SOURCE AND GOAL ASYMMETRY IN NON-LINGUISTIC MOTION EVENT REPRESENTATIONS

by

Laura M. Lakusta

A dissertation submitted to The Johns Hopkins University in conformity with the requirements for the degree of Doctor of Philosophy

Baltimore, Maryland

July 1st, 2005

© Laura M. Lakusta 2005

All rights reserved
ABSTRACT

In language there is a bias to represent Goals (end points) over Sources (starting points). The current studies explored whether this bias originates in non-linguistic Motion event representations. Study 1 explored whether and how 12-month-old infants encode Goals and Sources in Motion events. In Experiment 1, infants were familiarized to a toy duck moving to one of two Goal objects. During test, infants looked longer when the duck moved to a Different Goal rather than to a Different Location, suggesting that infants encoded the Goal. In Experiments 2 and 3 the objects were Sources rather than Goals. Infants did not show evidence for encoding the Source (Experiment 2), unless the Source was salient (Experiment 3). In Experiment 4, infants were familiarized to a toy duck moving from one of two (salient) Source objects to one of two (ordinary) Goal objects. During test, infants encoded the Goal in preference to the Source, suggesting a non-linguistic Goal bias.

Study 2 further explored a non-linguistic Goal bias. Adults and four-year-old children were shown pairs of Motion events in which the second event changed Source, Goal, Figure, or Motion or had no change at all. After viewing the second event, participants judged whether the events were the same or different. In Experiments 5a/5b, Goal changes were correctly detected more often than Source changes, suggesting a non-linguistic Goal bias. However, this bias became weaker when the actor gazed at the Source rather than at the Goal while moving (Experiments 6a/6b) and when the events contained only inanimate objects (Experiments 7a/7b), suggesting that intentionality plays a key role in the representation of events, and the importance of Goals.
CANDIDATE:
Laura M. Lakusta

READERS:
Barbara Landau
Howard Egeth
Stewart Hendry
Sharon Kingsland
Anna Papafragou
ACKNOWLEDGEMENTS

Since I don’t know where to begin, I will start at the very beginning. I thank my undergraduate advisor, Gerald McRoberts, for introducing me to language acquisition research and teaching me how to run an infant laboratory. Jerry you were an outstanding mentor and certainly played a large part in my decision to go to graduate school. I am also grateful for another Lehigh professor, Martin Richter, who taught me not only how to do statistics, but also how to like statistics. Dr. Richter you are a professor that I respect greatly and I hope to portray many of your qualities when I am a professor.

Next, thanks to my first graduate advisor, Rebecca Gomez. Although I only worked with Rebecca for one year, I learned a tremendous amount from her. Rebecca demonstrates a genuine interest and concern for her graduate students that makes her an exceptional advisor. As Rebecca was leaving Hopkins, times became a bit rocky. I am very grateful for Paul Smolensky and Geraldine Legendre ‘taking me under their wing’ and helping make it possible for me to continue my graduate training at Hopkins, not only as a Psychology student, but also as a Cognitive Science student. My training in Cognitive Science introduced me to a way of thinking about issues that I never knew existed. Whatever success I may encounter in the future, I owe a large part of it to my Cognitive Science training - it filled a gap that needed to be filled.

The next person in my ‘academic timeline’ of people to thank is my advisor, Barbara Landau. But, the problem is that words cannot even begin to express my gratitude. Barbara, you are everything I hope to be as an advisor, a teacher, a mentor, and a friend – I admire you greatly. It would be impossible to measure how much you have
taught me over these past four years; not only have you taught me about issues in the field, but you have taught me how to listen to, how to think about, how to express, and most important, how to formulate ideas. Your enthusiasm has been incredible, and I hope you know how much of an impact that enthusiasm has had on my motivation and desire to do research. Barbara, I can go on and on about your outstanding qualities, but, for now, I think I will just leave it at thank you – thank you for making the past four years of my life so enjoyable and fruitful, you will always be a respected mentor and friend.

I am very grateful for the entire Landau Lab and I cannot even begin to describe how much I have enjoyed lab meetings, and how much they will be missed. I am especially grateful for Gitana Chunyo, whose unbelievable assistance, support, and friendship are greatly appreciated. And thanks to Kirsten O’Hearn, who helped create the Landau Baby Lab and who helped me understand the ‘non-language’ side of infant research. Thank you Kirsten for being the sweet person that you are, I am thankful that we had the opportunity to become friends. Finally, thank you Danny Dilks for being you. You have become one of my best friends over the past four years. You have no idea how much I have learned from you and how much I value our friendship. I cannot imagine what the past four years would have been like without you, and I have no doubt that you will remain one of my closest friends and colleagues in the future.

I am grateful for all my Long Island, Lehigh, and Hopkins friends. My LI friends Valerie, Sarah, Jaclyn, and Erin have been there for me since junior high school and our fun nights out have kept me from becoming overwhelmed with ‘graduate school stress’. At Hopkins, thank you Rosalinda, Courtney, JP, and Allison for being amazing research assistants. Thank you Isabelle Barriere for demonstrating how to be such a good teacher.
Thank you to my officemates, Uyen, Becca, Becky, and Danny, for listening to me complain. I am especially grateful for Christina Castelino, John Serences, Jared Medina, Adam Buchwald, and Tamara Nicol. We’ve had many fun times together that I will never forget; you are wonderful friends. I am also grateful for the rest of my classmates in Psychology and Cognitive Science - I am thankful for knowing each one of you.

Thank you to all the people who were ‘actors’ in the movie stimuli used in Study 2, and thank you to all the infants, children, and adults who participated in these studies. Without you, this research would not have been possible. And thanks to Laura Wagner, a collaborator on these infant studies from the very beginning. Laura, your insight has been incredible, and I look forward to many more collaborations in the future.

Before thanking my committee, there are three special people I would like to thank. Brian, thank you for everything. Thank you for always being there for me, for helping me keep going when things get tough, for believing in me, for always succeeding in making me smile, and most important, for helping me ‘de-stress’ over incredibly delicious Friday night dinners. Thank you. Thank you. Thank you.

Thank you mom and dad. I really owe everything to you both. You both made me into the person I am today. Your constant love, guidance, and support made this accomplishment possible, and for this I will be forever thankful – this document is dedicated to you both.

Lastly, thanks to my dissertation committee, Barbara Landau, Howard Egeth, Amy Shelton, Anna Papafragou, Sharon Kingsland, and Stewart Hendry. Thank you for taking the time to read this thesis. I hope you enjoy reading it as much as I enjoyed writing it. It truly has been an extraordinary experience.
TABLE OF CONTENTS

Abstract ........................................................................................................... ii
Acknowledgements ............................................................................................ iv
Table of Contents ............................................................................................... vii
List of Tables ...................................................................................................... x
List of Figures .................................................................................................... xi
Chapter 1:  Introduction ...................................................................................... 1
  1.1 Overview .................................................................................................... 1
  1.2 Literature Review ....................................................................................... 4
    1.2.1 The Language/Space Interface: The Case of Motion Events ............... 4
    1.2.2 Broader Notions of Source and Goal ................................................ 12
    1.2.3 Learning Source and Goal Paths in Language ..................................... 16
    1.2.4 Sources and Goals in Non-Linguistic Cognition ................................. 19
    1.2.5 Goal/Source Asymmetry in the Language of Events ............................ 29
    1.2.6 Investigating a Non-Linguistic Goal/Source Asymmetry in Motion Events .......................................................................................................................... 45
    1.2.7 General Methodology ......................................................................... 47
Chapter 2:  Study 1: Goal/Source Asymmetry in Infants ...................................... 47
  2.1 General Methodology: Experiments 1-4 .................................................... 49
  2.2 Experiment 1: Goal Encoding at 12-months ............................................. 50
    2.2.1 Method: Experiment 1 ....................................................................... 50
    2.2.2 Results: Experiment 1 ....................................................................... 53
LIST OF TABLES

Table 3.1: Mean proportion (and SEs) of correctly named Source and Goal objects for the Source and Goal change trials that were correct
LIST OF FIGURES

Figure 1.1: Path types: TO, FROM, and VIA 6
Figure 1.2: The space/language interface 8
Figure 2.1: Schematic of the procedure for Experiment 1 (Goal experiment) 52
Figure 2.2: Experiment 1: Goal encoding at 12-months. Average looking time (and SEs) at the two different Trial Types 55
Figure 2.3: Schematic of the procedure for Experiment 1a (Control experiment) 58
Figure 2.4: Experiment 1a: Object encoding at 12-months. Average looking time (and SEs) at the two different Trial Types 61
Figure 2.5: Schematic of the procedure for Experiment 2 (Source experiment) 63
Figure 2.6: Experiment 2: Source encoding at 12-months. Average looking time (and SEs) at the two different Trial Types 66
Figure 2.7: Schematic of the procedure for Experiment 3 (‘Super’ Source experiment) 69
Figure 2.8: Experiment 3: ‘Super’ Source encoding at 12-months. Average looking time (and SEs) at the two different Trial Types 72
Figure 2.9: Schematic of the procedure for Experiment 4 (‘Super’ Source vs. Goal experiment) 76
Figure 2.10: Experiment 4: ‘Super’ Source vs. Goal encoding at 12-months. Average looking time (and SEs) at the two different Trial Types 79
Figure 3.1: Clip from one of the events used in Experiments 5a and 5b 84
Figure 3.2: Experiment 5a: Average proportion correct (and SEs) of Goal and Source change trials for adults

Figure 3.3: Experiment 5a: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 adults)

Figure 3.4: Experiment 5b: Average proportion correct (and SEs) of Goal and Source change trials for children

Figure 3.5: Experiment 5b: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 children)

Figure 3.6: Clip from one of the events used in Experiments 6a and 6b (‘Look Back’)

Figure 3.7: Experiment 6a, ‘Look Back’: Average proportion correct (and SEs) of Goal and Source change trials for adults

Figure 3.8: Experiment 6a, ‘Look Back’: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 adults)

Figure 3.9: Experiment 6b, ‘Look Back’: Average proportion correct (and SEs) of Goal and Source change trials for children

Figure 3.10: Experiment 6b, ‘Look Back’: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 children)

