that Froggy's guesses will reflect this.

Practice Section #2: Child and Froggy guessing game. During the next warm-up section, we put all the shapes in the box, and the experimenter turns the occluder so that the child can no longer see the box of shapes. She then shows Froggy and the child clues—which are in the form of a point sticking through a slot in the occluder. The point is ambiguous—one of the points on the star shapes is the exact same size and shape as the point on the heart shapes. This means that

neither the child, nor Froggy can see what the shape is. The child is told that they will be able to guess what the shape is, and then Froggy will guess, and then the experimenter will take the shape out so everyone can see. If the shape is a heart, the child gives Froggy a sticker. The shapes pulled out during this section reflect the distribution in the box. The point of this practice section is for the child to experience seeing the ambiguous clues, so that they truly understand that from the other side of the occluder, it is impossible to tell. They sometimes have the experience of guessing incorrectly and then being surprised when the clue is taken out. This section also demonstrates to the child what Froggy's default guesses are—namely that when the clue is red, Froggy thinks it's a heart, and when it's yellow he thinks it's a star.

Practice Section #3: Froggy's default guess check. The next practice section just confirms that children are sensitive to what they have observed that Froggy guesses when he sees clues in the previous section. The experimenter checks this by asking the following questions:

> *"So when Froggy sees a red clue, what kind of shape does he guess? Right, a heart! And when Froggy sees a yellow clue, what kind of shape does he guess? Right, a star!"*

This ensures that the child understands what Froggy's beliefs are, given the clue that he sees. This practice section also ensures that the child realizes that even though Froggy always *guesses* a shape based on the color of the clue he sees; he

still realizes that his guess is sometimes wrong. This is what makes sentences about Froggy's *hopes* felicitous, even when he has a false belief.

Practice Section #4: Practice with Booboo. In the final warm-up section of this task, children are introduced to the silly puppet, Booboo, who is going to watch them play the game with Froggy. The child is told the following about Booboo:

> *"OK, one more thing! This is Froggy's friend, Booboo! Booboo really wants to learn how to play the game, but he's really silly and he always gets things mixed up! He always forgets what kind of shapes Froggy likes, and what kind of stuff Froggy guesses when he sees clues. But you're super good at that, right? So maybe you could help Booboo learn, could you do that? OK, good! So Booboo is going to watch us play, and sometimes he's going to try to tell us something about Froggy, but he might get it wrong, and your job is going to be to help him out and tell him whether he's right or wrong so he can learn how to play the game. How does that sound?"*

After Booboo is introduced, the child is told that we are going to show Booboo some clues, and see what he says about Froggy. Then Booboo is shown four clues—one of each type—and says sentences about what Froggy will guess, and whether he likes that shape or not. While only the clue is visible to the child,

Booboo says a sentence about what Froggy will guess given the color (115), and after the shape is taken out, Booboo says a sentence about whether Froggy likes that shape or not (116).

(50) *This one is red/yellow… so Froggy is going to guess heart/star!*

(51) *Oh! Froggy likes/doesn't like that kind!*

The child's job is to tell Booboo whether he said each of the sentences correctly. This gives the child a chance to observe that Booboo is bad at remembering Froggy's mental states, and practice telling him when he is right and wrong when he says things about Froggy. This section also serves as a reminder of Froggy's desires and beliefs. If the child has any trouble correcting Booboo on this section, they are given help from the experimenter. We are in the process of coding these practice sections to look for correlations between performance on practice sections and test items.

4.3.3.2 Test Sentences

After all of the warm-up sections are finished, the box of shapes and the occluder are turned so that now that child can again see which shape is under discussion. They are told that now they are going to be able to "peek" while we show Froggy some more clues, and Booboo is still going to say something about "what Froggy likes, or what he might guess." Then we begin showing Froggy clues, and uttering test sentences. The whole game takes about 25 minutes.

4.3.4 Experiment 5: Hypotheses and Predictions

This experiment tests whether children are sensitive to syntactic frame in interpreting an attitude verb with which they have little experience. If children are sensitive to syntactic frame, we expect to see different performance in the *hope-to* and *hope-that* conditions on this task, as spelled out in Hypothesis 1 in Table 4-2 below. It is also possible that children are not sensitive to the syntactic frame. This is stated below in Table 4-2 as Hypothesis 2. There are several different ways in which we might see this manifest in this study. It is possible that at the time that children come in to the lab at 4 years of age, they have already had enough exposure to have an adult-like semantic representation for *hope*, or at least knowledge that in this context it references desires. This is spelled out as Hypothesis 2a in Table 4-2. It is also possible that children do not yet know the meaning of *hope*, and that they are learning its meaning through some other strategy (not syntax), in which case we expect to see chance performance on this task, and no differences between the *hope-to* and *hope-that* conditions, as spelled out in Table 4-2 as Hypothesis 2b.

TABLE 4-2: Experiment 5: Hypotheses

HYPOTHESIS 1	SYNTACTIC BOOTSTRAPPING: Children use the syntax of the complement to interpret *hope*.
HYPOTHESIS 2	NO SYNTACTIC BOOTSTRAPPING: Children do not use the syntax of the complement to interpret *hope*.
	HYPOTHESIS 2A: ADULT-LIKE KNOWLEDGE OF *HOPE:* Children are adult-like in their interpretation of *hope*.
	HYPOTHESIS 2B: NON-ADULT-LIKE KNOWLEDGE OF *HOPE:* Children do not yet know the meaning of *hope*, but they are not sensitive to syntactic frame in interpreting *hope.*

If children use the syntactic distribution to interpret attitudes, and syntactic frame is informative to them in interpreting *hope*, we expect to see children treat *hope* like *want* when they hear it with a non-finite complement, and treat *hope* like *think* when they hear it with a finite complement. This would be informative about (at least one) of the strategies that children are using to interpret attitude verbs, and possibly to learn their meanings.

4.3.5 Experiment 5: Results

4.3.5.1 Coding

Children's responses were coded online by the second experimenter. We are in the process of coding 25% of the videos offline by another coder to check for accuracy and reliability of the online coders.

4.3.5.2 Responses to test questions

As in experiment 4, there are three possible response patterns that we might expect to see given the experimental setup. The first expected pattern is one based on desires. Children behaving this way should assent to sentences that mention a heart, regardless of what shape and color the shape actually is. The second possibility is that children will give responses based on beliefs. In this case, children should assent to sentences that mention a heart whenever the clue is red, and to sentences that mention a star whenever the clue is yellow. Finally, we may see responses based on reality. In this case, children should assent to sentences that mention the shape corresponding to the actual shape (regardless of color, nor desire or belief). If children know that *hope* in this context references the desires of Froggy, then we expect desire-based responses regardless of syntax,

children should assent to both sentences (117) and (119). If children do not yet know the meaning of *hope*, and are sensitive to the syntax, we expect desire responses in the *hope-to* condition, and reality responses in the *hope-that* condition. This predicts that children will assent to sentences like (117) regardless of what the shape actually is; but should only assent to sentences like (119) when the shape actually *is* a heart.

Children's responses were measured in percent 'yes'-responses. Red heart items were counted as controls—because this is a realized belief and realized desire case, whether the participant responds based on desire, belief *or* reality, we predict the same pattern of responses. We predict that they will say 'yes' when a heart is mentioned (117)/(119) and 'no' when a star is mentioned (118)/(120), regardless of frame condition.

(52) *Froggy hopes to get a heart!*

(53) *Froggy hopes to get a star!*

(54) *Froggy hopes that it's a heart!*

(55) *Froggy hopes that it's a star!*

For this reason, we excluded participants who got fewer than 6 out of the 8 red heart items correct. We excluded 4 children for this reason. For the remaining children, we ran a 2x4 ANOVA with percent *yes* responses as the dependent measure. We find no main effect of frame ($F(1,376) = 0.67$, $p = 0.41$), but a main effect of realization of mental state ($F(1,376) = 57.63$, $p < .0001$), and an interaction between sentence type and realization of mental state ($F(1,376) = 4.49$, $p < .0001$). Children are more likely to give desire responses (i.e. look adult-like)

in the *hope-to* condition, and more likely to be influenced by reality (i.e. traditional false belief error) in the *hope-that* condition. Data for all conditions shown in Table 4-3.

TABLE 4-3: Experiment 5: Percent *yes*-responses by Condition

VERB (BETWEEN SUBJECTS)	CONDITION (within subjects)	REALIZATION OF MENTAL STATE	Mentioned Shape	Target	% Yes Responses
HOPE-TO	RED HEART	REALIZED DESIRE REALIZED BELIEF	Heart	Yes	100%
			Star	No	4%
	RED STAR	NON-REALIZED BELIEF NON-REALIZED DESIRE	Heart	Yes	50%
			Star	No	29%
	YELLOW HEART	NON-REALIZED BELIEF REALIZED DESIRE	Heart	No	95%
			Star	Yes	4%
	YELLOW STAR	REALIZED BELIEF NON-REALIZED DESIRE	Heart	No	48%
			Star	Yes	25%
HOPE-THAT	RED HEART	REALIZED DESIRE REALIZED BELIEF	Heart	Yes	95%
			Star	No	3%
	RED STAR	NON-REALIZED BELIEF NON-REALIZED DESIRE	Heart	Yes	32%
			Star	No	63%
	YELLOW HEART	NON-REALIZED BELIEF REALIZED DESIRE	Heart	No	95%
			Star	Yes	3%
	YELLOW STAR	REALIZED BELIEF NON-REALIZED DESIRE	Heart	No	32%
			Star	Yes	57%

Graphs for each of the conditions are shown below. The red heart condition, the control condition, is shown in Figure 4-3. As mentioned above, whether children respond based on reality, desire or belief, we predict that children will say 'yes' to a mentioned heart (117)/(119) and 'no' to a mentioned star (118)/(120). As shown below in the graph, the remaining children have no difficulty in this condition (after 4 of 52 were excluded).

FIGURE 4-3: Experiment 5: Red Heart Condition

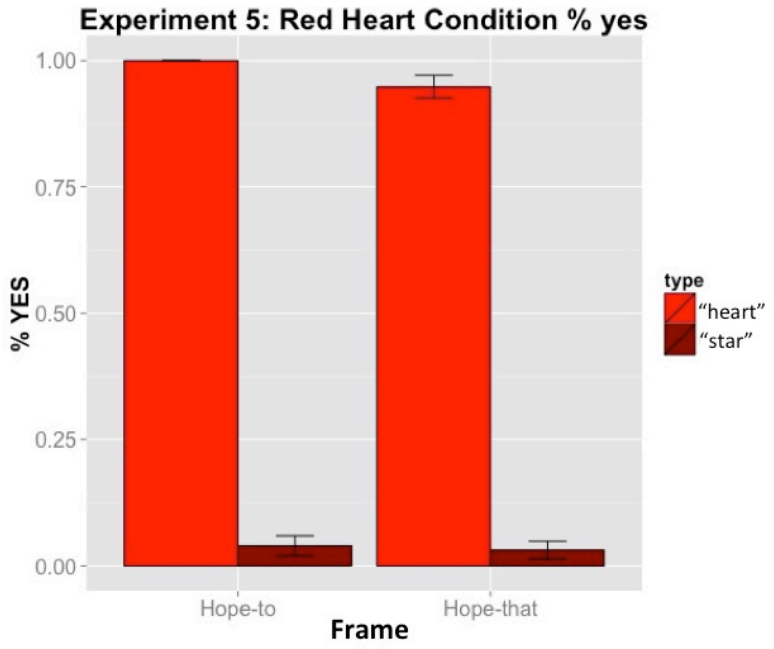


Figure 4-4 shows the yellow heart condition. In this case, if children respond based on desire or reality, they will say 'yes' to a mentioned heart (117)/(119) and 'no' to a mentioned star (118)/(120). Children who respond based on Froggy's beliefs will have the opposite pattern of responses. As shown in the graph, participants were very consistent in giving either desire or reality responses; almost no responses in this condition were consistent with a belief interpretation. This condition does not demonstrate (or predict) differential treatment of *hope* depending on syntactic structure.

FIGURE 4-4: Experiment 5: Yellow Heart Condition

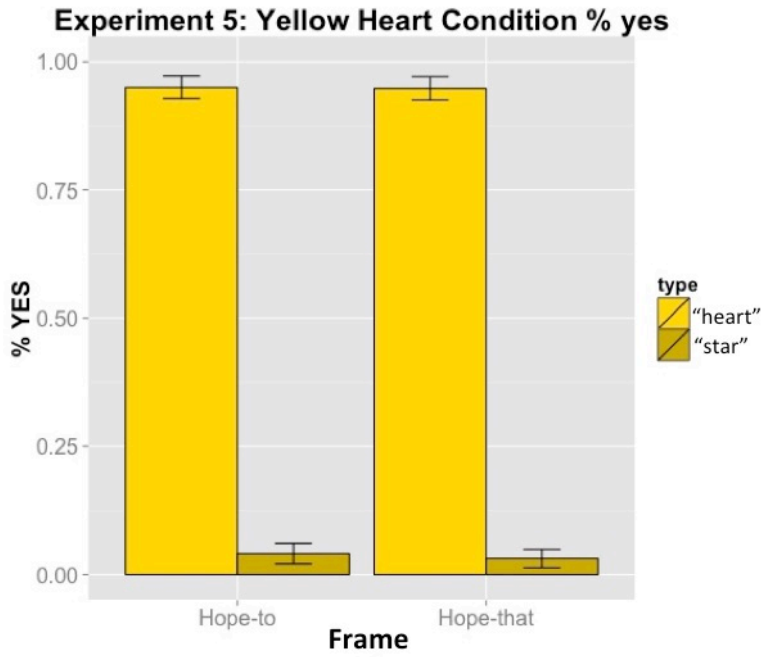


Figure 4-5 shows the red star condition. This condition is a non-realized belief and desire; therefore, reality patterns differently from both belief and desire responses. This condition allows us to compare the influence of reality in the *hope-to* and *hope-that* conditions. In this case, if children respond based on Froggy's beliefs or desires, they should say 'yes' to heart (117)/(119) and 'no' to star (118)/(120). Reality responses will show the opposite pattern of responses. As evident in the graph, children are able to overcome the lure of reality in interpreting sentences with *hope-to* more often than in interpreting *hope-that,* where children are more likely to be influenced by reality. This condition shows both differential treatment of *hope-to* and *hope-that*, as well as demonstrating that children are more likely to make the traditional false belief error in the *hope-that* case.

FIGURE 4-5: Experiment 5: Red Star Condition

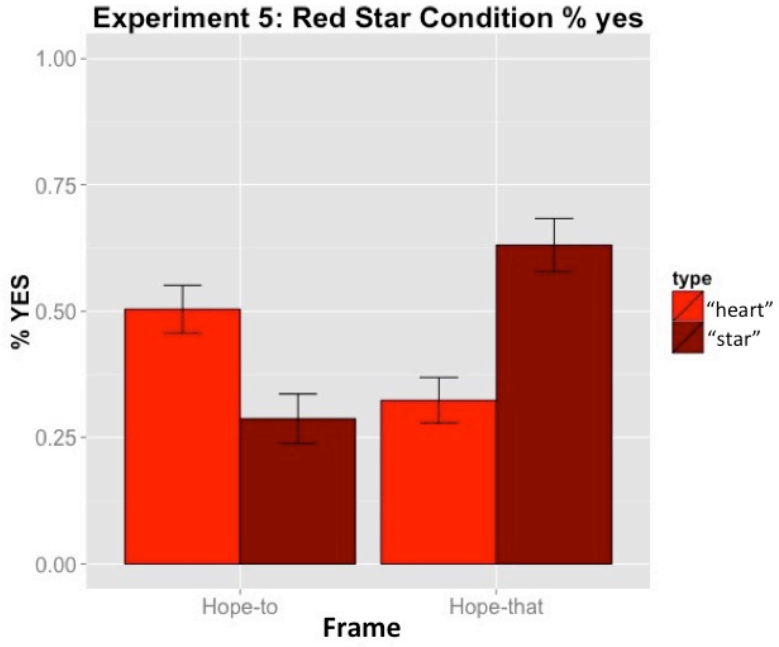
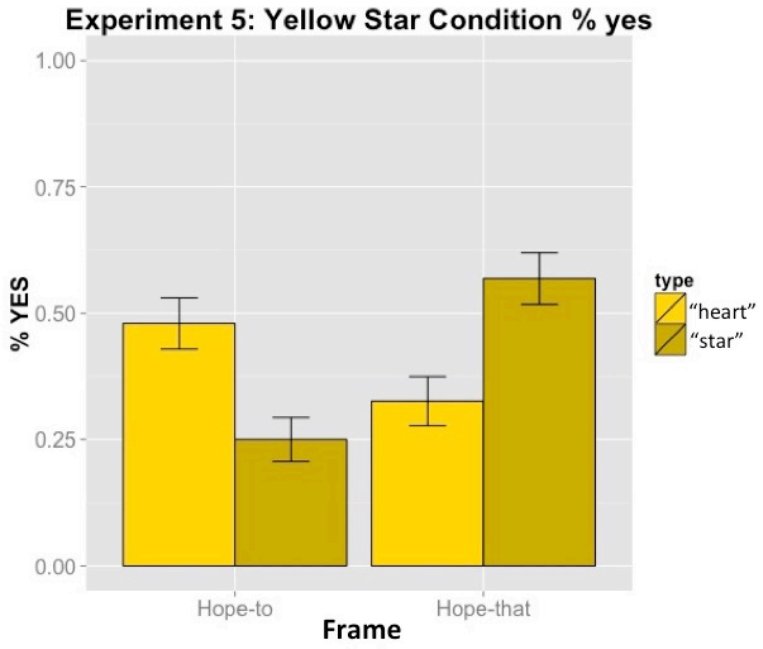


Figure 4-6 shows the yellow star condition. In this condition, Froggy's desire is unrealized, but his belief is realized. In this case, belief and reality pattern together. If children respond based on Froggy's beliefs or based on reality, they will say 'no' to heart (117)/(119) and 'yes' to star (118)/(120); while desire responses will show the opposite pattern. Again, we see that children are more likely to give desire responses in the *hope-to* condition, but more likely to respond based on reality/belief in the *hope-that* condition. This conditions shows differential treatment of sentences with *hope-to* and *hope-that*, although does not demonstrate the traditional false belief error.