Figure 3.11: Panel A. Average proportion correct (and SEs) of Goal and Source changes for adults in Experiment 5a (‘Look Forward’) and 6a (‘Look Back’). Panel B. Average proportion correct (and SEs) of Goal and Source changes for children in Experiment 5b (‘Look Forward’) and 6b (‘Look Back’).
Figure 3.12: Clips from two of the events used in Experiments 7a and 7b ('Physical Events')

Figure 3.13: Experiment 7a, ‘Physical Events’: Average proportion correct (and SEs) of Goal and Source change trials for adults

Figure 3.14: Experiment 7a, ‘Physical Events’: Difference scores (# Goal correct - # Source correct) for each participant (N = 24 adults)

Figure 3.15: Experiment 7b, ‘Physical Events’: Average proportion correct (and SEs) of Goal and Source change trials for children

Figure 3.16: Experiment 7b, ‘Physical Events’: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 children)
CHAPTER 1: INTRODUCTION

1.1 Overview

One fundamental aspect of human cognition is our ability to talk about events, such as a bird swooping down off the roof, past the mailbox, and into its nest. This involves not only accurately representing the event components (e.g., ‘bird’, ‘swoop’, ‘roof’) and the spatial relationships among them (e.g., ‘off’, ‘into’), but it also requires mapping these components into language (e.g., noun, verb, preposition). This observation – that we can talk about what we see - has led many researchers to claim that spatial cognition and language closely interact - that spatial representations serve as a basis for what gets mapped into linguistic structure (H. Clark, 1973; Fillmore, 1997; Landau & Jackendoff, 1993; Haywood & Tarr, 1995; Herskovits, 1986; Jackendoff, 1983; Miller & Johnson-Laird, 1976; Regier, 1996; Talmy, 1983; see Bloom, Peterson, Nadel, & Garrett, 1996 for recent reviews).

Our knowledge of the space/language interface has increased tremendously over the last few decades thanks to groundbreaking research in linguistics (e.g., Talmy, 1975; 1983, Jackendoff, 1983; 1990), psychology (e.g., Landau, 2001; Landau & Jackendoff, 1993; O’Keefe & Nadel, 1978), and cognitive science (e.g., Regier, 1996). Much of this work has contributed to our understanding of how linguistic and non-linguistic representations differ and how they are similar, as well as to how non-linguistic representations support language learning. Yet, despite these advances, the nature of the space/language interaction is still not yet well understood and many questions remain
unanswered. For example, to what extent is the structure of spatial representations reflected in language and to what extent does language affect the way we conceptualize space?

The broad goal of this thesis is to shed more light on how spatial cognition and language interact; i.e., to explore how non-linguistic spatial representations serve as a basis for language and as a support for language learning. To do so, I will focus on the domain of dynamic Motion events. As I discuss in Section 1.2.1, Motion events are especially well suited to investigate questions about the space/language interface because adults and even young children readily describe such events and these events have links to non-linguistic spatial representations.

Recently several researchers have used Motion events to explore the interaction between spatial cognition and language (Borodistsky, & Ramscar, 2002; Bowerman, 1996; Hunt & Agnoli, 1991; Gennari, Sloman, & Malt, 2002; Levinson, 1996; Lucy & Gaskins, 2001; Munnich, Landau, & Dosher, 2001; Papafragou, Massey, & Gleitman, 2002; Pederson, 1995; Pourcel, 2003; Slobin, 1995). Many use these events to investigate whether the language one speaks has any effects on the way one thinks. For instance, one intriguing question is whether cross-linguistic differences in the language of Motion events predicts corresponding differences in the way individuals represent Motion events non-linguistically - when they are not using language. Another intriguing question, and one that will be investigated in this thesis, is whether and in what ways the structure of non-linguistic representations serves as a basis for linguistic representations and as a support for the acquisition of spatial language. Thus, rather than asking about language’s
effects on non-linguistic thought, I will explore the opposite question – non-linguistic thought’s effects on language.

The starting point for the current studies is a set of findings suggesting that in language, Paths are represented asymmetrically, by both normally developing children and adults, and children and adults with a rare genetic disorder called Williams syndrome. Specifically, when describing a broad range of events (Manner of Motion, Change of Possession, Change of State, and Attachment/Detachment) individuals tend to linguistically encode Goal Paths (“into its nest”) more often and more accurately than Source Paths (“off the roof”). This suggests that there is a mapping bias whereby Goal Paths are more likely to be mapped into syntactic structure (prepositional phrase) than Source Paths (Landau & Zukowksi, 2003; Lakusta & Landau, 2005; Lakusta, Licona, & Landau, 2004).

These findings raise the question of whether this mapping bias is specific to language or whether it generalizes to non-linguistic event representations. If this bias is specific to language, then Goal and Source Paths should be represented equally well in non-linguistic spatial cognition (i.e., no Goal/Source asymmetry). But if a Goal bias extends to non-linguistic event representations, then a Goal/Source asymmetry should continue to be observed in situations where individuals are not using language to encode the events. The experiments in Study 1 and Experiments 5a and 5b in Study 2 will test these two possibilities by exploring whether Goals and Sources are asymmetrically represented when individuals non-linguistically encode Motion events.

In addition, the remainder of the experiments in Study 2 will explore the nature of asymmetric Goal/Source encoding. That is, what factors contribute to Goals being
represented in preference to Sources; does intentionality play a key role? This question will be explored in these experiments by manipulating the intention in the event. The results of these studies will shed light on the nature of a Goal bias in event cognition and will elucidate what kinds of Goals and Sources are asymmetrically encoded.

1.2 Literature Review

The remainder of this chapter will review the relevant literature. Section 1.2.1 provides a description of the language/space interface, focusing especially on the domain of Motion events and the Paths (e.g., Source and Goal Paths) that enter into these events. Section 1.2.2 discusses the broader notions of Source and Goal in linguistic theory. Sections 1.2.3 and 1.2.4 discuss the development of Source and Goal Paths, with Section 1.2.3 focusing on their acquisition in language and Section 1.2.4 focusing on their status in non-linguistic cognition. Section 1.2.5 reviews previous findings suggesting a Goal/Source asymmetry in language, and Section 1.2.6 explains why it is of interest to investigate whether this asymmetry exists non-linguistically. The chapter ends with a brief introduction to the general methodology that was used for the studies in this thesis.

1.2.1 The Language/Space Interface: The Case of Motion Events

The language of Motion events engages both linguistic and non-linguistic cognition. Consider the following Motion event: A bird flies out of a bucket, past a cup, and into a bowl. Talmy (1983, 1985) proposed that, in language, events such as these are
understood in terms of four key components. These include (a) the Figure object, or object that undergoes motion (‘the bird’); (b) the Motion that it undergoes (‘fly’); (c) the Path-function the Figure object traverses (‘out’, ‘past’, and ‘into’); and (d) the Reference object, or the object which the Figure object is located with respect to (‘a bucket’, ‘a cup’, and ‘a bowl’). In addition to these four main components, a Motion event can also have a distinct Manner or Cause. In English, Manner or Cause are often conflated in the verb. For example, in the ‘bird flying’ example, ‘flying’ is a verb that conflates Manner with the Motion, whereas in the Motion event ‘The tissue blew off the counter’, ‘blew’ is a verb that conflates Cause with the Motion (e.g., the tissue blew because of a strong wind) (Talmy, 1985).

The Path-function and Reference object will be of particular interest in this thesis. Together, these components make up the entire Path of the Figure object’s movement (‘out of a bucket’, ‘past the cup’, and ‘into a bowl’). According to Jackendoff (1983), Path-functions fall into three basic types: TO-Paths have a Reference object that is a Goal (end point) of the Figure object’s Motion (e.g., ‘into a bowl’), FROM-Paths have a Reference object that is a Source (starting point) of the Figure object’s Motion (e.g., ‘out of a bucket’), and VIA-Paths are Paths in which the Figure moves past the Reference object (e.g., ‘past the cup’) (see Figure 1.1 for an illustration of these three Path types). In this thesis, I will refer to FROM-Paths as Source Paths, highlighting the Reference object as a Source, and TO-Paths as Goal Paths, highlighting the Reference object as a Goal. Thus, in an event such as “The bird flew out of a bucket and into a bowl”, “out of the bucket” is the Source Path and “into a bowl” is the Goal Path.
Figure 1.1. Path types: TO, FROM, and VIA. Basic English spatial prepositions typically encode three types of Paths: TO, FROM, and VIA, with each term engaging different constraints for the Reference object (Jackendoff, 1983).
Jackendoff (1983, 1990) has proposed a formal theory to characterize this semantic level of mental representation.¹ To provide a brief illustration of this theory, consider again the event of a bird flying out of a bucket, past a cup, and into a bowl. The semantic units (e.g., ‘bird’, ‘fly’ and ‘out’) correspond to ontological categories, such as <OBJECT>, <ACTION>, and <PATH>. Like other linguistic systems (e.g., syntax), the semantic system has its own rules of combination that govern how these constituents combine. For example, the semantic constituent for ‘fly’ is [GO] and this constituent must combine with the semantic constituent encoding the Figure object (denoted as [OBJECT] in semantic structure). That is, the Figure object is an obligatory semantic argument of [GO]. In contrast, the semantic unit encoding Path expressions (e.g., denoted as [TO-, FROM-, or VIA- PATH] in semantic structure) may or may not combine with [GO]. That is, Path expressions are optional semantic arguments of [GO]. Thus, semantic constituents, in addition to rules of combination, yield a semantic argument structure for any given event.

For purposes of describing an event using language, semantic structure must interface with other linguistic structures, such as syntactic and phonological forms (see Figure 1.2). Various theories have been proposed to describe the detailed mechanics of these mappings (e.g., Jackendoff, 1990; Chomsky, 1981).² However, for purposes of this discussion, Talmy’s (1985) descriptive characterization will suffice. Talmy (1985) refers

---

¹ Jackendoff often uses the term ‘conceptual’ to characterize this level of mental representation. However, in order to avoid confusion, and be consistent with other discussions throughout this thesis, I will use the term ‘semantic’ and reserve the term ‘conceptual’ for describing non-linguistic, spatial representations.

² The details of the actual mapping processes differ among linguistic theories. For example, in traditional generative theories (e.g., Chomsky, 1981), the syntactic system generates syntactic structures and these structures are then sent to the semantic and phonological systems to receive appropriate interpretation (Logical Form and Phonological Form, respectively). Whereas, in less ‘syntacto-centric theories’ (e.g., Jackendoff, 1990, 2002), all three systems (semantic, syntactic, and phonological) generate structures and separate interface systems are responsible for the mapping.
Figure 1.2. The space/language interface. Different levels of representation and the interactions between levels. Note that phonology, syntax, and semantic structure are typically considered part of the linguistic system, whereas retinotopic, imagistic, and spatial representations are typically considered part of the spatial cognitive system. The site of interaction being considered in this proposal is between semantic structure and spatial representations (adapted from Jackendoff, 1996).

Note. I am using the term ‘semantic’, whereas Jackendoff (1996) uses the term ‘conceptual’ (see Footnote 1).
to the mapping between meaning and surface syntactic structure as lexicalization. Talmy states, “In general, we assume that lexicalization is involved where a particular meaning component is found to be in regular association with a particular morpheme” (Talmy, 1985, p. 59).

The details of how each semantic component is lexicalized differ across the world’s languages (Talmy, 1985). In English, the Figure and Reference objects are syntactically encoded by a Noun Phrase (NP), the Motion is typically encoded by a Verb, and the Path-function is usually mapped into a Preposition. Note that the entire Path expression (Path + Reference object) maps into a Prepositional Phrase (PP). Also, in English, the Manner component is often mapped into the Verb. In the example, the verb ‘fly’ lexicalizes both the Motion and the Manner, but this need not necessarily be the case. One could describe such an event as “A bird went out of a bucket, past a cup, and into a bowl, *by flying*”. That is, one could encode the Motion in the Verb, and the Manner in a separate clause (‘by flying’). Other languages show different lexicalization patterns. For example, Spanish often conflates the Path-function with the Motion, mapping both components into the Verb. For example, consider the event of a bottle floating into a cave. In Spanish, one may describe this event as “La botella entró a la cueva flotando”, where the verb ‘entró’ encodes both the Path-function and the Motion. The Manner, ‘flotando’ is mapped into a separate lexical item.

In addition to being linked to syntactic structure, semantic components (Figure, Reference object, Motion, and Path-function) have links to non-linguistic spatial representations (see Figure 1.2). Following Landau and Jackendoff (1993), by spatial representation I mean, “a level of mental representation devoted to encoding the
geometric properties of objects in the world and the spatial relationships among them” (p. 217). To illustrate how semantic components have links to this level of representation, consider again the example of a bird flying out of a bucket, past a cup, and into a bowl. The Figure and Reference objects (‘a bird’, ‘a bucket’, ‘a cup’, and ‘a bowl’) are each linked to a spatial representation that specifies the object’s geometric structure; e.g., a 3-D model representation proposed by Marr (1982). This geometric structure has certain properties that make it suitable for object identification and categorization. First, the structure is volumetric in that it occupies a 3-dimensional region of space that is unlike a 2-dimensional surface representation. It is also object centered in that the size and shape parameters of the object stay constant despite any changing viewpoint of the observer. Finally, the geometric structure is hierarchical in that it can be decomposed into its various parts (e.g., Biederman (1987) shapes) (Marr, 1982; and see Jackendoff, 1987 for a review). Given these properties, the task of identifying ‘the bird’ in our example as ‘a bird’ rather than as ‘a cat’ and categorizing it as ‘an animal’ rather than as ‘a chair’ becomes manageable.

The Motion (‘fly’) and Path-function components (‘out’, ‘past’, and ‘in’) are also linked to spatial representations. First, the Motion component is linked to a representation that specifies the geometric structure of the action ‘flying’. Similar to geometric object representations, this action representation is also suitable for identification and categorization. That is, a geometric action representation makes it possible to distinguish ‘flying’ from ‘walking’ and ‘walking’ from ‘running’.

The spatial representation linked to the Path-function component (e.g., ‘in’, ‘past’, and ‘out’) is much less well understood. In fact, much of what we do know comes from
linguistic analyses (e.g., Talmy, 1983; Jackendoff, 1983, 1990). The Path-function component encodes a schematization of the spatial relationship between two objects - the Figure object and the Reference object. As described by Talmy (1983), this representation is a schematization because it encodes only select spatial information contained in an event, while disregarding other spatial information. For example, in most cases (including our ‘bird flying’ example) the Figure object is encoded as a geometrically simple object (‘point-like’), whereas the Reference object is often encoded as more geometrically complex, since some Path-functions (e.g., ‘in’, ‘out’, ‘on’, ‘off’) place constraints on the Reference object (e.g., Fillmore, 1997; Landau & Jackendoff, 1993). To illustrate such constraints, consider the Path-functions, ‘in’, ‘out’, ‘on’, and ‘off’. ‘In’ and ‘out’ require a ‘container-like’ Reference object, whereas the terms ‘on’ and ‘off’ require a ‘surface-like’ Reference object (e.g., a bird can’t go in a table, unless the table has a hole in it that the bird literally flies into, but a bird can go on a table, since a table has a surface). However, not all Path-functions exert constraints on the Reference object. For example, the schematization of ‘to’ and ‘from’ contains less geometric detail of the Reference object (i.e., similar to the Figure object, the Reference object may be schematized as a ‘point’). Lastly, Path-functions in Motion events (e.g., ‘in’ and ‘out’) must link to directional information contained in the spatial representation (e.g., that ‘in’ is a TO-Path rather than a FROM-Path) (Jackendoff, 1983, 1990).

Without positing these links to spatial representation it is not clear how one would be able to identify and categorize objects, motions, and spatial relations (Jackendoff, 1993).

Note that some, but not many, prepositions require a more detailed schematization of the Figure and Reference object. For example, the preposition ‘along’ requires its Reference object to be both linear and horizontal (e.g., a road is along a river) and requires its Figure object (‘a road’) to have a main axis that is parallel to the main axis of the Reference object (Landau & Jackendoff, 1993).
One could posit that all this spatial information is contained within linguistic structure, but this seems redundant and unwieldy. Why should this information be specified multiple times in the cognitive system? In addition, research with special populations (e.g., brain-damaged individuals, individuals with Williams syndrome, and individuals who are blind) suggest that spatial information may be dissociated from linguistic information, supporting the idea that spatial and linguistic representations are independent systems that interact (e.g., Kemmerer, 1999; Landau & Gleitman, 1985). Thus, the interaction between language and spatial cognition appears to be one that is necessary and is likely to be a fundamental characteristic of our cognitive system.

The analysis presented above suggests that the representation of each Motion event component includes some spatial information. Thus, the Motion event provides a case where spatial cognition and language are likely to interact. This interaction is illustrated in Jackendoff’s (1996) model of the space/language interface. As shown in Figure 1.2, consistent with the discussion above, this model contains both linguistic systems (phonological, syntactic, semantic) and non-linguistic systems (spatial, vision, audition). And the crucial site of interaction between these two systems is between semantic structure and spatial representations. This is the site of interaction being explored in this thesis.

### 1.2.2 Broader Notions of Source and Goal

Before continuing, it is important to clarify exactly what I mean by the terms ‘Source’ and ‘Goal’, since these terms seem to be defined differently in psychological
and linguistic research. The term ‘Goal’ is used often in psychological research to mean the object or state of someone’s wants or desires. Thus, Goals are usually discussed in events involving intentionality and animacy. For example, consider the events of ‘A boy running to an ice cream truck’ and ‘A girl running out of a burning house’. Both of these events may be considered to have Goals. In the first event ‘ice cream truck’ may be defined as the Goal because one may infer that the boy wants ice cream. Likewise, in the second event, ‘burning house’ may be defined as the ‘Goal’ because one may infer the girl wants to get out of the house. Unlike the term ‘Goal’, ‘Source’ appears to be used much less frequently in psychological research.

Several linguistic theories use the terms ‘Goal’ and ‘Source’ in a very different and somewhat broader sense – one not restricted to objects or states that are part of intentional, animate events (e.g., Gruber, 1976; Jackendoff, 1983). Thus, ‘Goal’ is defined broadly as an end point and ‘Source’ is defined broadly as a starting point. This broad application is based on the linguistic fact that we are able to talk about Sources (starting points) and Goals (end points) in a broad range of events using the same linguistic structures (e.g., Preposition + Noun phrase). Based on Gruber (1976), Jackendoff (1983) formalized this linguistic observation in the Thematic Relations Hypothesis, which states that spatial terms can encode domains with parallel semantic and syntactic structures. For example, the domain of Possession allows encoding of transfer of possession in a way that is parallel to kinds of changes in location in a Motion event: “Lou gave the doll TO Vicky” is parallel to “Lou went TO the store”. In this example, the doll changes possession, just as Lou changes location; Vicky is the final possessor (Goal) of the doll just as the store is the final location (Goal) for Lou. Such
parallel structure is also observed in the domain of Change of State: “Lou went FROM sad TO happy” is parallel to “Lou went FROM the house TO the store”. In this example, Lou changes from one emotional state to another in the Change of State domain, just as he changes from one location to another in the Spatial domain (Jackendoff, 1983). The parallels in syntactic structure across verbs in different semantic fields suggest underlying parallels in the way that events are conceived, with spatial events serving as a kind of template to support the expression of change in other fields.