FIGURE 4-6: Experiment 5: Yellow Star Condition



The graphs for each condition demonstrate that in the conditions where reality and desire make different predictions, we also see different patterns of behavior in the *hope-to* and *hope-that* conditions.

4.3.5.3 Individual subjects analysis

Although we show different performance based on the syntactic frame in which *hope* occurs, the differences between the *hope-to* and *hope-that* conditions are not as large as the differences between *think* and *want* conditions in experiment 4. Figure 4-7 shows all verb/frame conditions together in the red heart condition; figure 4-8 shows all verb/frame conditions together in the yellow star conditions (these are the two conditions which show different patterns for *want/think* and *hope-to/hope-that*).

FIGURE 4-7: Experiments 4 & 5: Red Star Condition

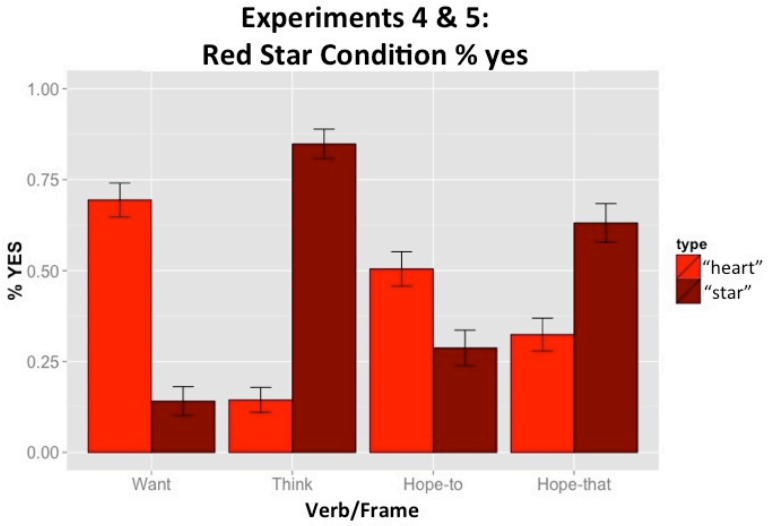
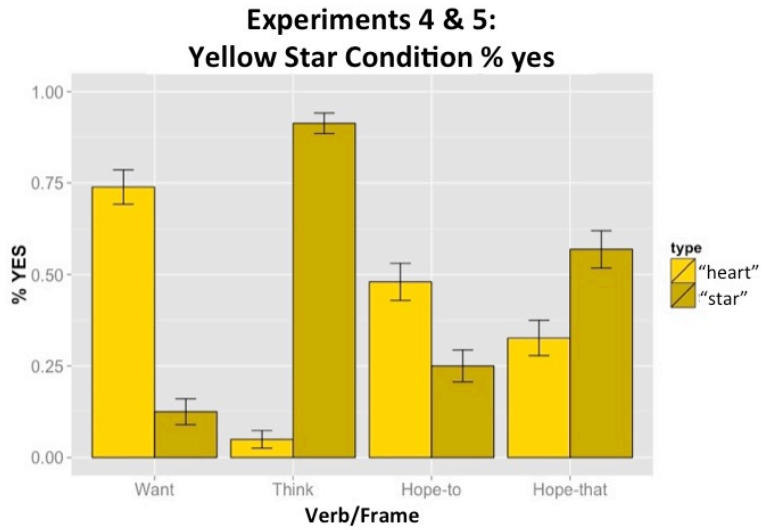


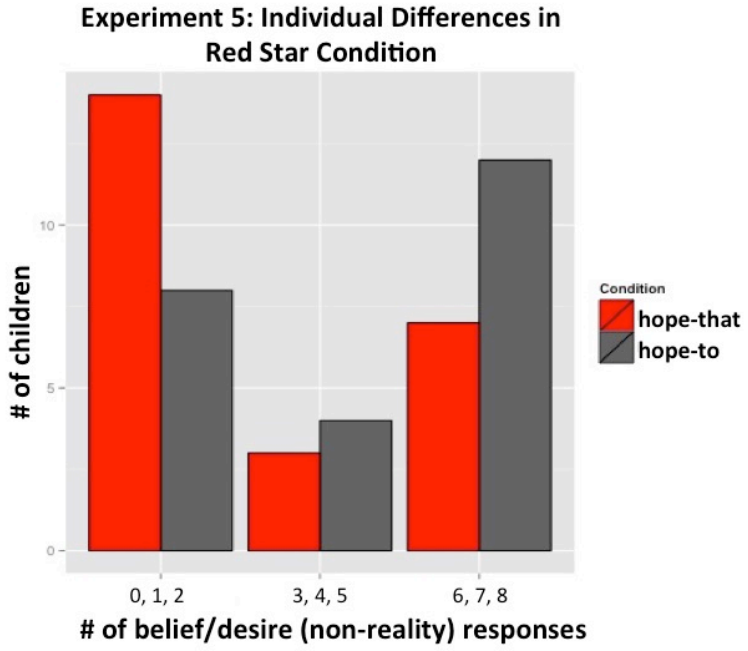
FIGURE 4-8: Experiments 4 & 5: Yellow Star Condition



This raises a question about what individual participants' response profiles look like. One possibility is that each individual child's responses are closer to chance than in the *want* and *think* conditions, and another possibility is that individual children have different interpretations, which are consistent throughout the task. Each one of these possibilities may suggest something different about the way

children use the syntactic frame. In order to get a better sense of individual children's performance, we tallied up the number of children with each type of response pattern in both the red star and the yellow star conditions, the conditions in which *hope-to* and *hope-that* show different performances. Figure 4-9 below shows this distribution of participants for the red star condition.

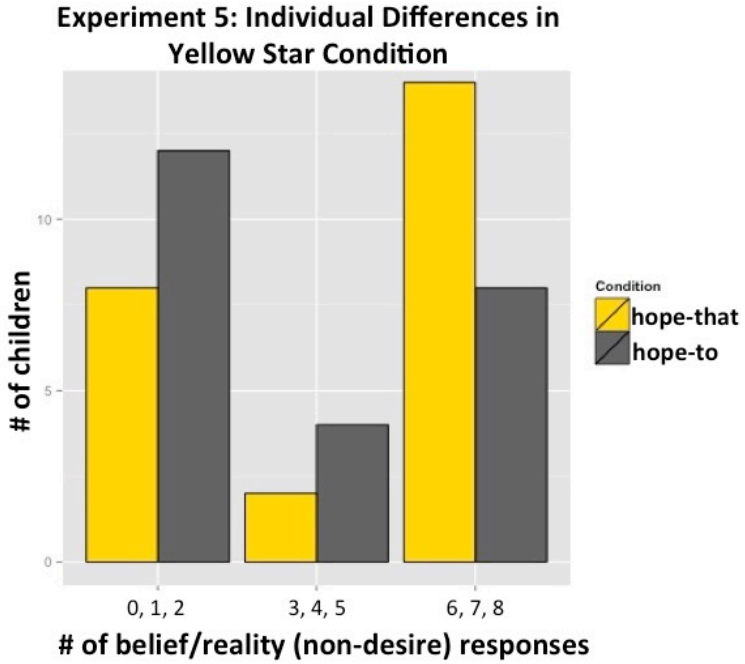
FIGURE 4-9: Experiment 5: Individual Differences Red Star Condition



The graph shows that the overwhelming majority of the children in both conditions are consistent in their responses. Most of the children give either all belief/desire responses or no belief/desire responses; very few children are performing at chance. It is also evident that more children in the *hope-to* condition give belief/desire responses than reality responses; while more children in the

hope-that condition give reality responses than desire/belief responses. We did the same analysis for the yellow star condition, shown in Figure 4-10.

FIGURE 4-10: Experiment 5: Individual Differences Yellow Star Condition



Again, the graph shows that the overwhelming majority of the children in both conditions are consistent in their responses. Most of the children give either all belief/reality responses or no belief/reality responses; very few children are performing at chance. We see the same type of bimodal distribution as in the red star condition. In this case, more participants in the *hope-to* condition give consistent desire responses; and more children in the *hope-that* condition give consistent belief/reality responses. In both the red star and the yellow star condition, most children are consistent in the type of responses they give. Children are bimodal in their interpretation type; very few children perform at

chance. In the *hope-to* condition, more children give responses across the experiment consistent with a desire interpretation for the sentences; and in the *hope-that* condition, more children give responses influenced by reality.

4.3.6 Experiment 5: Discussion

In experiment 5, we looked at whether children are influenced by syntactic frame when interpreting an attitude verb that they may not know the meaning of in a context which is neutral with respect to belief v. desire interpretations. We compared 2 hypotheses, presented below in table 4-4.

TABLE 4-4: Experiment 5: Hypotheses

HYPOTHESIS 1	SYNTACTIC BOOTSTRAPPING: Children use the syntax of the complement to interpret *hope*.
HYPOTHESIS 2	NO SYNTACTIC BOOTSTRAPPING: Children do not use the syntax of the complement to interpret *hope*.
	HYPOTHESIS 2A: ADULT-LIKE KNOWLEDGE OF *HOPE:* Children are adult-like in their interpretation of *hope*.
	SYNTACTIC BOOTSTRAPPING: Children use the syntax of the complement to interpret *hope*.

We found that hypothesis 1 was supported: children are sensitive to the syntactic frame in which they hear the verb *hope*, suggesting that they use syntax as a cue when they are interpreting an unknown attitude verb. This study shows that when children hear a verb with a non-finite complement, they are more likely to treat it as if it is about desires, whereas when they hear a verb with a finite complement, they make the same reality-error that we see in interpretation of *think*. This demonstrates that at least one of the factors that triggers the traditional false belief error is the syntax of finite complement clauses, or perhaps more abstractly, the syntax of main clauses appearing in complement clauses.

Although this experiment demonstrates that children are sensitive to syntactic frame in interpreting an attitude verb, it does not necessarily provide direct evidence of learning. Several follow-ups to this syntactic bootstrapping study attempt to shed more light on whether or not children are able to use syntax for learning, and exactly how much and what kind of input children use for learning. One of the follow-ups is presented here as experiment 6, and explores how children's hypothesis is formed during the task, and how flexible this is. We investigate this by changing the frame that *hope* is presented in halfway through the task. Another follow-up, which will speak more directly to how children use input in the real world, is ongoing, and will be discussed in the conclusions chapter.

4.4 Experiment 6: Hope-to v. Hope-that (within subjects)

In the previous study, we saw that children are influenced by syntactic frame when they interpret a potentially unknown attitude verb. While this indicates that syntactic frame is important in attitude verb understanding, and possibly learning, it does not tell us anything specifically about exactly how they use the frame, and whether the information gleaned from the syntactic frame they heard goes toward building a semantic representation for the verb. Experiment 5 doesn't give us any information about whether the meaning they build for *hope* in the experiment would apply in later cases when the syntactic context had changed, or whether they are using the syntactic frame directly to interpret the sentence without building an actual hypothesis about the semantics of the verb.

Additionally, if they are actually using the frame information to build a semantics, the previous experiment doesn't tell us anything about how much input is required, and how children ultimately use the different frames they may hear a verb in to settle on an adult-like semantic representation.

Experiment 6 attempts to investigate the question of how children are using the frame, and how flexible they are in the semantics that they are building based on frame. In this experiment, we give children sentences with *hope* in a neutral context, just like in experiment 5. This time, however, we give children sentences with *hope* in both syntactic frames—a finite complement and a non-finite complement. This allows us to see how children integrate information from both frames, and whether they build a meaning representation that is flexible enough to change when the syntactic frame changes. In other words, do children treat each trial as an individual case, or do they integrate information from previous trials into their semantic representation? Additionally, it is possible that the information provided by each of these types of frames is not equal in informativity. By counterbalancing the order in which each frame type is presented, we can see whether the effects are different based on which frame children are exposed to first.

4.4.1 Experiment 6: Subjects

Participants were 32 children aged 4;0 to 5;0 (mean = 4;7). Six additional children were excluded from the task; 4 due to getting too many controls incorrect, 1 due to parental report of the child's exposure to English as less than 80%, and 1 due to experimenter error.

4.4.2 Experiment 6: Design and Materials

Experiment 6 was exactly the same as experiment 5, except for a few minor changes to the task. First, in experiment 6, we manipulate frame within subjects, so that all participants are exposed to sentences with *hope* with both a non-finite complement (121) and a finite complement (122).

(56) *Froggy hopes to get a heart/star!*

(57) *Froggy hopes that it's a heart/star!*

The set up of the task is exactly the same as in experiment 5: the child and the experimenter show Froggy ambiguous clues, and Froggy has both a belief and a desire on every trial about the outcome. While this happens, a silly puppet, Booboo, watches the game and says test sentences with *hope* (121)-(122). Again, the child's job in the task is then to say whether Booboo is correct or incorrect in his statement about Froggy's mental state.

In a 2x4 design, we tested sentence type as a within-subjects factor. We had two orders, which were manipulated between subjects, order 1 (*hope-to* first (n=19)), and order 2 (*hope-that* first (n=13)). Like in experiment 5, "realization of mental state" was manipulated as a within-subjects factor, and the child's response of *yes* or *no* as the dependent measure. Each participant encountered every possible combination of realized and non-realized beliefs and desires, paired with both *hope-to* and *hope-that* sentences. In order to ensure that we had enough critical items, the proportions of shapes used in test sentences were different than in experiment 5. Instead of 8 of each type, in experiment 6, children saw 2 of each type of heart, and 6 of each type of star for each frame condition.

Table 4-5 shows each of the within-subjects conditions, and the number of each type included for each of the frame conditions. Half of each item type were yes-target sentences and half were no-target sentences.

TABLE 4-5: Experiment 6: Within-Subjects Conditions

Shape	Desire	Belief	# of hope-to	# of hope-that
Red Heart	Realized	Realized	2	2
Red Star	Non-Realized	Non-Realized	6	6
Yellow Heart	Realized	Non-Realized	2	2
Yellow Star	Non-Realized	Realized	6	6

The experiment includes 16 items in each frame condition—8 yes-target sentences and 8 no-target sentences, for a total of 32 *hope* test items per child. In addition, children were given several *want* and *think* items in between the two *hope* blocks. The purpose of these 8 *want/think* items was to give children a slight distance between the two *hope* blocks. In addition, we wanted to ensure that children actually listen to the test sentences. Because children were so consistent in their response patterns in experiment 5, we have no evidence that they actually listened to each test item. Because children's interpretations of *want* and *think* sentences are so robust, both in our experiment 4 and in many other studies, we expect to see children's performance on the *want/think* items in this task to match their interpretations on these items in experiment 4.

It is also critical to ensure that children are able to get different interpretations on different items in the context of this task. Although we see groups of children performing differently across different verb/frame conditions, experiments 4 and 5 show no evidence of the *same* group of children getting

different interpretation types in the task. In this task, observing an effect of syntax on sentence interpretation relies on the ability to potentially get multiple different interpretations for *hope* sentences across the task. Because we have no evidence that children can do this, we added the *want/think* control items. Children's ability to perform on these control items will ensure that they are capable of getting both desire and reality interpretations during the course of the task. Of course, by introducing two more verbs in the task, we increase the load even more, a fact that we will come back to in analysis of the (preliminary) results. Because we have already increased the number of test items on this task, in addition to the processing requirements (two different frames for *hope* sentences), we did not want to include *want/think* sentences for all the mental state conditions. We chose to include red star items, as this is the critical condition that demonstrates both conflict between Froggy's mental state and reality, and in addition triggers children's classic *think*-error. In experiment 4, we saw different performance on *think* and *want* conditions in the red star condition. We also included yellow heart items, as this is also an item which demonstrates the classic *think*-error. We included yellow heart items both to see whether any participants were adult-like in their *think* interpretation, and to increase the number of hearts in the task (there are many fewer hearts in this experiment than in experiments 4 & 5). The number of each of the *want* and *think* items are shown below in table 4-6.

TABLE 4-6: Experiment 6: *Want/Think* Items

Shape	**Desire**	**Belief**	**# *want***	**# *think***
Red Star	Non-Realized	Non-Realized	2	2
Yellow Heart	Realized	Non-Realized	2	2

Including these *want/think* controls, there were a total of 40 test items per child: 16 *hope-to* items, 16 *hope-that* items, 4 *want* items and 4 *think* items.

4.4.3 Experiment 6: Procedure

The procedure for this experiment was exactly the same as experiment 5, aside from the adjustment of test items that the child got (as detailed in the previous section). All procedural information is the same, including the space in which the children were tested, interactions with puppets and experimenters, the 4 practice sections, and the administration of the test sentences. Again, the whole game takes about 25 minutes. Although we have more items, this experiment included many fewer heart items, and therefore fewer stickers given by the child.

4.4.4 Experiment 6: Hypotheses and Predictions

The previous experiment demonstrated that children are sensitive to syntactic frame in interpreting attitude verbs. This suggests that sensitivity to syntactic frame may be a useful learning cue for children; but it doesn't tell us anything specifically about learning. In experiment 6, we use a within-subjects frame manipulation to get at the actual learning mechanism. One hypothesis is that children actually use the frame to make a hypothesis about a word's semantic representation, which carries over to future encounters with the same verb, regardless of whether the syntax is the same. If this is the case, we expect to see that reflected in children's performance on this task in the form of priming effects. If children use the frame that they are exposed to in the first half in order to build a meaning hypothesis, then, at least to some extent, this meaning should carry over to the second half (Hypothesis 1 below). If children are using the frame

information for interpretation only, and not integrating this information into a semantic representation, then we expect to see children influenced by the frame in each individual block of the task (Hypothesis 2 below). Each of these hypotheses are spelled out in Table 4-7 below.