Furthermore, linguistic theory even goes as far to extend the notions of ‘Source’ and ‘Goal’ to starting points and end points that are also Agents. To illustrate consider the following Change of Possession event and Motion event along with their semantic structures:

(1) Brian threw the doll to Sarah.               (2) Brian ran out of the store into the house.

\[
\begin{align*}
\text{EVENT} & \text{ GO POSS (doll),} \\
\text{FROM (Brian), TO (Sarah)]} & \text{GO SPATIAL (Brian),} \\
\text{FROM (store), TO (house)]} & \text{GO [FROM (Brian), TO (Sarah)]}
\end{align*}
\]

In event (1), ‘Brian’ is the Source (starting point of the doll’s movement) and ‘Sarah’ is the Goal (end point of the doll’s movement), just as in event (2), ‘store’ is the Source (starting point of Brian’s movement) and ‘house’ is the Goal (end point of Brian’s

---

4The precise definition of an agent has been the topic of much controversy in linguistic research (see Dowty, 1991 for a review). Dowty (1991) suggests that arguments that are typically agents usually have one or more of the following properties,

• Volitional involvement in the event or state
• Sentience (and/or perception)
• Causing an event or change of state in another participant
• Movement (relative to the position of another participant)

(Dowty, 1991, p. 572)

Dowty also suggests that depending on how many or to what degree an argument has these properties will determine how ‘proto-typical’ an agent it is. The term ‘agent’ takes on a somewhat different definition in the cognitive developmental literature. For example, Leslie (1995) defines agents as “a class of objects possessing sets of causal properties that distinguish them from other physical objects” (p. 122). These properties fall into three categories: mechanical, actional, and cognitive. For example, with respect to
movement). However, note that although both events have a Source and Goal, the Source in (1) (‘Brian’) is also an Agent (initiator of the action), but this is not the case for the Source in (2) (‘store’). Similarly, the Goal in (1) (‘Sarah’) is also a Beneficiary, but this is not the case for the Goal in (2) (‘house’). This difference is formalized by Jackendoff’s (1990) analysis suggesting that events can be understood in terms of two tiers: a Thematic tier which has Sources, Goals, and Themes (or Figures) and an Action tier which has Agents, Patients, and Beneficiaries. Thus, an event component can have two roles; e.g., Sources can also be Agents, Goals can also be Beneficiaries, et cetera.

The broad usage of the terms ‘Source’ and ‘Goal’ in language receives support from acquisition research. Clark and Carpenter (1989) present longitudinal data showing that by the age of 2;6 children have an abstract broad category of Source that encompasses starting points across many different types of events (e.g., Spatial, Change of Possession, Change of State). The evidence for this is that children seem to go through a period in development where they mark different types of starting points all with the locative marker ‘from’. Sometimes this marking is used non-conventionally; e.g., “*I was caught from you before” (Clark & Carpenter, 1994, p. 251). Clark & Carpenter (1994) explain:

Children have a category of source that encompasses not only locations but also agents, causes, possessors, standards of comparison, and prior events. When children need to mark sources in oblique arguments, they use the most available term to mark the category. They therefore choose from to introduce agents and causes because it expresses the notion of locative source. SOURCE, we propose is an emergent category with even broader membership than appears in English alone, where agents, for example, are not conventionally marked as sources (p. 252).

---

*mechanical properties, agents have internal ‘force’, whereas physical non-agents do not have internal ‘force’ (see Leslie, 1995 for a review of these properties).*
Clark & Carpenter (1989) also present empirical data supporting the idea of a broad Source category in acquisition. In this study, 2- to 6-year-old children were asked to imitate and repair sentences, some which marked oblique agents (ungrammatically) with ‘from’ (e.g., *“the little cat got caught from the man”). The findings revealed that 2-year-olds (incorrectly) produced ‘from’ to mark agents, whereas older children (correctly) used ‘by’ to mark agents, suggesting that children conceive agents as belonging to a broad category of Source. These findings are consistent with Jackendoff’s (1983) Thematic Relations hypothesis, which suggests that different kinds of events have similar semantic structures. In addition, these findings suggest that a broad category of Source is present even at the early stages of language development.

In this thesis, following linguistic theory, I will use the terms ‘Source’ and ‘Goal’ in the broad sense to refer to the starting points and end points across many different event types. However, whether this is the appropriate way to characterize Sources and Goals in non-linguistic cognition is an issue I consider in Chapter 4.

1.2.3 Learning Source and Goal Paths in Language

The conceptual underpinnings of Path expressions in language seem to emerge early. For example, Mandler (1992, 2004) proposed that infants represent these relationships in an ‘image schematic’ format that embodies properties suitable for mapping into language. For instance, image-schemas summarize spatial relationships and movements, thus eliminating many details (e.g., speed and direction) that may be part of the initial spatial representations that were formed. Image-schemas express fundamental
meanings, such as SELF-MOTION, CONTAINMENT, SUPPORT, and SOURCE-PATH-GOAL. Such image-schemas can then serve as the building blocks for infants when learning the language of events. For example, CONTAINMENT may be mapped to the preposition ‘in’ for an infant learning English, and CONTAINMENT and SUPPORT may be mapped to the preposition ‘en’ for an infant learning Spanish. Similarly, the image-schema SOURCE-PATH-GOAL may serve as the fundamental meaning underlying many verbs (e.g., ‘give’, ‘run’).

Given these early conceptual foundations, it is not surprising that the linguistic expressions of Paths also emerge early, even in the one- and two-word speech of children, regardless of whether the Path is expressed as a preposition (as in English) or as a verb (as is more common in Korean) (L. Bloom, 1973; Choi & Bowerman, 1991). For example, Choi and Bowerman (1991) reported that 14-21 month-olds who are learning English produce ‘out’, ‘up’ and ‘down’ to encode their own Paths and ‘on’, ‘in’, and ‘off’ for those of objects. Similarly, 14-21 month-olds who are learning Korean produce verbs such as ‘anta’ and ‘ancta’ to encode their own Paths and ‘kkita’ and ‘ppayta’ for those of objects. The Path expressions of English and Korean speaking children appear to encode both Goal and Source Path types: These include Paths in which one object is removed from another (e.g., ‘out’ in English; ‘ppayta’ in Korean) and Paths in which an object is inserted or placed in another (e.g., ‘in’ for English; ‘kkita’ for Korean).

In addition to knowing and talking about Paths, children also know and talk about the Sources and Goals (or initial states and result states) of such Paths. For example, by the age of 2;0, children start talking about resultant states (Goals) and have knowledge about a broad range of these states, including causal events in which the object affected
undergoes some change, as well as change of location events, in which an object moves from one location to another (Clark, 2002). Children also have knowledge of initial states (Sources) from an early age. Clark, Carpenter, and Deutsch (1995) reported that, in English, children mark reversals (return to a prior reference state) as early as 1;0 year old, with general verbs such as ‘open’ being used at first, followed by the use of particles, such as ‘out’, and then the prefix ‘-un’. A similar developmental trend was observed for children acquiring German (Clark et al., 1995). And, as previously mentioned, by the time children are 2;6 to 3 years old, they have also begun to use a variety of expressions to encode a broader notion of Source, or the starting point, which goes beyond the physical and spatial motions of objects (Clark & Carpenter, 1989, 1994).

This evidence tells us that both Goal and Source Path types are part of the child's repertoire in the earliest stages of language learning. But it does not tell us whether there is any asymmetry between the Path types--more broadly, those Path types that are Goal-oriented vs. Source-oriented. The studies discussed in Section 1.2.5 suggest that in language Paths may very well be encoded asymmetrically. In addition, the present studies will test the hypothesis that this asymmetry extends beyond language, to non-linguistic event representations of infants, young children, and adults. Observing such a pattern in non-linguistic event representations would suggest that asymmetric encoding of Goal and Source Paths is a fundamental characteristic of how people represent events, and may indeed support language learning.
1.2.4 Sources and Goals in Non-Linguistic Cognition

Research in infant cognition has not directly explored infants’ knowledge of Sources and Goals per se. Rather, a wealth of recent research has explored infants’ knowledge of Psychological/Mental events and Physical/Non-Mental events. Psychological/Mental events are events that usually involve an Agent and are goal-directed, whereas Physical/Non-Mental events do not involve an Agent and are not goal-directed. Researchers in both areas have explored how infants reason about the motions of objects and people in these sorts of events and what principles constrain infants’ representations (e.g., continuity, cohesion). Many of the results from these studies shed light on infants’ representations of Goals. However, it is questionable how much information these studies provide about infants’ knowledge of Sources in events. This is a point that I will return to at the end of this section.

1.2.4.1 Goals in Psychological/Mental Events

Using an imitation paradigm, many studies have shown that 14-24 month old infants are able to infer the Goal of an animate actor’s intentions (Carpenter, Akhtar, & Tomasello, 1998; Metzloff, 1995; Tomasello & Barton, 1994). For example, Meltzoff (1995) reported that 18-month-old children re-enacted an intended goal-directed act (e.g., pushing a button with a stick), even when the animate actor failed to accomplish the act (i.e., he missed the button). This pattern was not observed when an inanimate mechanical
device performed the act, suggesting that children at this age are able to infer the Goal state of an animate actor’s intentions. Carpenter et al. (1998) showed that 14-18 month old infants were also able to use language cues (e.g., “Woops” and “There”) to infer whether an observed action was accidental or intentional and were more likely to imitate the intentional, goal-directed action. Similarly, Tomasello & Barton (1994) have shown that infants are also able to use language cues to successfully infer an actor’s intentions in order to learn the meaning of a novel word. In one study 24-month-old children heard the phrase containing a novel word, such as “Let’s meek Big Bird”. The children then saw two novel actions – one that was accidental and one that was intentional. The accidental action was accompanied by the word “Woops”, and the intentional action was accompanied by the word “There”. The results showed that 24-month-old children were able to learn that the novel word (‘meek’) referred to the intentional action, suggesting that they were able to discriminate intentional, goal-directed from accidental actions and were able to infer which action the novel word referred to.

Recent studies using habituation-dishabituation paradigms have found that even infants younger than one year know about Goals in goal-directed actions (Baldwin, Baird, Saylor, & Clark, 2001; Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Csibra, Biro, Koos, & Gergely, 2003; Gergely, Nadasdy, Csibra, & Biro, 1995; Sodian, Schoepner, & Metz, 2004; Wagner & Carey, 2004; Woodward, 1998; Woodward & Sommerville, 2000). For example, Woodward (1998) habituated infants to an event in which an animate actor reached for one of two Goal objects. Then, after habituation, the locations of the two Goal objects were switched. During test, infants saw either the actor reach for the same Goal object as in familiarization (now in a different location) or a different Goal
object as in familiarization (but in the same location). The question of interest was whether infants would discriminate these two test endings and look longer (perhaps indicating that they were surprised) when the actor reached for a new Goal object. The results showed that 6- and 9-month-old infants did look longer when an animate actor reached for a new Goal, and 5-month-old infants showed a similar, although weaker pattern. This pattern was not observed when an inanimate grabber performed the reaching. Overall, these results suggest that by 6-months of age infants encode the Goal in reaching events when an animate actor performs the reaching.

Findings reported by Gergely, Csibra, & colleagues suggest that by 12-months of age infants not only know about goal-directed reaching events, but they also know about intentional goal-directed Motion events (Gergely, et al., 1995; Csibra, et al., 1999; Csibra, et al., 2003). For example, in one study (Csibra et al., 2003) infants were habituated to an animated ‘chasing’ event depicting a small ball moving towards and then through a narrow opening in a barrier. While the small ball moved towards the opening, a larger ball (that was too big to fit through the barrier) entered the screen and headed straight towards the small ball as if it were chasing the small ball. However, since the large ball could not fit through the opening, it made a sharp turn and went around the barrier, again as if it were trying to catch the small ball. Both balls then disappeared behind a black portion of the screen and infants were unable to view how the event ended. During test, infants saw two possible event endings. One ending showed the larger ball and the smaller ball touching each other as if the larger ball had caught the small ball. And the other ending showed the two balls separated as if the larger ball passed the smaller ball. Infants looked longer at the separated balls test ending,
suggesting that they were perhaps surprised at this ‘passing’ ending and expected the larger ball to ‘catch’ the smaller ball. The authors’ interpreted this finding as suggesting that 12-month-old infants are able to infer the Goal state of a goal-directed action event (see Wagner & Carey, 2004 for a replication of this experiment; see Sodian, et al., 2004 for an extension using real-life stimuli; i.e., puppets and humans rather than geometric objects).

Kuhlmeier, Wynn, & Bloom (2003) extended these findings to show that not only are 12-month-old infants able to infer the Goal in a goal-directed action, but they are also able to use a previously recognized goal-directed action to interpret future actions. In this study infants were habituated to two animated movies, both showing a ball moving up a hill. In one of the habituation movies a geometric object (e.g., triangle) ‘helped’ the ball up the hill and in the other habituation movie another geometric object (e.g., square) ‘hindered’ the ball from moving up the hill. After habituation infants saw two test movies, both that showed the three geometric objects (ball, triangle, and square) in a new context (no hill context). One test movie showed the ball ‘approach’ the helper (e.g., triangle) and another test movie showed the ball ‘approach’ the hinderer (e.g., square). The findings revealed that 12-month-old infants looked longer at the events where the ball approached the helper, suggesting that infants discriminated the helper and the hinder in the habituation events, and were able to use information contained in these events (whether the object helped or hindered) to interpret the action in the future test events (which object the ball should move next to).

Infants also know about goal-directed actions that are embedded in more complex events. For example, Baldwin, et al. (2001) reported that 10- to 11-month-old infants are
able to appropriately parse complex goal-directed action events. In this study infants were habituated to a goal-directed action (e.g., a woman notices a towel on the floor, reaches for it, grasps it, and then places it on the counter) and during test they either saw the same action with a pause inserted at a ‘natural breakpoint’ (e.g., at the end of the event when the woman’s intentions were fulfilled) or they saw the same action with a pause inserted at an ‘unnatural breakpoint’ (e.g., in the middle of the event while the woman was in the middle of carrying out her intentions). The findings showed that infants looked longer at the test events where there was an unnatural breakpoint suggesting that infants’ initial parsing of the habituation event coincided with the natural breakpoints. The authors’ interpret these findings as suggesting that infants are sensitive to the structure of goal-directed actions, and this knowledge may be serve as a foundation for later ‘adult-like’ intentional understanding.

Woodward and Sommerville (2000) expanded on the above findings and showed that 12-month-old infants are able to relate two actions to one overarching Goal. One group of infants was habituated to a single action that was ambiguous as to whether it was goal-directed (actor reaches for one of two boxes with a toy inside, but does not open the lid of the box to grasp the toy). Another group of infants was habituated to a two-action sequence – the ambiguous action described above followed by a goal-directed action (after the actor reaches for the box, she lifts the lid of the box and grasps for the toy inside). Then, after habituation, the locations of the two Goal objects inside each box were switched. During test, both groups of infants saw the same two types of test events. One test event showed the actor reaching for the same box which now contained a new toy, and another test event showed the actor reaching for a different box which now...
contained the old toy (the toy that was inside the box that the actor reached for during habituation). Infants in the two-action condition looked longer at the test trials where the actor reached for a new toy (in the old box) compared to the test trials where the actor reached for the old toy (in the new box). Infants in the single action condition did not show this pattern. Also, a follow-up experiment showed that infants in the two-action sequence related the two actions based on the causal relation between the actions, rather than on the temporal relation. Together these results suggest that 12-month-old infants are able to relate an ambiguous action to a goal-directed action (when they are causally related) and interpret the two actions together as goal-directed.

In sum, the findings discussed above suggest that children and infants know a lot about Goals in goal-directed actions – actions embedded in simple and complex reaching events and intentional Motion events (‘chasing’ and ‘fleeing’ events). The Goals in these events were objects, locations, and end states of an agent’s intentions; i.e., they were Goals in Psychological/Mental events.

1.2.4.2 Goals in Physical/Non-Mental Events

Baillargeon’s early studies (Baillargeon, Spelke, & Wasserman, 1985; Baillargeon, 1987) investigating infants’ knowledge of object permanence shed light on infants’ knowledge of Goals that are end states in Physical events. In these studies 3.5- to 5.5-month-old infants were habituated to a screen that rotated 180 degrees. During test, a box was placed behind the screen and infants saw two types of events: the screen rotating and stopping when it came in contact with the object (possible event) and the
screen rotating but not stopping when it came in contact with the object (impossible event). Infants 4.5-months and older looked longer at the test events where the screen continued to rotate suggesting that infants at this age have knowledge that an object continues to exist in space and time. However, one can also interpret these findings as suggesting that infants were able to reason about the event’s end state - that the screen should stop rather than continue. A very similar interpretation applies to other object permanence experiments involving a car rolling down a ramp (Baillargeon, 1986; Baillargeon & DeVos, 1991). In these experiments 6.5- to 8-month-old infants and 4.5-month-old females were surprised to see a car continue moving when a box lay in its path. These results seem not only to suggest that infants at this age have knowledge about object permanence (the interpretation provided by the authors) but they also suggest that infants have knowledge about the event’s end state – that an object should stop when there is another object in its path.

Results from studies investigating infants’ knowledge of support relations can be given a similar interpretation (Needham & Baillargeon, 1993). These findings suggest that by 3-months infants have knowledge of support relations; i.e., infants were surprised when an object that loses contact with its support remained suspended in mid air. However, these findings also seem to suggest that infants knew something about the end state of a support event – that an object should fall when it is not properly supported.

A final example of infants’ knowledge of end states in Physical events comes from a study by Spelke, Breinlinger, Macomber, & Jacobson (1992) that investigated infants’ ability to represent hidden objects and reason about their motion. In one experiment infants were habituated to an event of a ball falling behind a screen. After
each habituation trial, the screen was raised and the infants were able to view the ball on
the stage floor. During test infants were shown a similar (ball falling) event, but this time
a horizontal surface was introduced above the floor. Now when the screen was raised
infants either saw the ball located on the horizontal surface (possible event) or beneath
the horizontal surface (impossible event). Four-month-old infants looked longer at the
impossible event suggesting that they were able to reason about the hidden object’s
motion in accord with physical principles (solidity and continuity). However, these
results also seem to suggest that infants were able to reason about the end state of the
event – that the object should be located on the hidden surface rather than below.

The findings discussed above suggest that children and infants know much about
Goals that are end states in Physical events. Unlike the Goals discussed in Section
1.2.4.1, these Goals were not end points of an Agent’s intention. Rather they were the
natural end state in unintentional events involving inanimate objects.

In sum, the review presented above, although not exhaustive, suggests that infants
younger than 2-years of age have knowledge about Goals in Psychological/Mental events
and in Physical/Non-Mental events. In all these studies, infants’ knowledge of the Goal
played a critical role in how they perceived and conceptualized the events. I turn now
briefly to some recent research with adults, suggesting that adults’ knowledge of Goals
also plays an important role in event perception and conception.
1.2.4.3 The Importance of Goals in Adult Event Cognition

In a recent review, Zacks and Tversky (2001) point out, “The world presents nothing but continuity and flux, yet we seem to perceive activity as consisting of discrete events that have some orderly relations” (p. 3). This process of applying structure to an event is what Zacks and Tversky refer to as event structure perception. Interestingly, Goals seem to play an especially important role in establishing this event structure. For example, one characteristic of event structure is that it reflects a partonomic hierarchy; i.e., relationships between parts and subparts of an event. And identifying the Goal of an event and decomposing that Goal into subgoals shares a close relationship to an event’s parts and subparts. To illustrate this point Zacks and Tversky (2001) use an example from Barker and Wright (1954) which analyzes the event of ‘climbing to the top in life’ as being hierarchically composed of constituent parts, such as ‘getting an education’ ‘working to “pass” the third grade’, ‘walking to school’, ‘crossing the street’, and ‘stepping down from the curb’. Now this part structure of the event also reflects a goal structure. One Goal in somebody’s life may be to ‘climb to the top in life’, which itself contains the subgoal of ‘getting an education’, etc. Note that these ‘breakpoints’ in an event’s structure also tend to correlate with other factors such as observable physical changes in the event (Newtson, Engquist, & Bois, 1977) and perceptual causal properties contained in the event (Michotte, 1963). Thus, it is likely that event structuring makes use of many different kinds of information. But what is especially interesting from the point of view of this thesis is that Goals constitute one type of this event structuring information.
1.2.4.4 What about Sources?

Before concluding this section about individuals’ non-linguistic event knowledge, note that the discussion above focused exclusively on Goals and little on Sources. This is because it is less clear how these findings shed light on infants’ and adults’ knowledge of Sources in events. Yet, after further consideration, the findings may actually provide some information about the role of Sources in infant and adult cognition.