TABLE 4-7: Experiment 6: Hypotheses

HYPOTHESIS 1	INTEGRATION OF SYNTAX WITH SEMANTIC REPRESENTATION: Children are using the frame information not only for interpretation, but also integrating this information into their semantic representations.
HYPOTHESIS 2	NO INTEGRATION OF SYNTAX WITH SEMANTIC REPRESENTATION: Children are able to use syntax for interpretation of individual sentences, but do not integrate this information into semantic representations used for future encounters with the verb.

If children are integrating the syntactic information into their semantic representations, then we expect to see them using early frame information for later sentence interpretations. If children are only using the frame information in real time to interpret particular sentences, then we expect to see no priming effects, with no carry over from early syntactic frames into later trials.

4.4.5 Experiment 6: Results

4.4.5.1 Coding

Children's responses were coded online by the second experimenter. We are in the process of coding 25% of the videos offline by another coder to check for accuracy and reliability of the online coders.

4.4.5.2 Responses to test questions

Children's responses were measured in percent 'yes'-responses. Red heart items were counted as controls—because this is a realized belief and realized

desire case, whether the participant responds based on desire, belief *or* reality, we predict the same pattern of responses. We predict that they will say 'yes' when a heart is mentioned (123)/(125) and 'no' when a star is mentioned (124)/(126), regardless of frame condition.

(58) *Froggy hopes to get a heart!*

(59) *Froggy hopes to get a star!*

(60) *Froggy hopes that it's a heart!*

(61) *Froggy hopes that it's a star!*

For this reason, we excluded participants who got fewer than 3 out of the 4 total red heart items correct (this includes both the red heart items in the *hope-to* and *hope-that* conditions). We excluded 1 child for this reason. In this experiment, we are interested in comparing performance across the two orders as well as performance on the two frame conditions for each order. A 2x4 ANOVA comparing the first block of each order, we find a significant interaction between frame (or order) and realization of mental state ($F(1,232) = 5.56$, $p < 0.001$). In a 4x2 ANOVA comparing performance on *hope-to* in the first block (order 1) and performance on *hope-to* in the second block (order 2), we find no significant interaction between order and realization of mental state ($F(1,232) = 1.60$, $p = 0.13$). Children's interpretation of sentences with *hope-to* is the same whether they have heard sentences with *hope-that* first or not. In the same analysis for *hope-that* sentences, we find a significant interaction between order and realization of mental state—children's interpretation of sentences with *hope-that* is significantly different when they have heard sentences with *hope-to* first. In a

4x2 ANOVA comparing the first and second blocks of order 1, we find no significant main effect for frame ($F(1,288) = 0.26$, $p = 0.61$), or interaction between frame and realization of mental state ($F(1,288) = 0.99$, $p = 0.44$). Again, in a 4x2 ANOVA comparing the first and second blocks of order 2, we find no significant main effect for frame ($F(1,176) = 0.15$, $p = 0.70$), or interaction between frame and realization of mental state ($F(1,176) = 1.23$, $p = 0.29$). There is no significant effect of frame within subjects in either of the orders. Data for all conditions shown in Table 4-8.

TABLE 4-8: Experiment 6: Percent *yes*-responses by Condition

ORDER (BETWEEN SUBJECTS)	CONDITION (within subjects)	REALIZATION OF MENTAL STATE	Mentioned Shape	Target	% Yes Responses: First Half	% Yes Responses: Second Half
ORDER 1 (HOPE-TO first, HOPE-THAT second)	RED HEART	REALIZED DESIRE REALIZED BELIEF	Heart	Yes	95%	95%
			Star	No	21%	5%%
	RED STAR	NON-REALIZED BELIEF NON-REALIZED DESIRE	Heart	Yes	51%	50%
			Star	No	14%	30%
	YELLOW HEART	NON-REALIZED BELIEF REALIZED DESIRE	Heart	No	100%	95%
			Star	Yes	5%	10%
	YELLOW STAR	REALIZED BELIEF NON-REALIZED DESIRE	Heart	No	47%	47%
			Star	Yes	13%	32%
ORDER 2 (HOPE-THAT first, HOPE-TO second)	RED HEART	REALIZED DESIRE REALIZED BELIEF	Heart	Yes	100%	92%
			Star	No	0%	17%
	RED STAR	NON-REALIZED BELIEF NON-REALIZED DESIRE	Heart	Yes	25%	42%
			Star	No	60%	36%
	YELLOW HEART	NON-REALIZED BELIEF REALIZED DESIRE	Heart	No	92%	83%
			Star	Yes	8%	25%
	YELLOW STAR	REALIZED BELIEF NON-REALIZED DESIRE	Heart	No	14%	33%
			Star	Yes	54%	39%

Graphs for each of the conditions are shown below. The red heart conditions, the control conditions, are shown in figures 4-11 and 4-12, for both frames in both orders. As mentioned above, all three interpretation types predict

the same patterns of response in this condition. Children should say 'yes' to a mentioned heart (123)/(125) and 'no' to a mentioned star (124)/(126). As shown below in the graph, the remaining children have no difficulty in this condition, for any of the frame conditions (after 1 of 33 were excluded).

FIGURE 4-11: Experiment 6: Order 1 Red Heart

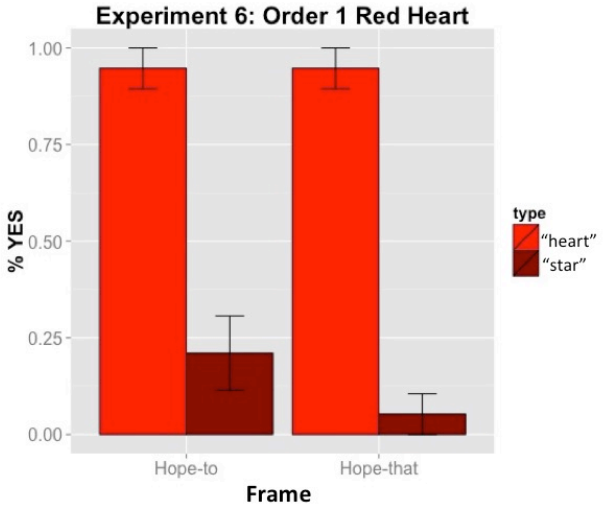
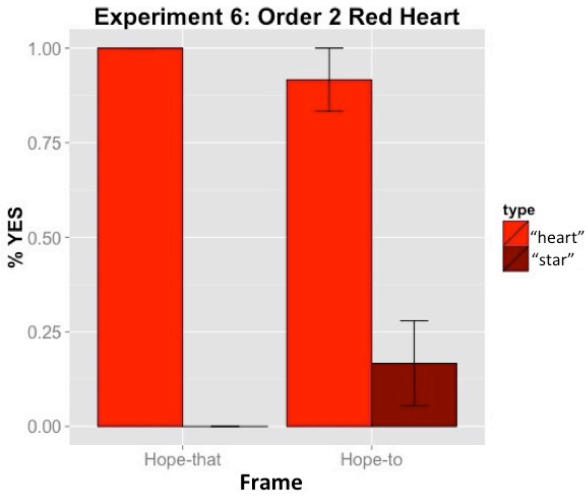


FIGURE 4-12: Experiment 6: Order 2 Red Heart



Figures 4-13 and 4-14 show the yellow heart conditions for both order 1 (4-13) and order 2 (4-14). In this case, if children respond based on desire or reality, they will say 'yes' to a mentioned heart (123)/(125) and 'no' to a mentioned star (124)/(126). Children who respond based on Froggy's beliefs will have the opposite pattern of responses. As shown in the graph, participants were very consistent in giving either a desire or reality response, almost no responses in this condition were consistent with a belief interpretation. This condition does not demonstrate (or predict) differential treatment of *hope* depending on syntactic structure, and as predicted, we see no difference in any of the frame conditions.

FIGURE 4-13: Experiment 6: Order 1 Yellow Heart

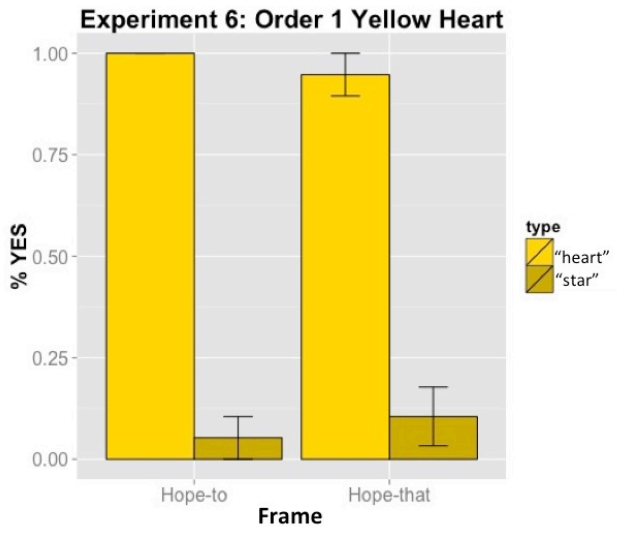
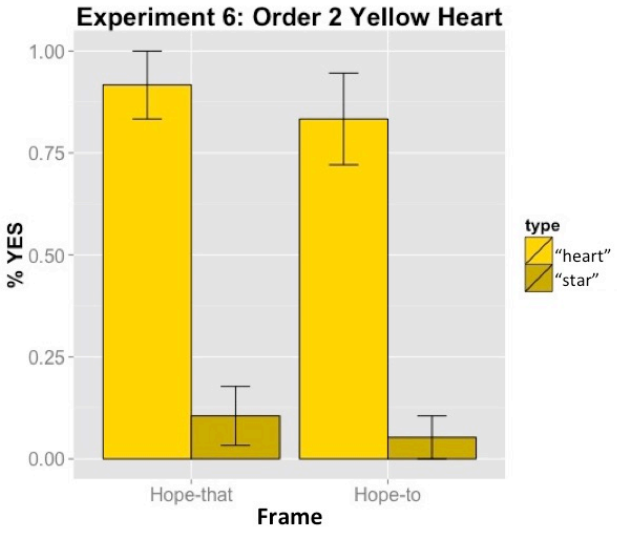


FIGURE 4-14: Experiment 6: Order 2 Yellow Heart



The following graphs show the red star condition. This condition is a non-realized belief and desire; therefore, reality patterns differently from both belief and desire responses. This condition allows us to compare the influence of reality in the *hope-to* and *hope-that* conditions. In this case, if children respond based on Froggy's beliefs or desires, they should say 'yes' to heart (123)/(125) and 'no' to star (124)/(126). Reality responses will show the opposite pattern of responses. Figure 4-15 shows the red star condition for order 1, in which children heard sentences with *hope-to* first. We see the same performance on the *hope-to* condition here as in experiment 5, children are often able to overcome the lure of reality in interpreting sentences with *hope-to.* In the *hope-that* condition, children look like they are being primed by having heart *hope-to.* Children are more likely to give a desire response here as well, which is different from the pattern that we see when they hear *hope-that* alone (experiment 5).

FIGURE 4-15: Experiment 6: Order 1 Red Star

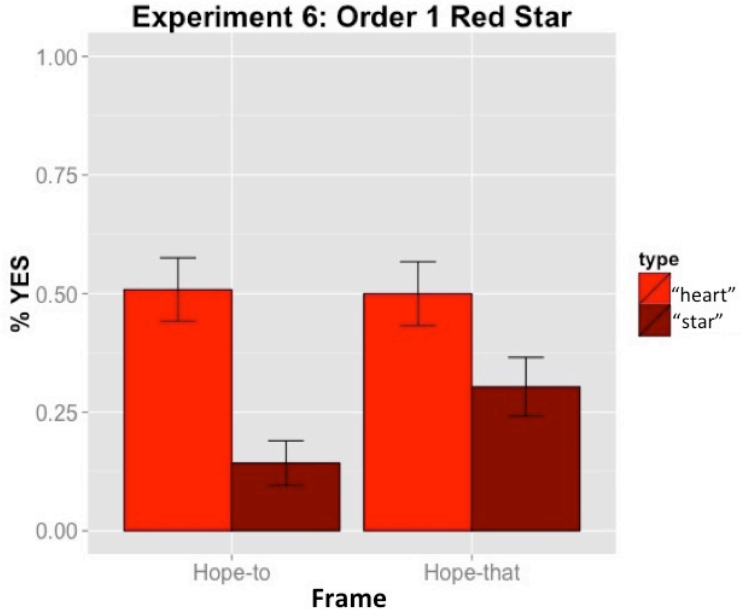
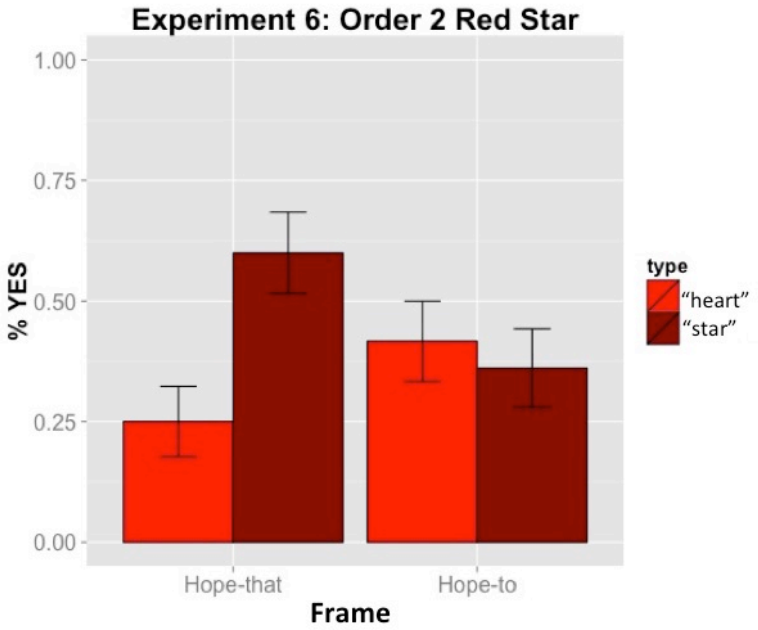


Figure 4-16 shows the red star condition in order 2, where children hear *hope-that* first. Here, we see that performance on *hope-that* sentences looks like performance in the *hope-that* condition in experiment 5. Children are more likely to be influenced by reality than to give desire responses. In the *hope-to* condition, we see that children are also primed to some extent by having heard *hope-that*. While their performance does not look exactly like when they hear *hope-to* alone (experiment 5; experiment 6, order 1); they are also not being overwhelmingly influenced by reality, as they are when they hear *hope-that* alone. This suggests that children are struggling to reconcile the pattern of responses that they have become accustomed to giving in the course of the task with the syntax that they are hearing (either on an individual level or as a group).

FIGURE 4-16: Experiment 6 Order 2: Red Star



This condition shows differential treatment of *hope-to* and *hope-that* in the first block of each order. We have also seen that although priming seems to be occurring to some extent in both orders, children in order 1 seem to be more primed, tending to stick with the desire interpretation that they got when interpreting *hope-to* in the first half; while children in order 2 seem to be better able to override their response pattern in the first half, and get a desire response for *hope-to* in the second half, at least some of the time, or for some children.

The next set of graphs show children's performance on the yellow star condition. In this condition, Froggy's desire is unrealized, but his belief is realized. In this case, belief and reality pattern together. If children respond based on Froggy's beliefs or based on reality, they will say 'no' to heart (123)/(125) and 'yes' to star (124)/(126); while desire responses will show the opposite pattern.

Figure 4-17 shows the yellow star condition for order 1, in which children heard sentences with *hope-to* first. Again, we see the same performance on the *hope-to* condition here as in experiment 5: children are often able to overcome the lure of reality in interpreting sentences with *hope-to.* In the *hope-that* condition, children again look like they are being primed by having heart *hope-to.* Children are more likely to give a desire response, which is different from the pattern that we see when they hear *hope-that* alone (experiment 5).

FIGURE 4-17: Experiment 6: Order 1 Yellow Star

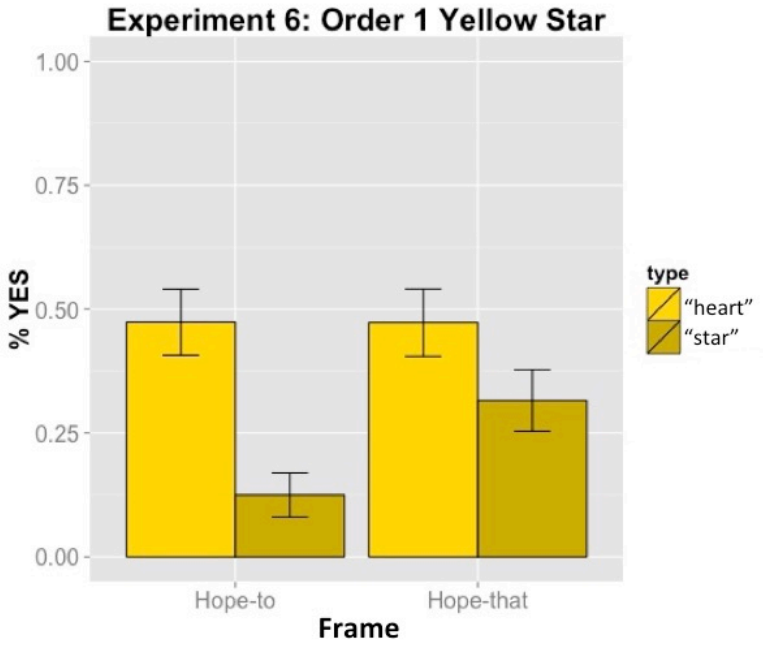
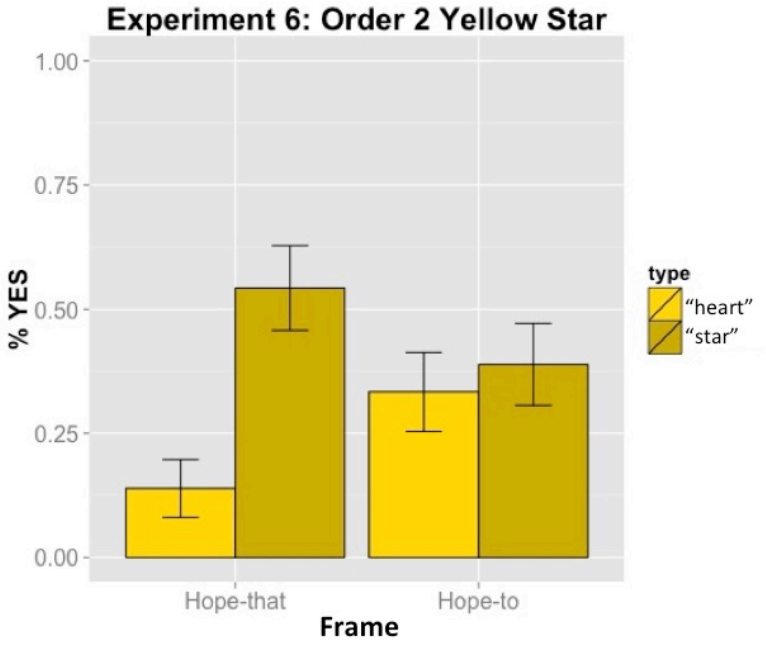


Figure 4-18 shows the yellow star condition in order 2, where children hear *hope-that* first. Again, we see that performance on *hope-that* sentences looks like performance in the *hope-that* condition in experiment 5. Children are more likely to be influenced by reality than to give desire responses. In the *hope-to* condition,

we see that children are again primed to some extent by having heard *hope-that*. While their performance does not look exactly like when they hear *hope-to* alone (experiment 5; experiment 6, order 1); they are also not being overwhelmingly influenced by reality, as they are when they hear *hope-that* alone. This suggests that children are struggling to reconcile the pattern of responses that they have become accustomed to giving in the course of the task with the syntax that they are hearing (either on an individual level or as a group).

FIGURE 4-18: Experiment 6 Order 2: Yellow Star



This condition shows differential treatment of *hope-to* and *hope-that* in the first block of each order. Both of the star conditions show different performance on *hope-to* and *hope-that*. In the first blocks of each of these star conditions, we have replicated the findings from experiment 5, showing that children are more likely to get a desire response when interpreting sentences with *hope-to*, while they are

more likely to be influenced by reality when interpreting sentences with *hope-that*. In the second blocks of both star conditions, we see evidence that priming seems to be occurring to some extent in both orders, perhaps demonstrating that children are not hypothesizing on each individual trial about the meaning of the verb *hope*, but rather building up some hypothesis over time and occurances as to what this verb means. This is evidenced in priming effect that we see: when children hear *hope-that* in the second block of order 1, they assign these sentences desire interpretations, despite the change in syntactic frame.

Although data collection in this study is ongoing (we will reach n=24 for both conditions), we also see an interesting effect of frame on the priming effect. Children in order 2, who hear *hope-that* first, are less primed than their peers in order 1. When children hear *hope-to* second, they are more able to override the syntax and their response pattern in the first half of the task, and get a desire response for *hope-to* in the second half, at least some of the time, or for some children. Children who hear *hope-to* first are more likely to stick with a desire interpretation, even after the change in syntax. This suggests that there may be something more informative about hearing an attitude verb with a non-finite complement than with a finite complement.

4.4.5.3 *Want/Think* Controls

In addition to the *hope* items, children got 4 *want* and 4 *think* items in between the two blocks. The purpose of these items was to ensure that children were still paying attention to the sentences being uttered, and to re-direct their attention to both the desire and belief components of the task. Children heart 4

yellow heart items (2 each for *want* and *think* sentences), and 4 red star items (2 each for *want* and *think* sentences). A 2x2 ANOVA reveals no significant interaction between verb and sentence type (red star condition/yellow heart condition for order 1 ($F(1,143) = 0.34$, $p = 0.11$) or order 2 ($F(1,88) = 1.04$, $p = 0.38$). Data for all *want/think* conditions is shown in Table 4-9 below.

TABLE 4-9: Experiment 6: Percent *yes*-responses on *Want/Think* Items

ORDER/ CONDITION	REALIZATION OF MENTAL STATE	Mentioned Shape	Target: *want*	% Yes: *Want*	Target: *think*	% Yes: *Think*
ORDER 1: RED STAR	NON-REALIZED BELIEF NON-REALIZED DESIRE	Heart	Yes	47%	Yes	47%
		Star	No	26%	No	47%
ORDER 1: YELLOW HEART	NON-REALIZED BELIEF REALIZED DESIRE	Heart	No	100%	No	84%
		Star	Yes	0%	Yes	22%
ORDER 2: RED STAR	NON-REALIZED BELIEF NON-REALIZED DESIRE	Heart	Yes	33%	Yes	25%
		Star	No	33%	No	58%
ORDER 2: YELLOW HEART	NON-REALIZED BELIEF REALIZED DESIRE	Heart	No	83%	No	67%
		Star	Yes	8%	Yes	17%

Children got 2 *want* and 2 *think* yellow heart items. In this case, desire and reality pattern together, and belief responses predict a different pattern. We included these items to determine whether any of the children are adult-like in interpreting *think*, as this is relevant to interpreting children's performance on the *hope-that* trials. Data for the yellow heart items is shown in Figures 4-19 and 4-20 below.

FIGURE 4-19: Experiment 6: Order 1 Yellow Heart *want/think*

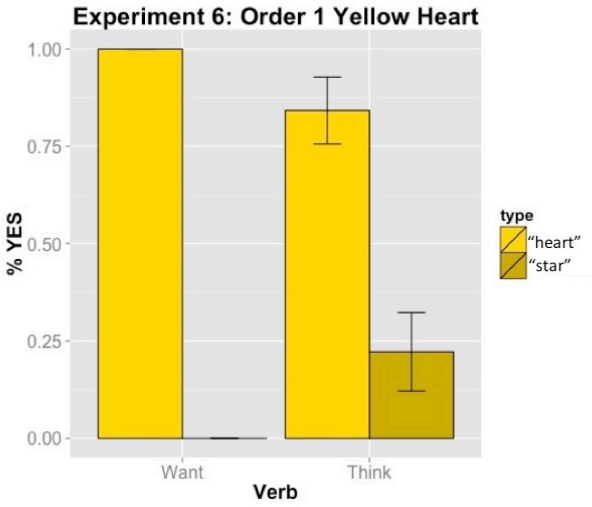
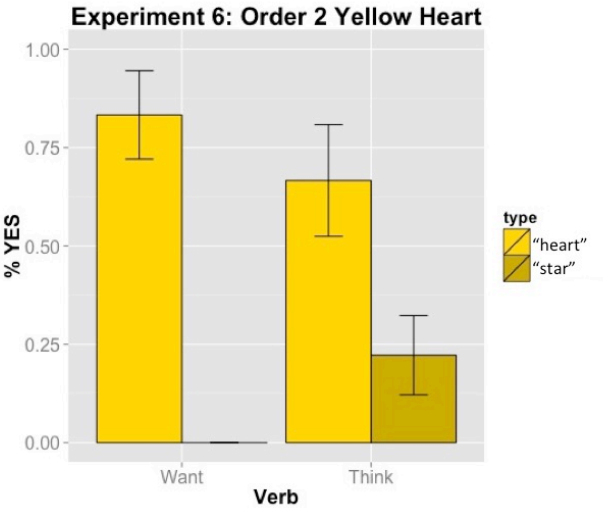
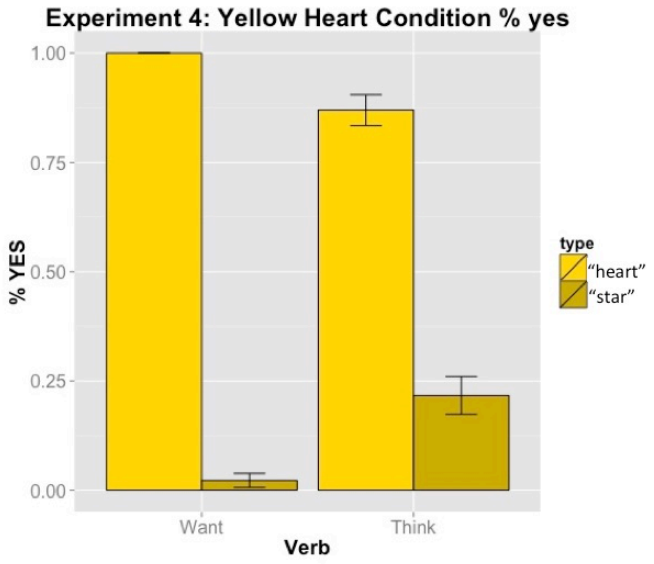


FIGURE 4-20: Experiment 6: Order 2 Yellow Heart *want/think*



We see that in the yellow heart condition, children in both orders give overwhelmingly desire/reality responses on both the *want* and the *think* items, which replicates findings for children's performance in this condition in experiment 4 (figure 4-21).

FIGURE 4-21: Experiment 4: Yellow Heart *want/think*



Children also heard 2 *want* and 2 *think* red star items. In this condition, desire and belief pattern together, while reality responses show the opposite pattern. We saw a different pattern of responses for *want* and *think* in this condition in experiment 4, and thus hope to see the same behavior in this case. Data for the red star condition is shown below in Figures 4-22 and 4-23.

FIGURE 4-22: Experiment 6: Order 1 Red Star *want/think*

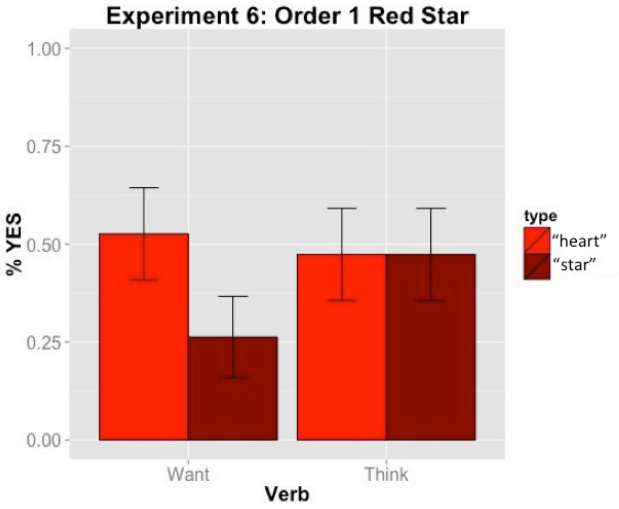
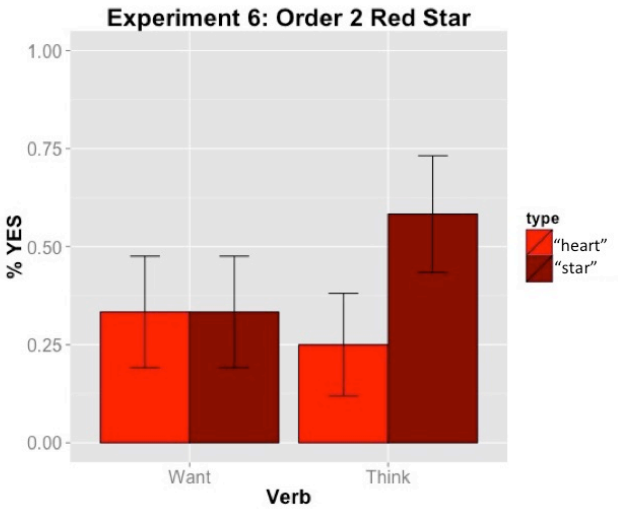
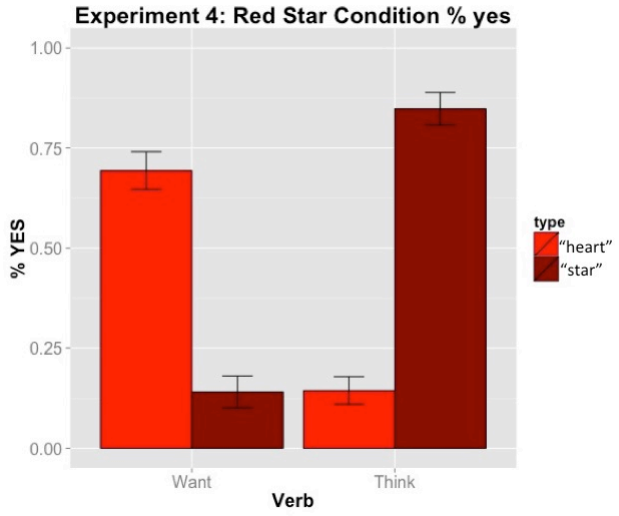


FIGURE 4-23: Experiment 6: Order 2 Red Star *want/think*



As is evident from the graph, although there appear to be trends toward differences between the *want* and *think* items, we find no significant differences. This is perhaps influenced by the fact that there are very few of these items, and we currently only have data for 32 children. We do not see the same pattern of responses shown in this condition for *want* and *think* in experiment 4, particularly for *think* in order 1 and *want* in order 2 (figure 4-24).

FIGURE 4-24: Experiment 4: Red Star *want/think*



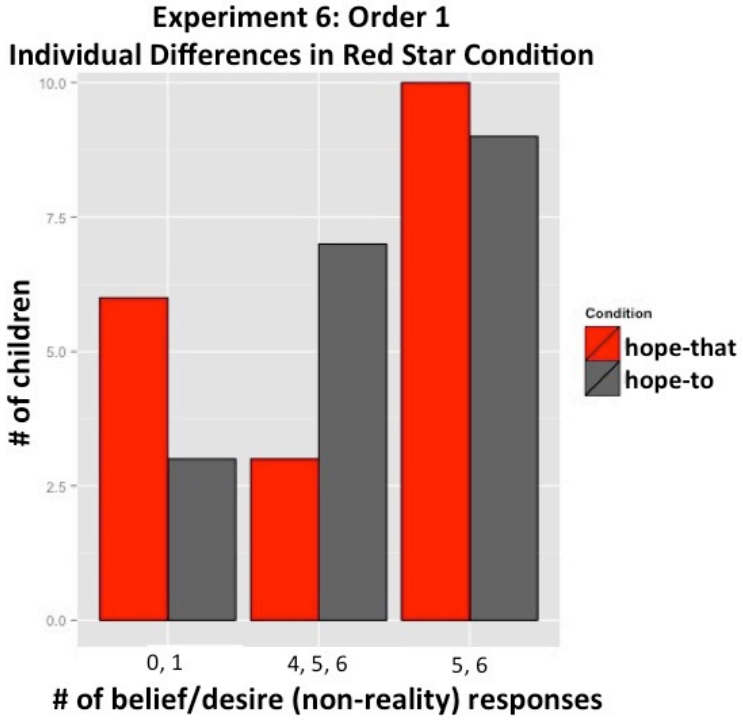
This could be due to several different factors. In experiments 5 and 6, children only heard one sentence type, whereas in this experiment they are exposed to all four sentence types. Thus, we have no information about whether children in experiments 4 and 5 were listening carefully throughout the entire experiment, or whether they just continued giving the same interpretation type (desire/belief/reality) throughout the whole task without listening carefully to the form of each test sentence. These results make it difficult to know how to interpret the *hope-to* and *hope-that* conditions in this experiment. It is possible that these results demonstrate that children's responses in the second half are not to be trusted, but it is also possible that children are performing poorly on the *want* and *think* items for independent reasons, which are not informative about their performance on the *hope* items, such as the interspersement of the *want/think* items, which may require more inhibition on the part of the child, or the fact that there are so few *want/think* items.

4.4.5.4 Individual subjects analysis

As in experiment 5, looking at percent *yes*-responses overall is not informative about whether children were noisy as a group due to differing individual response patterns, or due to noise in each individual child's data. In this section, we will present information about performance of individual subjects. In the same way as we did for experiment 5, we tallied up the number of children with each type of response pattern in both the red star and the yellow star conditions, the conditions in which *hope-to* and *hope-that* show different performances. Note that in this experiment, we have fewer items; therefore we have had to divide up the number of responses into slightly different "bins" than in the experiment 5 analysis. The first bin includes children who gave 0 or 1 of a certain type of response. (belief/desire responses in the red star condition, reality/belief in the yellow star condition). The second bin includes children who gave 2, 3, or 4 of a certain type of responses. The third bin includes children who gave 5 or 6 of a certain type of responses. Because of this distribution, we might expect to see more children in the second, or "chance" bin than in the previous experiment.

Figure 4-25 below shows this distribution of participants for the red star condition for order 1. In the red star condition, reality responses pattern differently from belief/desire responses.

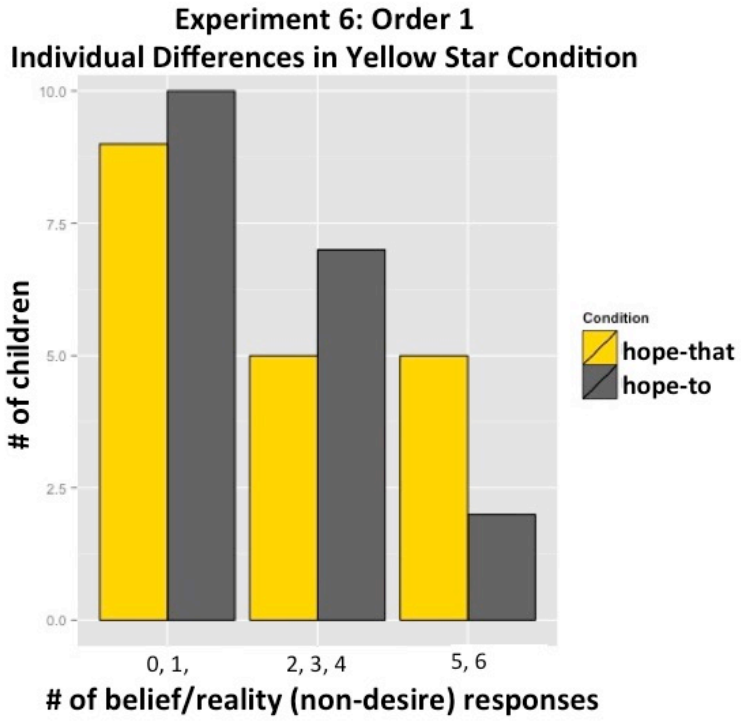
FIGURE 4-25: Experiment 6: Order 1 Individual Differences in Red Star Condition



In this condition, children heard sentences with *hope-to* first. The *hope-to* pattern that we see here shows that most of the children in both frame conditions are giving belief/desire responses in this condition. We do see that more children here fall into the "chance" category than in experiment 5—perhaps due in part to the difference in number of items, and therefore the bin sizes. Critically, we see more children giving primarily desire responses than primarily reality responses, just like in experiment 5. In the second block of this order, children heard *hope-that*. It is evident from the above histogram that in this condition, more children gave primarily desire responses than primarily reality responses—a different pattern than was observed when children heart *hope-that* alone in experiment 5.