Recall that Woodward (1998) found that infants considered the Goal to be an important component of a reaching event only when an animate actor performed the reaching. When an inanimate grabber performed the reaching the importance of the Goal diminished. According to linguistic analysis (see Section 1.2.2), the actor in this reaching event is also the Source – the origin of the reaching. Thus, when reconsidering Woodward’s findings in light of this analysis, one may conclude that infants also know about Sources, at least Sources that are also actors. Specifically, infants know that Goals are important in events that involve Sources that are animate actors, but are less important in events that involve Sources that are inanimate grabbers. Of course, whether infants actually view actors as Sources is an open question that awaits future investigation.

Sources, like Goals, may also play a significant role in how infants and adults structure their event representations. Consider again Zacks and Tversky’s (2001) review suggesting that the Goal of an event shares a close relationship to an event’s parts and subparts. When reconsidering their analysis, it seems that the Source may also share a close relationship to an event’s parts and subparts if the Source is viewed as a component
of an overarching Goal. For instance, consider again Barker and Wright’s (1954) example of how the event of ‘climbing to the top in life’ can be hierarchically decomposed in parts that correspond to Goals, such as ‘getting an education’ and ‘working to pass third grade’. One can imagine that some parts of the event may also potentially involve Sources, such as ‘getting out of jail’ or ‘escaping a burning building’. In these examples the Source (e.g., ‘out of jail’) may be construed as a component of an overarching Goal (e.g., ‘getting out of jail’) and also play a significant role in how the event representation is structured.

In sum, the research considered in this section reviewed infants’ and adults’ knowledge of Goals (and maybe Sources) in non-linguistic event cognition. In the next section, I address how Sources and Goals are represented with respect to each other.

1.2.5 Goal/Source Asymmetry in the Language of Events

Sections 1.2.3 and 1.2.4 suggest that Source and Goal Paths are acquired early in language learning and Goals (and maybe Sources) are an important part of non-linguistic knowledge even in pre-linguistic infants. Yet these studies do not provide any information about how Sources and Goals are represented with respect to each other. However, some research in linguistics, psycholinguistics, and psychology does address this issue, and in all cases the findings suggest that Goals and Sources are asymmetrically represented – specifically there is a bias to represent Goals in preference to Sources.

Since the studies in this thesis explore a non-linguistic Goal/Source asymmetry, I review the findings suggesting a linguistic Goal/Source asymmetry in detail below.
However, note that the following sub-sections (especially 1.2.5.1 and 1.2.5.2) focus primarily on language, and those inclined to skip these sections should proceed directly to Section 1.2.6 which discusses the hypothesis of the current studies.

1.2.5.1 Reflections of a Goal/Source Asymmetry: Linguistic Data

Ihara and Fujita (2000) note that many of the world’s languages reflect an asymmetry between Sources and Goals. For example, in Japanese and Korean, the Goal marker is sometimes substituted for the Source marker, but the opposite pattern never occurs. Also, in Japanese the Goal marker ‘ni’ can sometimes be omitted, whereas the Source marker ‘kara’ can never be omitted. These indicate that the expression of Goal is the unmarked form. The asymmetry in markedness is also observed in English, where Change of State verbs, such as ‘turn’, can take resultatives in which the Goal state directly follows the verb (as in "Danny's hair turned red" meaning he dyed his hair from brown to red). But it seems virtually impossible to find a verb that expresses a Change of State in which the Source only is mentioned directly following the verb, as in *The frog blurned green" meaning it started out green and turned some other color.

A Goal/Source asymmetry in linguistic structure is also supported by Fillmore’s (1997) analysis of directional prepositional phrase complements in English (e.g., ‘to the X’ and ‘from the X’). According to this analysis, Goal complements, but not Source complements, may have the same form as non-directional locative complements (i.e., complements that do not have Sources or Goals, but rather describe a particular location). Borrowing an example from Fillmore (1997), the complement ‘behind the sofa’ can be
used as a non-directional, place locative complement, such as ‘the slippers are behind the sofa’, or it can be used as a Goal Path complement, such as “the cat ran behind the sofa’ (notice that in this latter construction there is an implicit ‘to’ – the cat ran to and behind the sofa). However, ‘behind the sofa’ cannot be used as a Source complement because Source complements must be marked with Source prepositions (e.g., ‘from’, ‘off’, ‘out’). Thus, in order to express ‘behind the sofa’ as a directional complement involving a Source, ‘from’ must be included; e.g., ‘the cat ran from behind the sofa’. Another example used by Nam (2004) is the sentence ‘Harry swam under the bridge’. Notice that this sentence can mean ‘Harry was swimming under the bridge’, which has a non-directional, place sense, or it can mean ‘Harry swam under the bridge’, which has a Goal Path directional sense. Notice that ‘Harry swam under the bridge’ does not mean ‘Harry swam from under the bridge’. Rather, in order to get the Source directional sense reading, ‘from’ must be included. These examples suggest that the Goal is the unmarked form and support the idea of a Goal/Source asymmetry in language.

Nam (2004) presents a formal analysis that directly accounts for the Goal/Source asymmetry observed in linguistic structure. Nam’s analysis is based on several linguistic phenomena suggesting that the Goal has a closer relationship to the verb than the Source, and thus can be considered to be a ‘true’ argument of the verb. Sources, on the other hand, behave more like adjuncts. In standard linguistic theory, arguments are more directly linked to the meaning of the verb than adjuncts. Nam’s analysis accounts for a Goal/Source asymmetry in both semantic and syntactic structure.

5 Although the distinction between arguments and adjuncts is sometimes difficult to make, in practice, most linguists would agree that there is a distinction. Specifically, based on its meaning, a verb selects for a particular number and type of theta-roles (semantic categories, such as Agent, Patient, Theme). Each theta-role is associated with an syntactic argument (e.g., subject, object) and vice versa. Thus, via the theta-
Specifically, with respect to semantic structure, Nam suggests that locative Goal Paths constitute a core event, whereas locative Source Paths modify the process of the event. One semantic phenomenon that clearly supports this analysis is aspectual shift.

Aspect is a linguistic category that provides information about the temporal character of a verb (event); e.g., whether an event is completed or not completed. Consider the event ‘Vicky swam’. This event is an activity with no necessary end point, and is referred to as having an “atelic” aspect. In contrast, the event ‘Vicky swam to the tube’ is an activity with an end point, and is referred to as having “telic” aspect. Notice that in these examples, the aspectual character of the verb shifted as a result of adding the Goal Path (‘to the tube’) – now it is “completed”. In contrast, addition of a Source Path does not lead to an aspectual shift; the event ‘Vicky swam from the tube” continues to have no natural end point, and therefore remains atelic – or not necessarily “completed”. This phenomenon suggests an asymmetry between Goals and Sources in semantic structure, and supports the idea that the Goal, but not the Source, should be considered a core event – an event that significantly affects the verb’s meaning.

criterion, a verb’s arguments are directly related to its meaning. In contrast, adjuncts are not thematically linked with the verb, hence they are less directly related to a verb’s meaning (Haegeman & Gueron, 1999). For example, the meaning of the verb ‘throw’ assigns two theta-roles: an Agent (thrower) and a Theme (entity being thrown) and subcategorizes for two arguments: a Subject and a Direct Object. As can be seen, there is a direct relation between the number of arguments and number of theta-roles assigned. Now, consider the following expression, “Jaclyn threw the ball from the bleachers”. The prepositional phrase, ‘from the bleachers’, is not an argument of the verb, it is not directly related to its meaning. Rather, it provides additional information about the event - from where the ball was thrown. Thus, ‘from the bleachers’ is considered an adjunct, not an argument (see Haegeman & Gueron, 1999 for further explanation about the argument vs. adjunct distinction in syntax; see Koenig, Mauner, & Bower, 2003 for explanation about the distinction in semantics).

In many semantic theories, a verb and its arguments can be understood as an event. If the event is complex, then it can be decomposed into sub-events (for a more detailed explanation of event structure, see, for example, Jackendoff, 1990; Pustejovsky, 1991, 1995). To illustrate, I will borrow an example from Nam (2004) that is based on Pustejovsky’s analysis of event structure. Consider the event ‘Erin swam to the boat’. This is a complex event that can be understood in terms of a process sub-event (Erin swims) and result state sub-event (Erin is at the boat). The result state sub-event is considered the core event.

6 In many semantic theories, a verb and its arguments can be understood as an event. If the event is complex, then it can be decomposed into sub-events (for a more detailed explanation of event structure, see, for example, Jackendoff, 1990; Pustejovsky, 1991, 1995). To illustrate, I will borrow an example from Nam (2004) that is based on Pustejovsky’s analysis of event structure. Consider the event ‘Erin swam to the boat’. This is a complex event that can be understood in terms of a process sub-event (Erin swims) and result state sub-event (Erin is at the boat). The result state sub-event is considered the core event.
Nam (2004) further proposes that the asymmetry between Goals and Sources is reflected in syntactic structure. Specifically, Nam suggests that Goal and Source Paths have different base positions in syntactic structure - Goal prepositional phrases (PPs) are generated under the lower verb phrase (VP), whereas Source PPs are generated under the higher VP. Thus, “Goal PPs have more integrity with the verb than Source PPs do” (Nam, 2004, p. 26). It is not necessary to go into detail about syntactic structure in order to understand the implications of this analysis. Rather, simply note that syntactic constituents generated under the lower VP are considered internal, ‘true’ arguments of the verb – constituents closely related to a verb’s meaning. On the other hand, syntactic constituents generated under the higher VP are more like syntactic adjuncts – constituents which have more of a modifying function, rather than being directly related to a verb’s meaning (see Footnote 5).

One syntactic phenomenon that supports this analysis is the active/passive alternation. In English, an active sentence typically has the structure subject–verb-object (e.g., ‘Val hit Pete’). In the passive construction, the direct object of the verb (‘Pete’) moves out of its base position to subject position, and the subject (‘Val’) can be expressed in an optional by-phrase (‘Pete was hit by Val’). Expressions which have a prepositional phrase as a direct object can also participate in the active-passive alternation, with the constraint that the PP is a Goal Path and not a Source Path. Borrowing an example from Nam (2004, p.9), consider the following acceptable sentence:

1a. The store can be run to in a matter of minutes.
In this expression the Goal (‘the store’) moved out of its base position (‘to the store’) and moved into the subject position (a ‘true’ argument of the verb). However, Source Paths do not participate in this alternation, as illustrated in the following unacceptable sentence:

1b. *The store can be run from in a matter of minutes.