We did the same analysis for the yellow star condition, shown in Figure 4-26.

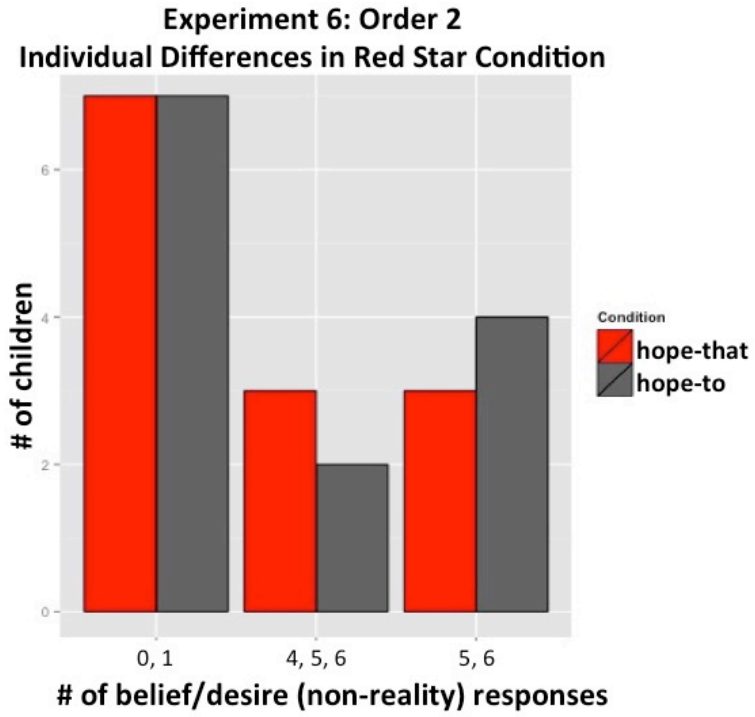
FIGURE 4-26: Experiment 6: Order 1 Individual Differences in Yellow Star Condition



In this condition, desire responses pattern differently from reality/belief responses. Again, we see that in the *hope-to* condition, more are in the "chance" group than we saw in experiment 5, potentially due to different binning. Critically, however, we see that in this condition, more children are giving primarily desire responses than primarily belief/reality responses. In the second block of this order, children heard *hope-that*. It is evident from the above histogram that in this condition, more children gave primarily desire responses than primarily reality responses—a different pattern than was observed when children heart *hope-that* alone in experiment 5.

We did the same analysis for the children in order 2. In this condition, children heard *hope-that* first. The histogram in figure 4-27 shows children's response patterns in the red star condition.

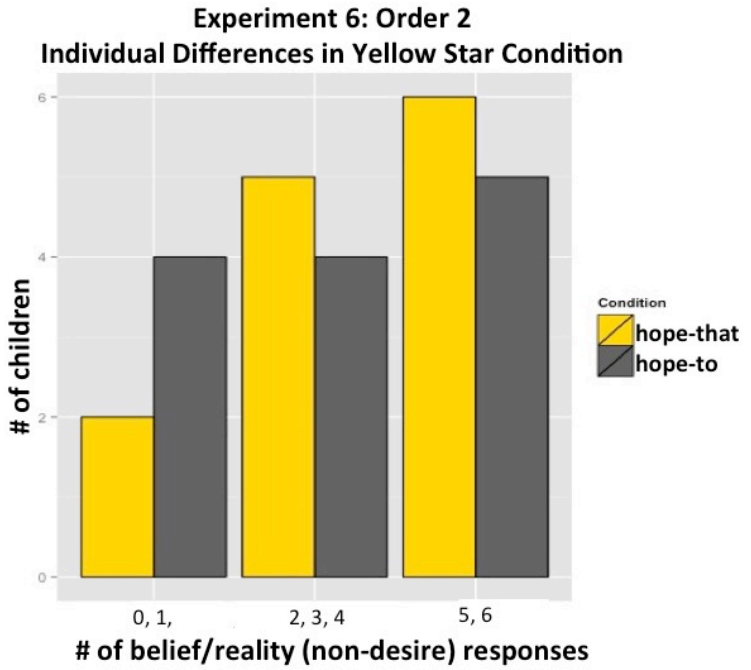
FIGURE 4-27: Experiment 6: Order 2 Individual Differences in Red Star Condition



We see that in this condition, when children hear *hope-that,* more children give primarily responses consistent with reality, and fewer children give responses consistent with belief or desire. In the second block, when they hear *hope-to*, most children are still giving majority reality responses, showing a different pattern then when they hear *hope-to* alone in experiment 5.

Figure 4-28 shows children's response patterns in the yellow star condition in order 2.

FIGURE 4-28: Experiment 6: Order 2 Individual Differences in Yellow Star Condition



Again, in this condition, when children hear *hope-that,* more children give primarily responses consistent with reality/belief, and fewer children give responses consistent with desire. In the second block, when they hear *hope-to*, most children are still giving majority reality responses, showing a different pattern then when they hear *hope-to* alone in experiment 5. In both the red and yellow star conditions in order 2, we see some children shifting away from reality toward chance or desire responses in the *hope-to* condition.

Many children were primed by the frame that they heard in the first block. Some subjects, however, shifted their responses in the second half after the frame changed. Consistent with the overall patterns that we noted in the above section, we see more subjects shifting their response patterns in the second half in order 2 than in order 1. In order 1, children heard *hope-to* in the first block, and *hope-that*

in the second block. These children were likely to be primed in the second half. Five out of the 19 subjects (26%) switched from majority desire interpretations to majority reality interpretations (or from chance to reality, or desire to chance performance). Across the two differentiating conditions, 6 out of the 19 children (32%) gave more reality responses in the second block than in the first block, indicating *some* shift toward reality. This indicates that the majority of children (68%) continued getting a desire interpretation at the same rate in the second block, as in the first block even after the syntax changed.

In order 2, children heard *hope-that* in the first block, and *hope-to* in the second block. These children were less likely to be primed in the second half, and more likely to be influenced by the syntax in the second half. Four out of the 13 subjects (31%) switched from majority reality interpretations to majority desire interpretations (or from chance to desire, or reality to chance performance). Across the two differentiating conditions, 7 out of the 13 children (54%) gave more desire responses in the second block than in the first block, indicating *some* shift toward reality. About half of the children made some shift toward desire interpretations for the *hope* sentences after the syntax changed to a non-finite complement in the second block.

4.4.6 Experiment 6: Discussion

In experiment 6, we replicated our findings from experiment 5, showing that children are influenced by syntactic frame when interpreting an attitude verb for which they may not know the meaning. Again, we have shown that children are sensitive to the syntactic frame in which they hear the verb *hope*, suggesting

that they use syntax as a cue for interpretation. We have shown that when children hear a verb with a non-finite complement, they are more likely to treat it as if it is about desires, whereas when they hear a verb with a finite complement, they make the same reality-error that we see in interpretation of *think*. This further demonstrates that at least one of the factors that that causes children to make the classic false belief error is the syntax of finite complement clauses, or perhaps more abstractly, the syntax of main clauses appearing in complement clauses. Additionally, in this experiment, we have shed some light on the process of building a hypothesis about an attitude verb's semantics. We tested two hypotheses, shown below in table 4-10.

TABLE 4-10: Experiment 6: Hypotheses

HYPOTHESIS 1	INTEGRATION OF SYNTAX WITH SEMANTIC REPRESENTATION: Children are using the frame information not only for interpretation, but also integrating this information into their semantic representations.
HYPOTHESIS 2	NO INTEGRATION OF SYNTAX WITH SEMANTIC REPRESENTATION: Children are able to use syntax for interpretation of individual sentences, but do not integrate this information into semantic representations used for future encounters with the verb.

We found hypothesis 1 to be supported: children are integrating syntactic information into their semantic representation. In this experiment, we explored children's interpretations of *hope* when it was presented to them with both a finite and a non-finite complement. When children hear *hope* with a non-finite complement first, they tend to assume a desire interpretation for the sentence, and continue to do so even when *hope* is presented afterwards with a finite complement. This is consistent with children assuming a desire meaning for the

verb *hope*, because it has occurred with a non-finite complement. When children hear *hope* with a finite complement first, they make reality-based errors, although they seem more able to override this interpretation when the syntax changes. This suggests that although they might be building a semantic representation for *hope* based on the syntax of finite complements, this representation may more fragile, or more flexible, than the meaning assigned by children who heard *hope* with a non-finite complement first. This is a (very hesitant) suggestion that perhaps hearing the syntax of a non-finite complement is more informative to the learner than the syntax of finite complements (at least for *hope*). Collecting the rest of the sample for experiment 6 will be the first step in better understanding the meaning of these results.

4.8 Chapter 4: Discussion

In this chapter, we have discussed children's sensitivity to syntactic frame in interpreting sentences with attitude verbs. We have looked at how they interpret individual sentences (experiment 5), and also how information from the syntax carries over into future encounters with the same verb in a different syntactic frame. We have done this by looking at children's interpretation of sentences with the verb *hope* in two different syntactic frames: one with a non-finite complement (127), which is typically associated with verbs that express desires; and one with a finite complement (128), which is typically associated with representational attitude verbs.

(62) *Froggy hopes to get a heart!*

(63) *Froggy hopes that it's a heart!*

In the first section of this chapter, we reviewed the *syntactic bootstrapping for attitudes* proposal, which requires both that the links between syntactic and semantic features are principled, and additionally that children are sensitive to these links. We demonstrated that the verb *hope* in English makes an ideal test case for this hypothesis for several reasons. *Hope* shares both syntactic and semantic components with both representational and preferential attitude verbs. It can occur both with a finite and a non-finite complement (127)-(128), and shares meaning components with both classes. The hope is that children are eventually cued in to both the desire and belief components and converge on the adult semantic representation for *hope* through the syntactic distribution. We suspected, and were correct, that children have not yet had enough exposure to recognize *hope* as referencing desires by the age of 4, thus using this verb as a "pseudo-novel" attitude verb made it an ideal test case for our bootstrapping hypothesis. In experiment 5, we tested whether children are sensitive to syntactic frame when interpreting sentences with *hope* in a context that equally supported either a desire or a belief interpretation. We found that children are, in fact sensitive to syntactic frame. When 4-year-olds hear *hope* with a non-finite complement, they interpret the sentence as being about desires, and when they hear *hope* with a finite complement, they are influenced by reality in interpreting the sentence, in the same way that they are when interpreting sentences with *think* at this age.

In experiment 6, we ask whether the behavior in experiment 5 is simply about an interpretation strategy, or whether children are integrating the information that they are gleaning from syntactic complement when building a semantic representation for *hope*. In this study, we gave children sentences with *hope* with both finite and non-finite complements in two blocks. We looked first at whether the data from the first block replicated the results in experiment 5, which it did. We then looked at whether performance on the second block looked the same or different from the pattern observed when children only heard that frame in isolation. If we see a different pattern, for example, a priming effect, this is evidence that children are using the early syntactic information to update their semantic representation of the verb. This shows us something more than just interpretation, but actually speaks to a learning mechanism. We see an interesting pattern of results in experiment 6.

We see that when children hear sentences with *hope-to* first, they are primed in the second half of the experiment. Even when they get *hope-that* sentences in the second block, they continue to get a desire interpretation. This suggests that they are not only hearing *hope-to* and getting a desire interpretation, but are actually hearing *hope-to* and updating their knowledge of the verb *hope*, perhaps storing information about *hope* as a desire verb. Then, when they hear *hope-that,* they continue to get a desire interpretation. Hearing *hope* with a finite complement does not seem to be counter-evidence to their desire hypothesis, or if it does, the desire hypothesis was strong enough that overriding this hypothesis is difficult. In the other order we see a different pattern. When children hear *hope-*

that first, they get a reality interpretation. But then, when the frame switches and they hear *hope-to* in the second half, they are much more conflicted. Some children are primed, and continue to get a reality interpretation even when they hear *hope-to*, but other children are shifting toward giving more responses consistent with a desire interpretation. This shows us that children (as a group) seem more conflicted about integrating finite complement information into their semantic representation.

Although the results shown here provide an interesting and important first step in uncovering the process that children go though in learning the semantics of attitude verbs, there are limitations to this set of studies. In both experiments 5 and 6, we carefully designed the studies to make sentences with *hope* felicitous. Even when Froggy believes that the shape is a star, because the clue is yellow, he can still *hope* that the shape is a heart, because there are some yellow hears. However, there is no guarantee that children know that Froggy knows that a heart is still a possibility. They could be rejecting sentences like (129)/(130) because they assume that Froggy doesn't think that getting a heart is a possibiltity, particularly if they are already aware of *hope*'s belief component.

(64) *Froggy hopes that it's a heart!*

(65) *Froggy hopes to get a heart!*

It is worth noting, however, that even if this is the reason some children are rejecting sentences like (129)/(130), we see different rates of rejection in each of the frame conditions, showing that there is still an effect of syntactic environment for children's interpretation of *hope*. Additionally, this predicts that we might see

different patterns for the red and yellow star conditions (since in the red star condition Froggy *does* believe that the shape is a heart), which we do not. We might rule out this hypothesis by running a similar study with more emphasis on Froggy's uncertainty.

Another possible limitation of this study is the possibility of getting a future-oriented reading for the *hope* sentence in the non-finite frame condition. Given a sentence like (131), it is perfectly reasonable to interpret this sentence as being about a future shape, or a more general statement about what kind of shapes Froggy likes getting.

(66) *Froggy hopes to get a heart!*

It is possible that children gave *yes*-responses to these sentences based on a future-oriented reading. Interpreting this sentence with a future-orientation means that participants do not have to process the conflict with reality, making this condition perhaps easier for children to give desire responses. Experiment 1 of this dissertation suggests that children have no difficulty with *want*, even in cases where no future-orientation is possible, suggesting that possible future-orientation may not be an issue here. Regardless, running the same task with a novel verb and a non-finite complement with a subject (like the syntax for the *want* condition in experiment 4) will help rule out this possible confound (132).

(67) *Froggy blicks it to be a heart!*

Several questions are left open by the results of experiment 6. First of all, it is difficult to know how much to conclude from the results on the second block, given children's performance on the *want* and *think* conditions in this task. It is

possible that poor performance on these items indicates that the task is simply too overwhelming, or designed in such a way that biases children toward continuing to get the same type of interpretation over and over (perhaps based on so many items of the same type at the beginning). In that case, the priming effects that we observed may not be indicative of any real syntactic priming, but simply an artifact of the design of the task and the cognitive capacities of 4-year-olds. It is possible, however, that the observed priming effect really is an effect of the syntax, and that poor performance on the *want/think* controls is due to external factors, which do not affect the *hope* items in the second block. Because these sentences are interspersed, processing them may require more inhibitory control that the *hope* items, given that they require children to switch back and forth between multiple different interpretation types in a very short period of time. Another possibility is that the poor performance on the *want/think* controls is due to too few of these items. Even if children are able to switch between multiple interpretation types over the course of the experiment, it is possible that they need a few items to "warm up" to this. Perhaps given more *want/think* controls, they would have shown their competence.

Another question that this study leaves open is about how much exposure to a new verb in a given syntactic frame is necessary for children to build a semantic representation linked to that frame. In this task, children always got 16 items in the first frame, and then we looked at the effect that that exposure had on their performance on the other frame. We have shown that this much exposure to frame only (without any contextual content that leads children to hypothesize

belief vs. desire) is enough for children to build some kind of semantic representation such that we see priming effects. But it is unclear based on this study alone, how much exposure is necessary, and how contextual information may aid children's acquisition in the real world. Related to this, it is unclear what the effect of getting this exposure in a lab setting is, and how their hypotheses about verb meanings might be different given more "real world" exposure—both because of factors relating to being in a lab setting, for example possible performance anxiety, and being around strangers, and additionally because in the real world they are more likely to have at least some help from the context. Future tasks, discussed in Chapter 5, will look at some of these factors.

There are several different hypotheses for why priming effects may have been stronger for *hope-to* than for *hope-that*, or why the non-finite complement may be more informative information to the learner in this case than information from the finite complement. One possibility is related to the input. We saw earlier in this chapter that although children encounter *hope* far less than they encounter *think* or *want*, when they do hear *hope*, the finite complement frame is overwhelmingly dominant. Perhaps the reason that *hope-to* seems to be more powerful in this task, is because hearing *hope* in this frame is more surprising to children given that they hear it so much less often in this frame, and may never have heard it in this frame at all before participating in this task. This ability to "correct for" the skewed distribution in the input may be one factor that eventually helps them become adult-like in their semantic representation. The desire component of *hope* is often the foregrounded meaning component in when

hope is being used, and at first glance, if the syntax is informing children, it seems like the observed distribution would not make learning this easy for children. If they are able to weigh the information gleaned from different frames differently, this would help correct for this factor. It is not yet clear how children should know when to weight different syntactic information differently, and how to do so.