Nam explains that the fact that the Goal can move out of its base position into the subject position – a syntactic position that is considered a ‘true’ argument of the verb – suggests that the Goal, but not the Source, is also a ‘true’ argument of the verb.

Nam’s linguistic analysis, and the semantic and syntactic phenomena supporting this analysis, clearly illustrate a Goal/Source asymmetry in semantic and syntactic structure. The next section discusses empirical studies that also suggest a Goal/Source asymmetry in the language system.

1.2.5.2 Further Reflections of a Goal/Source Asymmetry: Empirical Data

In addition to the linguistic findings discussed in the previous section, studies in psychology have also suggested a Goal/Source asymmetry in language. For instance, Freeman, Sinha, and Stedmon (1980) reported that 3- and 4-year-old children found it easier to answer questions about the Path of an object that moved ‘to’ a landmark than ‘from’ a landmark. This occurred despite the fact that children were equally good at imitating the motions moving objects made either towards or away from each other. Freeman et al suggested that there might be a general "allative" bias, i.e. that young children might find it easier to encode motions towards a Goal, rather than away from a Source.
Fisher, Hall, Rakowitz, & Gleitman (1994) found that 3- and 4-year-olds interpreted novel verbs as referring to goal-directed actions rather than from a perspective that highlighted the Source. For example, when a transfer event was shown in which a ball moved from a toy elephant to a toy bunny, and participants were told this was ‘zikking’, children and adults overwhelmingly guessed that the verb was ‘give’ (The elephant is giving the ball to the bunny), although the event was also consistent with ‘take’ (The bunny is taking the ball from the elephant). Fisher et al. interpreted the findings as support for an ‘agency bias’, in which children assume that agents—especially animate ones—are encoded as sentential subjects. However, the results are also consistent with the idea that children had an attentional bias in favor of Goal Paths or end points, which resulted in their choosing the verb ‘give’ rather than ‘take’.

Furthermore, Zheng and Goldin-Meadow (2002) reported that American and Chinese congenitally deaf children who were not exposed to any conventional language model produced Figures and End points more often than Agents, Origins, Recipients, and Places when describing various types of motion. Since these children were not exposed to any conventional language model, these results suggest that the bias to express Goals, rather than Sources, may be brought to the task by the language learner.

The idea of a Goal bias is also supported by studies of Japanese aggramatics (Ihara & Fujita, 2000). When these patients described Change of Possession events, they correctly provided the Goal marker (‘ni’) for GIVE verbs (e.g., ‘ageru’) more often than the Source marker (‘kara’) for RECEIVE verbs (e.g., ‘uketoru’). And when they did not use the correct Source marker (-kara), they sometimes substituted a Goal marker (-ni).
Studies by Landau and Zukowski (2003) and Lakusta, Licona, and Landau (2004) found a similar phenomenon in English-speaking children and adults. These researchers investigated the language of Manner of Motion events and found that Williams Syndrome (WS) children, WS adults, and normally developing 3-4 year-old children regularly encoded the Goal Path of Manner of Motion events, but often omitted the Source Path. For example, when shown an event containing a Goal Path such as a girl jumping into a pool, all groups usually included the Goal Path and said, “The girl jumped into the pool.” But when shown an event containing a Source Path such as a log falling off a swing, WS individuals and 3-4 year old normally developing children often omitted the Source Path and said, “The log fell.” Thus, children demonstrated a bias for encoding Goal Paths over Source Paths.

To provide a direct and strong test of this asymmetry, Lakusta and Landau (2005) showed normal adults, normally developing children between the ages of three and six, and children with Williams syndrome a broad range of events (Manner of Motion, Change of Possession, Change of State, and Attachment/Detachment) that included Sources and/or Goals. After watching each event, participants were asked, “What happened?” The findings revealed that all groups, especially children (normally developing and WS children), regularly and accurately encoded the Goal Path, but less so the Source Path. This asymmetry continued to exist even when the experimenter biased subjects’ viewpoint on the event by supplying them with a target verb (i.e., one that selects for a Goal or Source Path in the prepositional phrase) before they described the event (e.g., “Your hint is catch” or “Your hint is throw”).

Research by Regier (1996, 1997) has directly addressed the idea that Sources and Goals may be represented asymmetrically. Regier (1996) constructed a computational model to account for the acquisition of spatial terms (i.e., closed classed lexical items such as ‘off’, ‘on’, and ‘through’ that encode the spatial relationship between two objects). The model’s task was to learn the meaning of spatial terms of a natural language, such as English. To do so, the model was presented with a set of input movies, such as a two-dimensional visual stimulus depicting objects moving relative to one another. For example, a stimulus movie for ‘through’ contained five pictures presented in a sequence that depicted a square starting outside a circle, then entering inside of the circle, and then exiting the circle. Each stimulus movie was associated with a positive instance of the spatial term (e.g., movie depicting ‘through’ would be labeled with ‘through’). Based on the stimulus-spatial term pairings, the model’s task was to associate the linguistic form (e.g., ‘through’) with a semantic generalization obtained from the set of movies (e.g., ‘through’ means ‘starting outside a container, then being located inside the container, and then exiting the container’). After training, if the model was able to accurately judge how well a new test movie fit the meaning of a spatial term (e.g., ‘through’), then it was said to have successfully learned the meaning of the spatial term.

One important aspect of Regier’s model was that it was constrained. That is, it had (independently motivated) architectural principles built into its structure. One architectural principal that is especially relevant to this discussion is the source-path-
destination principle (note that Regier’s use of the term ‘destination’ seems analogous to my use of the term ‘Goal’).

This principle states that Source, Path, and Destination (Goal) are important components for spatial term learning across languages. This is because each one of these components contributes significantly to a spatial term’s meaning in the context of a Motion event. For example, consider the term ‘out’ in the context of an event depicting motion (e.g., ‘The circle moved out of the square’). In this context, ‘out’ means that some object is first located inside another object and then moves outside that object. In contrast, the meaning of the spatial term ‘in’ is that some object is first located outside one object and then moves inside that object. Given the importance of Source, Path, and Destination for spatial term acquisition, Regier built the source-path-destination principle into the model’s architecture in the following way. First, the model contained a structure labeled ‘Current’. This structure contained a representation of the stimulus picture currently being viewed (e.g., given a stimulus movie for ‘out’ that contained five pictures, the Current would contain a representation for the picture currently being viewed). The model also contained a ‘Source’ structure whose function was to retain a copy of the first picture in a stimulus movie (e.g., if the stimulus movie for ‘out’ was a movie containing five pictures, the Source structure would contain a representation of only the first picture). Finally, the model contained a Path structure that stored information about an object’s path as the stimulus movie unfolded. Note that there was no ‘Destination’ structure because, at the end of the stimulus movie, the Current structure contained the destination (Goal) information (i.e., a representation of the last stimulus picture in the movie). Thus, building the source-path-destination principle into the
architecture of the model allowed the information about Source, Path, and Destination (Goal) to be available to the model when learning a spatial term’s meaning. Note that, thus far, this model does not include anything that would suggest a Goal/Source asymmetry. Rather, it actually highlights the importance of Source (as well as Goal) in the acquisition of spatial terms (an important fact that may be forgotten when discussing asymmetric Goal/Source encoding).

Now for the asymmetric part. One important constraint in the model is that, during training, the model received feedback for the last picture of the input movie. Stated differently, the model received a training signal (e.g., this picture depicts ‘on’) only during the final picture of the input movie. For example, after being shown a five picture movie depicting ‘out’, only the last picture would receive feedback. Regier refers to this constraint on learning as the ‘end point configuration constraint’. This constraint has the following consequence: “this means that the network learns to detect those static features that appear at the end of movies and is much less likely to detect those that do not” (Regier, 1996, p. 132). Thus, the way the model learns reflects a starting point/end point (Source/Goal) asymmetry.

The end point configuration constraint makes interesting predictions concerning the acquisition of spatial terms and the set of spatial terms in any natural language. However, before considering these predictions it is important to note why the end point constraint was built into the model in the first place. If there is no principled reason for including this constraint, then using this model to understand the child’s spatial term learning system is questionable. First, imposing this constraint made the model a simpler system. Second, as Regier (1997) points out, “end point training falls naturally out of
the nature of the data…” (p. 206). That is, the entire stimulus movie must be processed before training can take place. To illustrate this point, consider the meanings of ‘into’ and ‘through’. These spatial terms are distinct because of information that comes from the end of the movie stimulus; i.e., the last movie picture of ‘in’ depicts containment, whereas the last movie picture of ‘through’ does not depict containment. But other than the last movie picture, the movie stimulus for each of these terms may be identical. Finally, it seems that this constraint makes sense intuitively. The asymmetry between starting and end points is the product of a plausible scenario: "The child has more of a chance to absorb the result of the event than its starting configuration. By the time the child's attention has been captured by the motion, the starting configuration is no longer perceptually available--only the motion itself is, followed by the resultant end-state” (Regier, 1997, p. 202).

Having justified the end point configuration constraint, let’s consider the implications it has on spatial term learning. According to Regier (1997), this constraint predicts that the model would not be able to learn ‘out’ without having already learned (or being in the process of learning) the spatial term ‘in’. Why? Because the final movie picture of ‘out’ (the one the model receives the training on) depicts an object located outside another object. Thus, “the critical feature of containment is not present in the final frame” (Regier, 1997, p 206). In contrast, the end point configuration constraint predicts that the model will learn ‘in’ very easily. This is because the crucial information for ‘in’ (i.e., containment) is located in the final picture of the stimulus movie. The data produced by the model support these predictions (see Regier 1996 Chapter 6 for examples of these data).
When generalizing this finding to children, “the model suggests that developmentally, the acquisition of a word for motion into a particular spatial configuration will precede and assist the learning of a word for motion out of that configuration – and not vice versa” (Regier, 1997, p 207). This statement makes a prediction about the order of acquisition of spatial terms. Specifically, terms marking end points (e.g., ‘in’) should be acquired earlier than terms marking starting points (e.g., ‘out’). It also makes a, perhaps somewhat less obvious, prediction about the semantic specificity of spatial terms. Semantically, spatial terms marking end points (e.g., ‘in’) should be more finely differentiated than those marking starting points (e.g., ‘out’). This is because one should not possess a ‘really good’ meaning of ‘out’ until they possess a ‘really good’ meaning of ‘in’. Research in language development supports these predictions.