Another hypothesis for why *hope-to* seems to be more informative to children in this task is that this difference is actually reflecting a much deeper theoretical difference, and this behavior observed in children is perhaps informative about the syntax-semantics interface. Maybe a representational attitude semantics is the default assumption for attitude verbs, and then certain frames (non-finite complements in English, for example), trigger very strongly a desire interpretation. One way to follow up on this question is to test children's interpretations of sentences with a novel verb. If the difference in priming effects in experiment 6 is input driven, then we would expect to see equal priming across both condition, as there is no previous exposure to draw from in the case of a novel verb. If we see the same pattern emerge, however, this suggests that this pattern is driven by something deeper.

Another way to follow up may be to look cross-linguistically at the compatibility of representational and preferential attitude verbs with different syntactic complements. In the first chapter of this dissertation, I cited a hypothesis (Hacquard 2014, a.o.) which proposed that the specific syntactic cue to children as to whether a verb is preferential or representational is whether the verb can embedded clauses with main clause features in that language. In English, the way

this manifests is through finiteness. For example, *think,* embeds finite complements, which could be main clauses on their own; while *want*, can only embed non-finite complements, which are not the correct form to be sentences on their own (133)-(134).

(68) *John thinks [Mary is home]*.

Mary is home.

(69) *John wants [Mary to be home]*.

#Mary to be home.

As discussed in the first chapter, this manifests differently in different languages. For example, in romance languages, the distinction seems to be subjunctive v. indicative in the complement. But the critical feature that children may look for is whether or not the verb embeds clauses that take the form of main clauses or not. The observed differences between the priming effects in experiment 6 may shed some light on how exactly this works. If this priming difference is caused by a deep syntax-semantics interface connection, we might expect to see that finite complements (or any language's main clause syntax equivalent) is more likely to be compatible with desire verbs, but that non-main clause syntax is less likely to be compatible cross-linguistically with representational attitudes. This would explain why children are more likely to override the *hope-that* syntax in the second block with a desire interpretation, but more conflicted about overriding the *hope-to* syntax in the second half with a reality interpretation. Looking at the distribution and children's assumptions cross-linguistically may speak to this.

In this chapter, we have seen that syntax plays an important role in interpreting sentences with attitude verbs, and in learning their meanings. Although this is an important step in better understanding acquisition of attitude verbs, there is still much work to be done to better understand the specific role of syntax. The last chapter of this dissertation will discuss some future directions of this project.

Chapter 5: Future Directions & Conclusion

5.1 Summary and Integration

5.1.1 Summary of Findings

In this dissertation we have explored the role of syntax in children's interpretation of sentences with attitude verbs. Specifically, we have seen that even under the most stringent conditions, children are adult-like in interpreting sentences with *want* before they are in interpreting sentences with *think* (chapter 3). Additionally, we have seen that children use the syntactic frame in interpreting an attitude verb for which they have not yet determined a meaning. Although this early investigation into the role of syntax in attitude verb learning is an important step, there is still much work to be done to fully understand the specific role that syntax plays. This final chapter of this dissertation will discuss some future directions of this project.

In experiment 6, we looked at children's interpretation of sentences with *hope* with a non-finite (135) and a finite complement (136).

(70) Froggy hopes to get a heart/star!

(71) Froggy hopes that it's a heart/star!

Children heard both types of sentences, blocked so that they heard one type for the first half of the study, and the other type for the second half. In the first half of both conditions, we replicated results from experiment 5, showing that when children hear *hope* with a non-finite complement clause (1), they assign a desire interpretation to the sentence; and when children hear *hope* with a finite

complement (2), they are influenced by reality. We found priming effects in both conditions, suggesting that children are using the input they heard in the first half to update their hypothesis about the meaning of the word *hope*. Interestingly, we found that the priming effects that we saw in each condition looked different: children that heard *hope* in a non-finite frame first tended to assign a desire meaning to *hope*-sentences in the second half as well, overriding the finite complement syntax. In the other condition, however, when children heard a finite complement first, half of the children were primed in the second half, but the other half assigned *hope* a desire meaning in the second half, overriding their initial hypothesis for the meaning of *hope* and using the syntax in the second half of the task. The results of the experiments presented here, in particular the preliminary findings from experiment 6, leave open several fruitful lines of research.

5.1.2 Integration

In chapter 2, I reviewed several hypotheses that have been proposed to account for the difficulty that has been observed with children's interpretation of sentences with *think*. In this section, we will revisit each of the hypotheses summarized in chapter 2, providing more details about the accounts, and discussing the implications of each in light of the new data presented here.

5.1.2.1 Conceptual Accounts

Perner and Gopnik and colleagues have proposed conceptual hypotheses, arguing that children fail in interpreting sentences with *think* because they have not yet developed the relevant concept of belief. There are several different ways

that a conceptual hypothesis has been proposed. Perner and colleagues assume that belief-representation ability develops due to some domain-general processes. They argue that children's ability to reason about beliefs develops at the time in which a more general 'metarepresentational capacity' develops. However, this seems to predict that reasoning about false or unfulfilled desires should be equally challenging for children. Previously, children's ability to interpret *want* sentences describing counterfactual or unfulfilled desires was an unresolved question in the literature (Litchermann 1991, Moore et al. 2005, Rakoczy 2007, 2010). Experiments 1-3 of this dissertation showed that given the right methodology and appropriate training, children are adult-like in their ability to interpret *want* sentences in these contexts. These results provide evidence against the acquisition of *think* being tied to the development of a general 'metarepresentational' ability.

Other researchers, such as Gopnik and colleagues (Forguson & Gopnik 1988) have proposed a domain-specific constructivist hypothesis. This type of proposal suggests that while both of these concepts develop over the course of childhood, their development is not necessarily tied to development of other, more general, cognitive abilities. This hypothesis says that children develop a 'theory of desire' and a 'theory of belief', and that we will see them develop separately, not necessarily related to each other, and perhaps at different time points over development. While this hypothesis is not specifically undermined by the developmental priority of desire, it also has no explanatory value—it suggests no reason *why* it should be the case that the 'theory of desire' emerges earlier.

Rakoczy (2007, 2010) and colleagues propose that experiential factors that cause belief to emerge later than desire. They claim that children encounter more explicit desire references than belief references during development. This is because beliefs are often taken for granted, particularly in cases where all participants in a conversation have the same knowledge and access to facts. Additionally, many of the cooperative activities that children participate in often revolve around coordinating desires, not beliefs. Rakoczy and colleagues also point out that processing beliefs may be more psychologically taxing, due to reasons related to the 'logical properties' of beliefs and desires. Beliefs are evaluated based on truth, and they get updated based on facts about the world. Desires, on the other hand, are evaluated for fulfillment at a later time, and then the world gets revised to fit the desires. In other words, the 'direction of fit' is different for beliefs and desires—beliefs change based on the world, whereas the world itself often changes to fit desires. Because of this, processing desires may requiring representing the world in such a way that conflicts with the actual state of the world. While it is possible that these facts contribute to the ease with which children acquire *want*, many previous studies examined interpretation of *want* with a future-orientation, finding that children were adult-like very early on, and experiment 1 of this dissertation demonstrates that children are also adult-like in interpreting sentences with *want* that directly conflict with reality, suggesting that direction of fit for beliefs vs. desires is not driving the asymmetry.

A conceptual account explains why we see success on all explicit tasks emerge around the same time, but cannot explain why language development

seems to be tied to conceptual development in this domain, and some versions cannot account for chidlren's success on *want* tasks that have equal complexity to false belief tasks. Conceptual accounts also have difficulty explaining recent findings showing infant success on implicit belief-tracking tasks.

5.1.2.2 Deployment Accounts

Different deployment hypotheses have been proposed to account for the difficulty with *think*. These accounts have claimed that there is no deficit with the belief concept, but that other factors interfere with children's ability to deploy the belief concept in tasks.

5.1.2.2.1 Interaction with Task Demands

Other researchers have proposed alternative accounts to the conceptual hypothesis; claiming that there is no conceptual difference between children's abilities to represent beliefs and desires; but that certain elements of the belief and desire tasks that have been used give rise to the appearance of an asymmetry.

Moore and colleagues, and Rakoczy and colleagues explored this by testing sentences with *want* in counterfactual and conflicting contexts, as a better comparison to false belief tasks. The results from both of these researchers were conflicting: in both cases, the studies found that children had more difficulty with desire in counterfactual or conflicting cases than in non-counterfactual or non-conflicting cases; however Moore et al. claimed that their results demonstrated that conflicting desires were just as difficult as false beliefs, while Rakoczy et al. found that although children were not at ceiling, they performed significantly better than in false belief tasks. In order to further probe the influence of task

factors in the *think*-*want* asymmetry, experiments 1-3 test comprehension of *want* in counterfactual and conflicting situations, improving on the methodology presented in the Moore et al. and Rakoczy et al. studies in several ways. Additionally, experiment 4 directly compared *think* and *want* under the same experimental conditions. If task factors were driving the difficulty with *think*, this predicts that under the same exact experimental conditions the same difficulty would arise with *want.* We find that this is not the case. In all four of these studies, we found three-year-olds to be adult-like in their interpretation of sentences with *want*, suggesting that task factors alone cannot be driving the difficulty with *think.*

Another proposal by Leslie and colleagues focuses on the role of executive function in children's difficulty with belief reports. This account provides an explanation for why we see success in implicit tasks and failure in explicit tasks, but does not directly speak to the asymmetry between *think* and *want,* and, like Perner's conceptual account, and the accounts focusing on task factors, predicts that given the right experimental context, children should have as much difficulty with *want* as they do with *think.* Again, in experiments 1-4 of this dissertation, we find that children are adult-like in interpreting sentences with *want* in counterfactual and conflicting contexts by age three (experiments 1-3), and that four-year-olds are adult-like with *want* but not *think* in the same experimental context (experiment 4). Particularly in experiment 4, the executive function demands are likely identical for the *think* and *want* conditions,

suggesting that executive function demands in tests of *think* cannot be the sole reason for the difficulty.

5.1.2.2.2 Interaction with Language

Other deployment accounts have focused on the role of language. De Villiers and colleagues have proposed that there is a tight relation between children's acquisition of the relevant syntactic features and their belief representation capacities. Lewis and colleagues argue that relevant pragmatic features contribute to the delay in comprehension of belief reports.

5.1.2.2.2.1 Syntax

de Villiers and colleagues have argued that syntactic development plays a critical role in belief representation abilities. This proposal, called *Linguistic Determinism,* states that development of the relevant syntactic knowledge is the critical factor in children's success on false belief tasks. De Villiers has claimed that children are delayed in their ability to embed certain types of content. Verbs like *think* embed truth-evaluable (or *realis*) content, meaning that the syntactic form of the complement is something that can be evaluated for *truth* or *falsity* (21).

(39) *Joe thinks [it's raining.]*

The complement of the sentence in (21), *it's raining*, can be either *true* or *false*. She argues that verbs like *want* embed non-truth-evaluable (or *irrealis*) content, meaning that the syntactic form is not one that allows the proposition to be evaluated for *truth* or *falsity* (22).

(40) *Joe wants [it to rain.]*

The complement in (22), *it to rain*, cannot be evaluated for *truth*. Many studies by de Villiers and colleagues have shown that until children gain the relevant syntactic knowledge, they do not succeed on false belief tasks. This proposal makes a testable prediction—that we should see a direct link between acquisition of this type of syntactic structure, and belief-representation ability.

A large body of experimental evidence does suggest a connection between syntactic development and development of belief representation. One type of evidence de Villiers and colleagues have used to demonstrate the relation between language and belief representation is longitudinal data. de Villiers and Pyers (2002) found that comprehension of false complements at 3-4 years predicts FB performance 3-6 months later. In de Villiers and Pyers' (2002) studies of late-signing Deaf children born to hearing parents, they not only found a relation between language development and performance on belief tasks, but crucially, they found that these children do not pass the false belief task until they acquire the relevant syntax for complementation in ASL. Training have also studies provided some evidence of the relation between syntax and conceptual development. Hale and Tager-Flusburg (2003) trained 3-5 year-olds who initially failed explicit false belief tasks on false complements. Crucially, they were trained on false complements using non-mental state verbs, such as *say*. They found that performance on false belief tasks had improved.

Other evidence casts doubt on the de Villiers' theory. Implicit tasks suggesting that children are able to represent beliefs well before the preschool

years are problematic for this theories proposing that belief representation is tied to language development. If children are able to represent beliefs as early as 7 months, it is unlikely that syntax, plays a role in the actual development of the belief representation capacity. A version of a language interference theory that applies specifically to interpretation of sentences with *think* is potentially compatible with the infant findings, but does not adequately explain why children should have such difficulty with false belief tasks that do not require interpretation of *think*-sentences. If the difficulty lies in the actual interpretation of sentences with *think*, this does not predict difficulty on action-prediction tasks.

Cross-linguistic data is also problematic for the linguistic determinism proposal. Some languages encode beliefs and desires differently than English, and so the claim that there is something privileged about the role of the syntax of tensed sentential complementation does not hold up across languages. For example, in German, *think* and *want* can both take a tensed sentential complement (23)-(24).

(41) *Was will die Mutter, dass Andreas tut?*
What wants the Mom that Andy does?
'What does Mom want Andy to do?'

(42) *Was glaubt die Mutter, dass Andreas tut?*
What thinks the Mom that Andy does?
'What does Mom think that Andy is doing?'

Perner et al. (2003) found that even when the test sentences were matched for syntax, children were more adult-like in interpreting sentences with *want* than

with *think*. Again, this is problematic for de Villiers' claim that representing, or reasoning about the concept of belief requires understanding the syntax of tensed clausal complementation. If this were the case, we would expect individual children in this study to either be good at both types of sentences with clausal complements *and* be adult-like in representing beliefs, or fail on all three. This hypothesis suggests that for children learning languages like German, interpreting sentences with *want* with a finite complement and conflicting desires should be just as hard.

Additionally, there is independent evidence from English suggesting that it is not a specific difficulty with embedding a finite complement. Several recent studies show that children as young as 3 are adult-like in interpreting sentences with finite complements in certain conditions. Dudley et al (2014) demonstrates that some 3-year-olds are sensitive to matrix negation in sentences with *think* and *know* by testing embedded and matrix negation. Because *know* is a factive verb, sentences with *know* presuppose the truth of the complement. Adults interpret the complement as true even when there is negation in the matrix clause (25)-(26). *Think*, on the other hand is non-factive: the complement is not presupposed to be true (27)-(28).

(43) *Lambchop knows that the toy is in the red box.* (= red box)

(44) *Lambchop doesn't know that the toy is in the red box.* (= red box)

(45) *Lambchop thinks that the toy is in the red box.* (= red box?)

(46) *Lambchop doesn't think that the toy is in the red box.* (= blue box?)

Dudley et al. finds that some 3-year olds behave like adults, treating sentences like (26) and (28) differently, suggesting that they cannot be incapable of interpreting sentences with an embedded finite complement.

Other evidence that children's difficulty cannot stem from syntax alone comes from Lewis (2013). Lewis uses stories similar to the traditional change-of-location false belief tasks, but increases the salience of belief in the story by having two agents with conflicting beliefs about the object's location. Lewis shows that children's performance on sentences with *think* in false-belief contexts improves when the relevance of belief is made more salient in the story. This is not predicted by an account that says that it is the syntax that is ultimately driving children's errors. Lewis also manipulated the truth-value of *think*-sentences about a character's false beliefs, and found that 3-year-olds were able to correctly reject false *think*-sentences.

This evidence suggests that it is probably not syntactic development that causes children to develop the representational capacity to interpret false belief reports. A more recent proposal by de Villiers and de Villiers (2009) focuses on semantic representations. They have claimed that the critical feature of false complementation must be a semantic 'point of view' feature; marking how different perspectives on a proposition are represented.

There is, largely due to de Villiers' original proposal, still a large body of evidence pointing toward a relation between language development, in particular syntactic development, and performance on explicit belief-representation tasks. In experiments 5 and 6 of this dissertation, we have

demonstrated that children are sensitive to syntactic complement when interpreting potentially unknown attitude verbs. This demonstrates that although syntax may not be related to attitude verb acquisition in the exact way that de Villiers initially proposed, syntactic knowledge does play a role in acquisition of these verbs.

5.1.2.2.2.2 Pragmatics

The pragmatic hypothesis is another deployment hypothesis. According to this account, children have no difficulty with the concept of belief, or the semantics of *think*, but children over-assume that the speaker meanings of *think* sentences are indirect assertions, and not merely belief reports. This account successfully accounts for difficulty with *think*, and is also compatible with the infant data. The pragmatic hypothesis may not be able to account for children's performance on explicit tasks that do not require interpretation of *think*-sentences.

Additionally, the pragmatic hypothesis has not specifically addressed the acquisition asymmetry between *think* and *want*. In the following sections, I will explain the details of the pragmatic account, and then speculate about how it may be extended to account for the observed asymmetry between *want* and *think.* Additionally, I will demonstrate that the pragmatic hypothesis may be combined with the syntactic bootstrapping account of attitude verb acquisition that we have presented here. This , to show that syntactic distribution is at least one of the factors cuing children in in to these pragmatic properties which account for the asymmetry. In this section, we have seen that the pragmatic properties are

different for the verb *want*; therefore it is a reasonable assumption that the same difficulty with *think* will not occur with *want*.

The 6 experiments in this dissertation address questions left open in the literature, which address specific predictions made by deployment accounts for interpretation of *think* sentences. Experiments 1-4 will address differences in task demands that may have contributed to the observed asymmetry between acquisition of *think* and *want*, and show that even under the most stringent comparison, children are adult-like in interpreting sentences with *want* before *think.* Experiments 5-6 further explore the role of linguistic features in the acquisition trajectories of *think* and *want*. We demonstrate that children are sensitive to syntactic distribution in interpreting attitude verbs, and propose that children use the syntactic features to access information about semantic properties and pragmatic uses; and that differential pragmatic uses for *think* and *want* are ultimately driving the asymmetry.

5.2 Future Directions

The first way in which we would like to follow up on this work is to probe more carefully to determine whether the priming effects observed in experiment 6 are caused by a real syntactic priming effect, or whether there were interfering factors related to the design of the study that may have been driving these results. In particular, there is some worry that the priming results are not to be trusted, given children's poor performance on the *want/think* control items. We suggested

the possibility that poor performance on these items indicates that the task is simply too overwhelming, or designed in such a way that biases children toward continuing to get the same type of interpretation over and over (perhaps based on so many items of the same type at the beginning). In that case, the priming effects that we observed may not be indicative of any real syntactic priming, but simply an artifact of the design of the task and the cognitive capacities of 4-year-olds. It is also possible, however, that the observed priming effect really is an effect of the syntax, and that poor performance on the *want/think* controls is due to external factors, which do not effect the *hope* items in the second block. Because these sentences are interspersed, processing them may require more inhibitory control that the *hope* items, given that they require children to switch back and forth between multiple different interpretation types in a very short period of time. Another possibility is that the poor performance on the *want/think* controls is due to too few of these items. Even if children are able to switch between multiple interpretation types over the course of the experiment, it is possible that they need a few items to "warm up" to this. Perhaps given more *want/think* controls, they would have shown their competence.

We have thought of several follow-up studies that could shed light on this question. The first is to test the interpretation of the verbs *want* and *think* within subjects. We know from experiment 4, as well as many other studies, that children's interpretations of sentences with these verbs are very robust at age 4. This manipulation will allow us to see how much priming effects observed in experiment 6 may have been due to task effects. In other words, if we see

"priming" in testing *want* and *think* within subjects as well, we can assume that priming is due to the design of the task, and not the syntax in the first blocks of experiment 6. Another way to tease apart the role of the task in the priming effects observed in experiment 6 would be to pair blocks of *want/think* items with blocks of *hope* items in the second half (figure 5-1).

TABLE 5-1: Future Directions Conditions

Condition	**First Block**	**Second Block**
Condition 1 (control)	*Want*	*Hope-to*
Condition 2 (test)	*Want*	*Hope-that*
Condition 3 (test)	*Think*	*Hope-to*
Condition 4 (control)	*Think*	*Hope-that*

In one critical condition (condition 2), children would hear sentences with *want* in the first block, and sentences with *hope-that* in the second block. This will show us how much of the desire interpretation in the *hope-that* items in the second block of experiment 6 was caused by an "interpretation bias" due to the overwhelming majority desire responses in the first half, and how much of the desire interpretation was actually caused by children making a hypothesis for *hope*'s meaning based on the syntax of the *hope-to* sentences in the first half. In the second critical condition (condition 3), children would hear sentences with *think* in the first block, and sentences with *hope-to* in the second block. This will show us how much of the reality interpretation in the *hope-to* items in the second block of experiment 6 was caused by an "interpretation bias" due to reality responses in the first half, and how much of the reality interpretation was actually caused by children making a hypothesis for *hope*'s meaning based on the syntax of the *hope-that* sentences in the first half. A third way that we could attempt to

better understand the nature of the priming effects observed is to test children's interpretation of sentences with *hope* in both syntactic frames, but instead of manipulating the sentences such that they were arranged into blocks by frame, sentences of both syntactic frames would be interspersed throughout the experiment. This will be informative about how children respond when they are immediately confronted with conflicting information. Is there a default semantic assumption when it is evident that a verb occurs in both syntactic frames? The preliminary results suggest that perhaps a verb occurring in the *hope-to* frame is a strong cue for children; and that children have an easier time allowing a finite complement with desire semantics. If this pattern holds up, we expect that in an interspersed experiment, even given immediate evidence that both complement types are allowed, children may be more likely to assign a desire meaning to *hope*.

A second follow-up direction that we would like to pursue would further investigate how the syntactic input is driving learning. Experiment 6 leaves an open question as to *how much* and *what kind* of exposure to a new verb in a given syntactic frame is necessary for children to build a semantic representation linked to that frame, and then how flexible is that representation at different stages of acquisition. In experiment 6, children always got 16 items in the first frame, and then we looked at the effect that that exposure had on their performance on the other frame. We saw that this amount of exposure to frame only (without any contextual content that could lead children to hypothesize semantic subclass) is enough for children to build some kind of semantic representation such that we

see priming effects. But it is unclear based on this study alone how much exposure is necessary, and what the role of contextual information is, or what the role of the input occurring in a lab setting might be. In a future task which we are currently in stages of designing, we plan to explore some of these questions looking at the role of "real world" input to better understand what the child's hypothesis-building mechanism looks like. In this task, children will be exposed to input with *hope* in the form of a children's book about a young boy's birthday surprise. The book includes 20 naturalistic uses of *hope*, each of which can occur with either a finite or a non-finite complement. Children will have the opportunity to read the book at home, a minimum of 5 times over the course of one week. After their exposure at home, they will come in to the lab and participate in the task presented in experiment 5, in which we gauge their interpretation of sentences with *hope* either with a finite or a non-finite complement. We will also collect information about how often they were exposed to the book over the course of the week. The book will have two versions: one in which all of the *hope* sentences occur with a finite complement, and a second in which all the *hope* sentences occur with a non-finite complement. Children will be assigned to four groups (table 5-2).

TABLE 5-2: Priming Study Conditions

Condition	**Input Frame**	**Lab Frame**	**Congruency**
Condition 1	*Hope-to*	*Hope-to*	Congruent
Condition 2	*Hope-to*	*Hope-that*	Incongruent
Condition 3	*Hope-that*	*Hope-to*	Incongruent
Condition 4	*Hope-that*	*Hope-that*	Congruent

This experiment will allow us to follow-up on several interesting aspects of experiment 6. The first is how the priming effects that we saw in experiment 6 translate to real-world exposure to an attitude verb. In this study, the input that children are getting for sentences with *hope* is much closer to real world input for several reasons. The input that children were exposed to in experiment 6 was specifically designed to be completely context-neutral with respect to a belief v. a desire interpretation—the only cue the children had was the syntactic frame. In this priming study, children will hear sentences with *hope* in the context of a story. This priming study allows us to explore the role of context or discourse information in building a hypothesis. Future versions may directly explore the role of different learning cues—syntax, context, etc.—by specifically manipulating these features.

This priming study will allow us to see whether the pattern observed in experiment 6 carries over to real world input. If we replicate the findings in experiment 6, we expect to see children in conditions 1 and 2 should come into the lab with the hypothesis that *hope* is a desire verb. Because this hypothesis will be very strong, given the syntax that they were exposed to, we expect that even the children in the incongruent condition (condition 2) should override the syntax in the lab and continue to give sentences with *hope* a desire interpretation. Participants in conditions 3 and 4 should come into the lab with the hypothesis that *hope* is a representational attitude verb. We expect that in the congruent condition (condition 4), children will continue to assign *hope* a representational semantics, and make reality errors like they do with *think*. The children in

condition 3, however, might show a different pattern. Because these children have only been exposed to *hope* with a finite complement, and results from experiment 6 suggest that *hope-to* is more informative, the children in this condition might be more likely to revise their hypothesis, or at least be more conflicted when they hear *hope* with a non-finite complement in the lab. Of course, we might see other patterns, too, given that the nature of this input is different from that in experiment 6.

Another avenue that this priming experiment will allow us to explore is a question of *how much* input is necessary to create a hypothesis. Because children in our sample will have different amounts of exposure (depending on how much they read the book), we can ask whether this makes a difference to how strong their hypothesis for *hope*'s meaning is (i.e., how hard is it to override the hypothesis), and if this differs based on the kind of exposure that they got at home. This priming study will allow us to follow up on several interesting aspects of our findings in experiments 5 and 6; in particular, this experiment will give us a better idea of how results in experiment 6 translate to the type of input for attitude verbs that children are likely to encounter.

A third direction in which we would like to follow up on this work aims to explore the asymmetry between the priming effects in each of the conditions in experiment 6. We discussed several different hypotheses for why the priming effects may have been stronger for *hope-to* than for *hope-that.* One possibility is related to the input that children get for *hope. Hope-to* may be more surprising to children because that they hear it so much less often in this frame, and this fact

may be driving the stronger priming effects for this condition. It is also possible that this difference is actually reflecting a much deeper theoretical difference, and this behavior observed in children is informative about the syntax-semantics interface. Maybe representational attitude semantics is the default assumption for attitude verbs, and then certain frames (non-finite complements in English, for example), trigger very strongly a desire interpretation. One piece of evidence that will speak to what is driving this asymmetry is the results of the priming study described above. If the results of experiment 6 are input driven, then we expect this to disappear once we have exposed children to a large amount of input with *hope*. We are essentially manipulating the input that a sample of children get for *hope*, which means we could expect that any small amount of "real world" input that they have gotten before participating in the study will no longer be as relevant. If, however, we see the same pattern in the priming study as observed in experiment 6, this is evidence that there is truly something more informative to children about the non-finite complement cases, reflecting something greater than just the small amount of input that they have gotten before coming into the lab.

Another way to follow up on this question would be to look cross-linguistically. In the first chapter of this dissertation, I cited a hypothesis (Hacquard 2014, a.o.) which proposed that the specific syntactic cue to children as to whether a verb is preferential or representational is whether the verb can embedded clauses with main clause features in that language. In English, the way this manifests is through finiteness. For example, *think,* embeds finite complements, which could be main clauses on their own; while *want*, can only

embed non-finite complements, which are not the correct form to be sentences on their own (137)-(138).

(72) *John thinks [Mary is home]*.

Mary is home.

(73) *John wants [Mary to be home]*.

#Mary to be home.

As discussed in the first chapter, this manifests differently in different languages. For example, in romance languages, the distinction seems to be subjunctive v. indicative in the complement. But the critical feature that children may look for is whether or not the verb embeds clauses that take the form of main clauses or not. The observed differences between the priming effects in experiment 6 may shed some light on how exactly this works. If this priming difference is caused by a deep syntax-semantics interface connection, we might expect to see that finite complements (or any language's main clause syntax equivalent) is compatible with desire verbs, but that non-main clause syntax is less compatible cross-linguistically with representational attitudes. This would explain why children find it easier to override the *hope-that* syntax in the second block with a desire interpretation, but more conflicted about overriding the *hope-to* syntax in the second half with a reality interpretation. Looking at the distribution and children's assumptions cross-linguistically may speak to this.

Another way to get at whether this effect reflects something deeper about the syntax-semantics interface is to use a novel verb. We could run the exact same

study as experiment 6, except instead of sentences with *hope*, participants would hear sentences with a novel verb (139)-(140).

(74) *Froggy blicks to get a heart!*

(75) *Froggy blicks that it's a heart!*

If the difference in priming effects in experiment 6 is input driven, then we would expect to see equal priming across both condition, as there is no previous exposure to draw from in the case of a novel verb. If we see the same pattern emerge, however, this suggests that this pattern is driven by something deeper.

5.3 Conclusion

This dissertation has explored children's understanding of sentences with attitude verbs. In particular, we have looked at the role that syntax plays in children's early ability to categorize representational and non-representational attitude verbs. This dissertation had addressed 2 specific topics related to attitude verb acquisition. The first investigates as claim that had been made in the literature: that children acquire the verb *want* sooner than the verb *think*. In chapter 2, I gave an overview of the evidence that has been cited supporting the *think-want* asymmetry. I pointed out ways in which the tests of *think* and *want* have not made a fair comparison, due to several task demands that are often present in tests of *think*, but not *want*. In chapter 4, I present 4 studies addressing each of these concerns, and better comparing children's understanding of sentences with *think* and *want.* One of the task demands that had not previously been controlled for was whether or not the mental state in question conflicted with

reality. Previously, many tests of *want* allowed a future-oriented interpretation of the desire, thus did not set up a direct conflict between a mental state and reality. Tests of *think* on the other hand, often use a false belief task, and do set up a conflict with reality. In experiment 1, I showed that even when a present-oriented reading is forced for *want*-sentences and there is a conflict with reality, 3-year-olds are still adult-like in interpreting these sentences. A second task demand that had not been controlled for in previous comparisons of *think* and *want* was a conflict with the participant's own mental state. In the traditional false belief task used to test children's understanding of *think*, a character has a false belief that conflicts not only with reality, but also with the participant's own beliefs, due to the fact that beliefs are automatically generated. Desires, on the other hand, are not generated automatically. So even when a desire conflicts with reality, there is not necessarily a conflict with the participant's own desires. Experiments 2 and 3 address this difference, by setting up situations in which a puppet has a desire that conflicts with the participant's desires in a game setting. We find that 3-year-olds are adult-like in interpreting sentences about the puppet's conflicting desires. Experiments 1-3 showed that even when testing *want* sentences under the strictest conditions, and attempting to control for differences in the way that *think* and *want* have been tested in the past, 3-year-olds are adult-like in interpreting sentences with *want*. This is much sooner than they have been reliably shown to interpret sentences with *think* involving conflicts. A final experiment comparing *think* and *want* attempted to control for any other possible methodological differences between previous tests of the two verbs. In experiment 4, we set up a

context in which a puppet had both beliefs and desires, and then measured 4-year-old's interpretation of sentences with *think* and *want.* We find, like previous studies, that children are adult-like in their interpretation of sentences with *want*, but are influenced by reality when interpreting sentences with *think.* Experiments 1-4 in chapter 3 show that even given a more stringent comparison of *think* and *want,* children are still adult-like in interpreting *want* sooner than they are in interpreting *think.*

The second topic that this dissertation addresses is the role of syntax in the interpretation and acquisition of attitude verbs. We ask whether or not children are sensitive to syntactic frame in interpreting and learning a less commonly used attitude verb: *hope.* We observe a correlation between semantic class and syntactic features: representational attitude verbs embed clauses that with main clause features (in English, finite complements); non-representational attitude verbs embed clauses without main clause features (in English, non-finite complements). Children hear the verb *hope* much less often than other attitude verbs, thus are most likely less secure in its semantic representation by age 4 than that of more common attitude verbs such as *think* and *want. Hope* shares meaning features with both classes, and can also occur in both types of syntactic frames. These features make *hope* an ideal test case for a syntactic bootstrapping hypothesis. In chapter 4, I present 2 studies looking at the interpretation of *hope.* In experiment 5, we use the same task as in experiment 4, in which a puppet has both a belief and a desire. In this case, however, instead of manipulating the verb that children hear in the test sentences, all children heard the verb *hope*, some

with a non-finite complement and others with a finite complement. We find that children are sensitive to the syntactic frame when interpreting sentences with *hope:* when children hear *hope* with a non-finite complement, they assign a desire meaning; when children hear *hope* with a finite complement, they are influenced by reality, in the same way that they are when they interpret *think*. This shows us that children are using the syntactic frame in interpreting unknown attitude verbs, and may be using this as a mechanism for categorizing attitude verbs as either representational or non-representational. In experiment 6, we gave children sentences with *hope* with both finite and non-finite complements in two blocks. We looked at whether performance on the second block looked the same or different from the pattern observed when children only heard that frame in isolation. We found that when children hear sentences with a non-finite complement, they are primed in the second half of the experiment. Even when they hear finite complements in the second block, they continue to get a desire interpretation. Hearing *hope* with a finite complement does not seem to be counter-evidence to their desire hypothesis, or if it does, the desire hypothesis was strong enough that overriding this hypothesis is difficult. In the other order we see a much weaker priming effect. When children hear *hope* with a finite complement first, they get a reality interpretation. But then, when the frame switches and they hear *hope* with a non-finite complement in the second half, they are much more conflicted about integrating finite complement information into their semantic representation.

In this dissertation, we have answered two questions looming in the literature. The first is about whether there is actually an asymmetry in acquisition of *think* and *want* such that *want* is acquired before *think*. We show that even under the most stringent comparison, children are still adult-like in interpreting *want* sooner than *think*. The second question answered by this dissertation addresses the role of syntax in learning attitude verbs. We have shown that children are sensitive to syntactic frame when interpreting an unknown attitude verb, assigning a verb a desire meaning when it takes a non-finite complement and making reality-errors when it takes a finite complement. We have shown that they are able to use this syntactic information to update their semantic representation for a new verb. We have also argued that the results of these studies are compatible with a pragmatic deficit hypothesis (Lewis 2013), which says that children's errors in interpreting *think* sentences are due to their over-use of a pragmatically-enriched *think* used to make indirect assertions. We have shown the same reality-errors when children interpret sentences with *hope* with a finite complement. This suggests that one of the factors driving these reality errors is the syntactic cue of finiteness, or perhaps more abstractly, with main clause features in the embedded clause of a verb. The work presented here helps us better understand the factors involved in children's acquisition of attitude verbs, specifically showing that syntactic distribution is an important cue for children's categorization of attitude verbs into representational and non-representational subclasses.

Chapter 6: References

Anand, P. & Hacquard, V. (2013). Epistemics and attitudes. *Semantics and Pragmatics* 6(8), 1-59.

Apperly, I.A. & Butterfill, S.A., (2009). Do humans have two systems to track beliefs and belief-like states? Psychological Review.116(4), 953-970

Baillargeon, R., Scott, R. M., & He, Z. (2010). False-belief understanding in infants. Trends in Cognitive Sciences, 14, 110–118.

Baldwin, D. A. (1991). Infants' contribution to the achievement of joint reference. Child Development, 62(5), 875–890.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a 'theory of mind'? *Cognition, 21,* 37-46.

Bartsch, K. & Wellman, H.M. (1995). Children talk about the mind. New York: Oxford University Press.

Bickerton, D. (1981). The roots of language. Ann Arbor, MI: Karoma.

Bloom, P. (2000). How children learn the meanings of words. Cambridge, MA: MIT Press.

Bolinger, D. (1968). *Aspects of language.* New York: Harcourt, Brace, and World.

Butterfill, S. & Apperly I.A. (2013). How to construct a minimal theory of mind. Mind and Language*28(2)* 606-637

Carey, S. (2009) The Origin of Concepts. New York: Oxford University Press.

Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan, & G. A. Miller (Eds.), *Linguistic theory and psychological reality* (pp. 264–293). Cambridge, MA: MIT Press.

Clements, W. A., & Perner, J. (1994). Implicit understanding of belief. Cognitive Development, 9, 377–395.

Crain, S., & Thornton, R. (1998). Investigations in universal grammar: A guide to experiments on the acquisition of syntax and semantics. Cambridge: MIT Press.

Crain, S., & McKee, C. (1985). The acquisition of structural restrictions on anaphora. In *Proceedings of NELS* (vol. 16, pp. 94–111). Amherst, MA: GLSA Publications, University of Massachusetts.

Dayal, V., & Grimshaw. J. (2009). Subordination at the interface: A quasi-subordination hypothesis. Ms., Rutgers.

de Villiers, J. G. (1995). Questioning minds and answering machines. In D. MacLaughlin, & S. McEwen (Eds.), *Proceedings of the 19th Boston University Conference on Language Development* (pp. 20-36). Somerville, MA: Cascadilla Press.

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

de Villiers, J. (2007). The interface of language and theory of mind. *Lingua , 117,* 1858-1878.

de Villiers, J.G. & de Villiers, P.A. (2000) Linguistic determinism and false belief. In P. Mitchell & K. Riggs (eds) *Children's Reasoning and the Mind*. Hove, U.K.: Psychology Press.

de Villiers, J.G. & Pyers, J. (2002) Complements to Cognition: A longitudinal study of the relationship between complex syntax and false-belief-understanding. Cognitive Development. *Cognitive Development , 17*, 1037-1060.

de Villiers, P.A., Burns, F., & Pearson, B. Z. (2003). The role of language in the theory of mind development of language impaired children: Complementing theories. In B. Beachley, A. Brown, & F. Conlin (Eds.) *Proceedings of the 27th Boston University Conference on Child Development* (pp. 232-242). Cambridge, MA: Cascadilla Press.

Devine R. T., Hughes C. (2014). Relations between false belief understanding and executive function in early childhood: a meta-analysis. *Child Dev*. [Epub ahead of print]

Dudley, R., Orita, N., Moyer, M., Hacquard, V., & Lidz, J. (2013). Three year olds' understanding of 'know' and 'think'. Talk at the 49th annual meeting of the Chicago Linguistics Society.

Dudley, R., Orita, N., Hacquard, V. & Lidz, J. (2015). In Florian Schwarz (ed.) *Experimental Perspective on Presuppositions*. Studies in Theoretical Psycholinguistics Series. Springer.

Eimas, P . D., & Miller, J. L. (1990). Infant catego- ries and categorization. In C. M. Edelman, W. E. Gall, & W. M. Cowan (Eds.), Signal *and sense: Local and global order in perceptual maps.* New York: Wiley-Liss.

Farkas, D. (1985). Intensional Descriptions and the Romance Subjunctive Mood. New York: Garland.

Fisher, C., Gleitman, H., & Gleitman, L. R. (1991). On the semantic content of subcategorization frames. *Cognitive Psychology , 23,* 331-392.

Fisher, C., Gertner, Y., Scott, R. M., & Yuan, S. (2010). Syntactic bootstrapping. Wiley Interdisciplinary Reviews: Cognitive Science, 1, 143–149.

Fisher, C., Klingler, S. L., & Song, H. (2006). What does syntax say about space? 26-month-olds use sentence structure in learning spatial terms. Cognition, 101, B19– B29.

Fiske et al. (2014)

Flavell. (1988). The development of children's knowledge about the mind: From cognitive connections to mental representations. In J.W. Astington, P.L. Harris & D.R. Olson (eds.), *Developing theories of mind* (pp. 244-267). Cambridge, England: Cambridge University Press

Forguson, L., & Gopnik, A. (1988). The ontogeny of common sense. In J.W. Astington, P.L. Harris & D.R. Olson (eds.), *Developing theories of mind* (pp. 226-243). Cambridge, England: Cambridge University Press

German, T. P., & Leslie, A. M. (2000). Attending to and learning about mental states. *Children's reasoning and the mind*, 229-252.

Giannakidou, A. (1997). The landscape of polarity items. PhD. thesis, University of Groeningen, The Netherlands.

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

Grice, H. P. (1975). Logic and Conversation. In P. Cole, & J. L. Morgan (Eds.), Syntax and semantics 3: Speech arts (pp. 41-58). New York: Academic Press.

Guajardo, J. J., & Woodward, A. L. (2004). Is agency skin-deep? Surface attributes influence infants' sensitivity to goal-directed action, *Infancy, 6*, 361-384.

Hacquard, V. (2014, October). Bootstrapping attitudes. In *Semantics and Linguistic Theory* (Vol. 24, pp. 330-352).

Hacquard, V. & Lidz, J. (2012). Attitude Problems. Rutgers Colloquium, April 26, 2013.

Hadwin, J., & Perner, J. (1991). Pleased and surprised: Children's cognitive theory of emotion. *British Journal of Developmental Psychology, 9,* 215-234.

Hale, C. M., & Tager-Flusberg, H. (2003). The influence of language on theory of mind: a training study. *Developmental Science, 6,* 346-359.

Heyes, C. 2014: False belief in infancy: a fresh look. *Developmental Science*

Heim, I. (1992). Presupposition Projection and the Semantics of Attitude Verbs. *JOS 9,* 183–221.

Hintikka, J. (1971). Semantics for Propositional Attitudes. In L. Linsky (Ed.), *Reference and Modality* (pp. 145-167). London: Oxford University Press.

Hooper, J. B. (1975). On assertive predicates. In J. P. Kimball (Ed.), *Syntax and Semantics* (Vol. 4, pp. 91-124). New York: Academic Press.

Johnson, C. N., & Maratsos, M. P. (1977). Early comprehension of mental verbs: Think and know. Child Development, 48, 1743-1747.

Katsos, N., & Bishop, D. V. (2011). Pragmatic tolerance: Implications for the acquisition of informativeness and implicature. Cognition, 120, 67-81.

Kovács, Á.M., Téglás, E. & Endress, A.D. (2010). The social sense: susceptibly to others' beliefs in human infants and adults. *Science*, *330*, 1830-1834.

Landau, Barbara and Leila Gleitman. 1985. *Language and Experience. Evidence from the blind child.* Cambridge, MA: Harvard University Press.

Leslie, A. M., German, T. P., & Polizzi, P. (2005). Belief-desire reasoning as a process of selection. *Cognitive Psychology*, *50*(1), 45-85.

Leslie, A. M., & Polizzi, P. (1998). Inhibitory processing in the false-belief task: Two conjectures. Developmental Science, 1, 247–254.

Leslie, A. M., & Roth, D. (1993). What autism teaches us about metarepresentation. In S. Baron-Cohen, H. Tager-Flusberg, & D. Cohen (Eds.), Understanding other minds: Perspectives from autism (pp. 83–111). Oxford: Oxford University Press.

Leslie, A. M., & Thaiss, L. (1992). Domain specificity in conceptual development: Neuropsychological evidence from autism. Cognition, 43, 225–251.

Lewis, S. (2013). Pragmatic enrichment in language processing and development. PhD. Thesis, University of Maryland, College Park.

Lewis, S. Harrigan, K. & Lidz, J. (in prep.) *3-year-olds compute relevance inferences in indirect requests.*

Lidz, J., H. Gleitman and L. Gleitman. (2003). Understanding How Input Matters: The Footprint of Universal Grammar on Verb Learning. *Cognition* 87:151-178.

Lidz, J. White, A. S., & Baier, R. (under review). The role of incremental parsing in syntactically conditioned word learning.

Lichtermann, L. (1991) *Young children's understanding of desires. Third year project report*, unpublished manuscript. As cited by Rakoczy et al., 2007.

MacWhinney, B. (2000). *The CHILDES Project: Tools for Analyzing Talk.* Mahwah, NJ: Lawrence Erlbaum Associates.

Meinunger, A. (2006). Interface restrictions on verb second. *Linguistic Review 23*, 127–160.

Morgan, G., Kegl, J. (2006) Nicaraguan Sign Language and theory of mind: The issue of critical periods and abilities. *Journal of Child Psychology and Psychiatry 47,* 811–819.

Moore, C., Jarrold, C., Russell, J., Lumb, A., Sapp, F., MacCallum, F. (1995). Conflicting desire and the chil's theory of mind. *Cognitive Development, 10*, 467-482.

Moore, C., & Corkum, V. (1994). Social understanding at the end of the first year of life. *Developmental Review*, *14*(4), 349-372.

Moyer, M., Harrigan, K., Hacquard, V. & Lidz, J. (2014, submitted) *Two-year-olds' Comprehension of Pronouns.* Submitted: BUCLD 39 Proceedings, Cascadilla Press.

Naigles, L. (2000). Manipulating the input: Studies in mental verb acquisition. In B. Landau, J. Sabini, J. Jonides, & E. L. Newport (Eds.), Perception, cognition, and language: Essays in honor of Henry and Lila Gleitman (pp. 245-274). Cambridge, MA: MIT Press.

Naigles, LR. Children use syntax to learn verb meanings. Journal of Child Language. 1990 Jun; 17(2):357-74.

Naigles 1996, The use of multiple frames in verb learning via syntactic bootstrapping. Cognition, 58, 221-251.

Naigles, LR., & Kako, E. (1993). First contact in verb acquisition: Defining a role for syntax. Child Dev. 1993 Dec;64(6):1665-87.

Naigles, LR, Swensen, LD. (2007). Syntactic supports for word learning. Pp 212-231 in Hoff, Erika and Marilyn Shatz, eds. The Handbook of Language Development. Blackwell: New York.

Onishi, K. H., & Baillargeon, R. (2005). Do 15-month-old infants understand false belief? *Science , 308,* 255-258.

Papafragou, A. (2006). From scalar semantics to implicature: Children's interpretation of aspectuals. Journal of Child Language, 33, 721-757.

Papafragou, A., & Musolino, J. (2003). Scalar implicatures: experiments at the semantics-pragmatics interface. Cognition, 86, 253-282.

Papafragou, A., & Skordos, D. (to appear). Scalar implicature. In J. Lidz, W. Snyder, & J. Pater (Eds.), The Oxford Handbook of Developmental Linguistics. Oxford: Oxford University Press.

Papafragou, A., & Tantalou, N. (2004). Children's computation of implicatures. Language Acquisition, 12, 71-82.

Perner, J. (1991). Understanding the representational mind. Cambridge, MA: MIT Press.

Perner, J. (1988). Developing semantics for theories of mind: From propositional attitudes to mental representation. In J. Astington, P Harris & D. Olson (Eds.), *Developing theories of mind* (pp. 141-172). Cambridge: Cambridge University Press.

Perner, J., & Ruffman, T. (2005). Infants' insight into the mind: How Deep? Science, 308, 214-216.

Perner, J., Sprung, M., Zauner, P., & Haider, H. (2003). 'Want that' is understood well before 'say that', 'think that', and false belief: a test of de Villiers's linguistic determinism on German-speaking children. *Child Development , 74,* 179-188.

Perner, J., Zauner, P., & Sprung, M. (2005).

Pinker, S. (1989). Learnability and congnition: The acquisition of argument structure. Cambridge, MA: MIT Press.

Plunkett, Kim. "Theories of early language acquisition." *Trends in cognitive sciences* 1.4 (1997): 146-153.

Portner, Paul 1992. *Situation theory and the semantics of propositional expressions*. PhD. thesis. UMass Amherst.

Pyers, J. and A. Senghas (2009). Language promotes false-belief understanding: Evidence from a new sign language. *Psychological Science, 20:7,* 805-812.

Rakoczy, H., Warneken, F., & Tomasello. M. (2007). 'This way!', 'No! That way!'—3 year olds know that two people can have mutually incompatible desires. *Cognitive Development, 22,* 47-68.

Rakoczy, Hannes. "Executive function and the development of belief–desire psychology." *Developmental Science* 13.4 (2010): 648-661.

Repacholi, B. M., & Gopnik, A. (1997). Early reasoning about desires: Evidence from 14- and 18-month-olds. *Developmental Psychology, 33(1)*, 12–21.

Ross, J. R. (1973). Slifting. In M. Gross, M. Halle, & M.-P. Schützenberger (Ed.), The formal analysis of natural languages. Proceedings of the First International Conference. (pp. 133-169). The Hague: Mouton.

Roth, D., & Leslie, A. M. (1998). Solving belief problems: Toward a task analysis. Cognition, 66, 1–31.

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

Quinn, P C , & Eimas, P.D. (1986), Pattern-line effects and units of processmg in infants, *tnfant Behavior & Development. 12,* 57-70.

Scheffler, T. (2008). *Semantic Operators in Different Dimensions*. PhD. Thesis, UPenn.

Shatz, M., Wellman, H. M., & Silber, S. (1983). The acquisition of mental verbs: A systematic investigation of the first reference to mental state. Cognition, 14, 301- 321.

Scott, R. M., & Fisher, C. (2009). 2-year-olds use distribu- tional cues to interpret transitivity-alternating verbs. Language and Cognitive Processes, 24, 777–803.

Searle, J. & Vanderveken, D. (1985). *Foundations of illocutionary logic.* Cambridge, England: Cambridge University.

Simons, Mandy. 2007. Observations on embedding verbs, evidentiality, and presupposition. *Lingua* 117(6), 1034-1056.

Skordos, D., & Papafragou, A. (2014). Lexical, syntactic, and semantic-geometric factors in the acquisition of motion predicates. *Developmental Psychology* 50: 1985-1998.

Smith, L. B., Jones, S. S., & Landau, B. (1996). Naming in young children: A dumb attentional mechanism?. *Cognition*, *60*(2), 143-171.

Snedeker, J., & Trueswell, J. C. (2004). The developing constraints on parsing decisions: The role of lexical-biases and referential scenes in child and adult sentence processing. *Cognitive psychology*, *49*(3), 238-299.

Soja, N. N., Carey, S., & Spelke, E. S. (1991). Ontological categories guide young children's inductions of word meaning: Object terms and substance terms. *Cognition*, *38*(2), 179-211.

Soja, N. N., Carey, S., & Spelke, E. S. (1992). Perception, ontology, and word meaning. *Cognition*, *45*(1), 101-107.

Southgate, V., Senju, A., & Csibra, G. (2007). Action anticipation through attribution of false belief by 2-year-olds. *Psychological Science, 18(7),* 587–592.

Spelke, E. S. (1998). Nativism, empiricism, and the origins of knowledge. *Infant Behavior and Development*, *21*(2), 181-200.

Spelke, E. S., Kestenbaum, R., Simons, D. J., & Wein, D. (1995). Spatiotemporal continuity, smoothness of motion and object identity in infancy. *British Journal of Developmental Psychology*, *13*(2), 113-142.

Stalnaker, R. (1984). *Inquiry*, Cambridge, MA: The MIT Press.

Steglich-Petersen, A., & Michael, J. (2015). Why desire reasoning is developmentally prior to belief reasoning.

Stein, N. L., & Levine, L. J. (1989). The causal organisation of emotional knowledge: A developmental study. *Cognition & Emotion*, *3*(4), 343-378.

Stowell, T. (2004). Tense and modals, in J. Guéron and J. Lecarme (eds.) *The syntax of time,* 495-537. Cambridge, Mass.: MIT Press.

Surian, L., Caldi, S., & Sperber, D. (2007). Attribution of beliefs by 13- month-old infants. *Psychological Science, 18(7),* 580–586.

Thoermer, C., Sodian, B., Vuori, M., Perst, H., & Kristen, S. (2012). Continuity from an implicit to an explicit understanding of false belief from infancy to preschool age. *British Journal of Developmental Psychology*, *30*(1), 172-187.

Truckenbrodt, H. (2006). On the semantic motivation of syntactic verb movement to C in German. *Theoretical Linguistics* 32:257-306.

Villalta, E. (2000). 'Spanish subjunctive clauses require ordered alternatives', in *Proceeding of SALT X*.

Villalta, E. (2008). Mood and gradability: an investigation of the subjunctive mood in Spanish. *Linguistic and Philosophy 31*. 467–522.

Wellman, H. M., & Banerjee, M. (1991). Mind and emotion: Children's understanding of the emotional consequences of beliefs and desires. *British Journal of Developmental Psychology,* 9, 191-124.

Wellman, H. M., & Bartsch, K. (1988). Young children's reasoning about beliefs. *Cognition,* 30, 239-277.

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: the truth about false belief. *Child Development , 72,* 655-684.

Wellman, H. & Woolley, J. (1990). From simple desires to ordinary beliefs: The early development of everyday psychology. *Cognition, 35,* 245-275.

White, Aaron Steven, Valentine Hacquard, and Jeffrey Lidz. *In progress*. Main clause syntax and the belief-desire distinction. UMD.

White, A. S., Dudley, R., Hacquard, V., & Lidz, J. (2012). Discovering classes of attitude verbs using subcategorization frame distributions. Talk at the 43rd annual meeting of the North East Linguistic Society. CUNY.

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

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition, 69,* 1-34.

Woodward, A. L. (1999). Infants' ability to distinguish between purposeful and non-purposeful behaviors, *Infant Behavior and Development, 22,* 145-160.

Woodward, A. L. (2003). Infants' developing understanding of the link between looker and object. *Developmental Science, 6:3*, 297-311.

Xu, F., & Carey, S. (1996). Infants' metaphysics: The case of numerical identity. *Cognitive psychology*, *30*(2), 111-153.

Yuan, S., & Fisher, C. (2009). ''Really? She blicked the baby?'': Two-year-olds learn combinatorial facts about verbs by listening. Psychological Science, 20, 619–626.

Yuill, N. (1984). Young children's coordination of motive and outcome in judgements of satisfaction and morality. *British Journal of Developmental Psychology*, *2*(1), 73-81.