For example, Clancy (1985) reported that children acquiring Japanese express the locative Goal case particle (‘ni’) earlier than the Source particle (‘kara’); a similar phenomenon has been reported for children acquiring Hungarian (Pléh, 1998). Bowerman reported that children tend to broadly overgeneralize spatial terms that describe separation but not those that describe joining (Bowerman, Lourdes de León, & Choi, 1995; Bowerman, 1996). This pattern was found across English, Korean, Dutch, and Tzotzil Mayan, indicating that the spatial terms marking end points are more finely differentiated than spatial terms marking starting points. Regier and Zheng (2003) found a similar pattern. In this study, native English, Mandarin, and Japanese speakers were shown video-clips depicting joining (e.g., putting a key in a lock) or separation (taking a key out of a lock). Participants were then asked to describe these events in their native
language. The results showed that spatial terms marking end points were applied to a narrower range of events than those marking starting points. Native English speakers, for example, used the spatial term ‘in’ to describe a narrower range of events than the spatial term ‘out’.

Regier’s model also makes another interesting prediction concerning the set of spatial terms in any given natural language. Regier refers to this prediction as the End point configuration prediction:

“All language that has a closed-class form denoting motion out of or motion through some configuration will also have a closed-class form denoting either motion into that configuration or static location in it.” (Regier, 1996, p. 156).

For example, since English has the terms ‘out’ and ‘off’, it should also have the spatial term ‘in’ and ‘on’. This prediction extends to every other language in the world and to date, is has been supported with data from the spatial semantic systems of English, German, Russian, Arabic, and Korean (Regier, 1997).

Thus, Regier’s (1996) model of spatial term acquisition includes a constraint on learning (end point emphasis constraint) that reflects a starting point/end point (Source/Goal) asymmetry. And, as discussed above, this constraint leads to several linguistic predictions that have received empirical support. But, in addition to providing support for the model, these empirical findings themselves suggest a Goal/Source asymmetry in language.

In addition to making linguistic predictions, Regier’s model (1996) also makes an important assumption about perception. By including the end point emphasis constraint, Regier assumes that individuals allocate more attention to end points of events over starting points. Regier and Zheng (2003) empirically tested this assumption. In one study
they showed adults pairs of video-clips depicting Attachment/Detachment events. That is, events depicting joining (e.g., ‘putting a lid on a container’) and separation (e.g., ‘taking a lid off a container’). Participants were asked to judge whether the events were the same or different. The results showed that adults made fewer errors detecting the difference between changes in joining (actions containing Goal Paths) than changes in separation (actions containing Source paths). These findings suggest that adults pay more attention to end points (Goals) over starting points (Sources), and thus suggest asymmetric Goal/Source encoding in perception. One aim of my thesis is to extend these findings to Sources and Goals in Motion events.

In sum, Regier’s research has several important implications for the idea of a Goal/Source asymmetry both in language and non-linguistic cognition. First, his model makes several linguistic predictions that have received empirical support. Specifically, a Goal/Source asymmetry is reflected in the order in which spatial terms are acquired and in the way that these terms are acquired (i.e., semantic specificity). In addition, a Goal/Source asymmetry is reflected in the distribution of spatial terms within many of the world’s languages. Together, these findings suggest that a Goal/Source asymmetry exists in language. Second, Regier’s model makes an assumption about the human perceptual system – that end points should receive preferential attention over starting points. This assumption has also received empirical support, although further investigation is needed. Perhaps the greatest implication of Regier’s research, not only for understanding a Goal/Source asymmetry but for understanding spatial term learning in general, would be if his model turns out to be a valid model of spatial term acquisition. If so, this model would provide important insight about the nature of the linguistic semantic system. For
example, it would provide information about how the system may be organized (what structures it contains) and under what constraints it operates (e.g., end point emphasis constraint). All in all, Regier’s research has made a significant contribution to understanding asymmetric Goal/Source encoding, as well as spatial term acquisition in general.

Together, the findings reviewed in this section strongly suggest that, in language, a Goal/Source asymmetry appears to be a broad and robust phenomenon. It has been observed empirically in many different groups (normal adults, normally developing children, children and adults with Williams syndrome, and Japanese aggramatics), across many different kinds of events (Motion events, Attachment/Detachment events, Change of Possession Events, and Change of State events) and in many different languages (e.g., English, Japanese, Hungarian). This asymmetric pattern has also been observed in many different forms (order of acquisition of spatial terms, semantic specificity of spatial terms, spatial term substitution errors, and likelihood of spatial term being mapped into the prepositional phrase). Furthermore, linguistic data strongly suggest that Sources and Goals have unequal status in the linguistic system.

The breadth and robustness of this linguistic phenomenon raises the intriguing possibility that a Goal/Source asymmetry may have its roots in the non-linguistic cognitive system. This possibility is the primary motivation for the experiments presented in this thesis and will be discussed further in Section 1.2.6.
1.2.6 Investigating a Non-Linguistic Goal/Source Asymmetry in Motion Events

The main aim of this thesis is to test the hypothesis that Goals and Sources have unequal status in non-linguistic Motion event representations. Specifically, this thesis will explore whether there is a bias to represent Goals in preference to Sources.

It is possible that this hypothesis is correct and the asymmetry between Sources and Goals extends beyond the linguistic system to non-linguistic spatial cognition. Thus, the Goal/Source hierarchy that seems to exist in language may reflect the structure of non-linguistic event representations, just as the meaning of many spatial terms (e.g., above, below, right, left) reflects the reference systems that organize our representations of space (Haywood & Tarr, 1995; Landau & Jackendoff, 1993; Landau & Hoffman, in press; Munnich, Landau, & Dosher, 2001).

Or it is possible that the hypothesis is incorrect and that the asymmetry between Sources and Goals is a characteristic unique to the linguistic system. In other words, in the semantic system there may be a hierarchy that ranks Goals higher than Sources, similar to the fact that Agents are ranked higher than Patients (Fisher, Hall, Rakowitz, & Gleitman, 1994; Grimshaw, 1981; Slobin, 1985). This asymmetry is then reflected in syntactic structure. And, despite this linguistic asymmetry, Sources and Goals may be represented equally well in non-linguistic cognition. That is, when viewing an event that includes a Source and/or a Goal (e.g., the bird flew out of the bucket and into the bowl), the spatial system may compute representations of the Source and Goal objects that are of equal status. For instance, they may each have an appropriate spatial structure and may each be a durable and stable representation. Hence, the representation of Source and
Goal may each be a well-formed object representation that undergoes similar processing effects (e.g., effects of memory and attention). However, for purposes of language, these representations are mapped into a semantic structure that is hierarchical in nature, specifically one that illustrates a Goal bias.

To evaluate these hypotheses, the experiments in Study 1 will test whether pre-linguistic infants (infants who do not yet have a fully developed linguistic system) represent Goals and Sources asymmetrically in Motion events. Experiments 5a and 5b in Study 2 will explore the same question with adults and 4-year-old children. In these experiments, adults and children will be asked to encode Motion events while having their language disrupted (via verbal shadowing), thereby preventing them from linguistically encoding the events. If a Goal/Source asymmetry extends to the non-linguistic spatial cognitive system, then pre-linguistic infants, children, and adults should show evidence for a Goal bias in these experiments.

A second aim of this thesis is to explore the nature of asymmetric Goal/Source encoding. What factors contribute to a Goal bias; does intentionality play a significant role? And does a Goal/Source asymmetry extend to Physical/Non-Mentalistic events – events falling under a different core cognitive domain than the Motion events previously studied? The findings from these experiments will shed light on the nature of the Goal bias in event cognition and will elucidate what kinds of Goals and Sources are asymmetrically encoded in event representations.

Overall, these studies will shed light on the nature of the space/language interface (e.g., whether linguistic asymmetries reflect non-linguistic asymmetries), and will provide important information about the structure of non-linguistic event representations.
1.2.7 General Methodology

In order to achieve these aims, the stimuli in all the experiments will be Motion events because these events have clear links to non-linguistic spatial cognition. Since I wish to explore an asymmetry between Goals and Sources in Motion events, all the Motion events will contain a Source and/or a Goal. The experiments in this thesis will use two different paradigms. Neither of the paradigms involve language, thus all the experiments test individuals’ non-linguistic representations. The experiments in Study 1 will test 12-month-old infants using a Visual Familiarization Paradigm. The fact that the infants will be pre-linguistic makes these experiments non-linguistic by definition. The experiments in Study 2 will test 4-year-old children and adults using a non-linguistic Detecting Changes Method. Finally, investigating this phenomenon in three different age groups provides the opportunity to explore the developmental trajectory of any asymmetric Goal/Source encoding. I will ask whether all groups represent Sources less well than Goals, or whether it is something that emerges or disappears over development.

CHAPTER 2: STUDY 1: GOAL/SOURCE ASYMMETRY IN INFANTS

The experiments in this chapter test the hypothesis that the Goal/Source asymmetry found in language extends to the non-linguistic Motion event representations of pre-linguistic infants. If Goals and Sources in Motion events are asymmetrically represented at the non-linguistic spatial cognitive level, then pre-linguistic infants –
infants who have not yet fully developed language – should be more likely to encode Goals over Sources in Motion events.

Before testing whether infants encode Goals and Sources asymmetrically, it must first be shown that infants encode Goals and Sources independently in Motion events. As discussed in Section 1.2.4.1, research by Woodward (1998) has shown that infants encode Goals in reaching events when an animate actor performs the reaching. Yet reaching events are very different from the Motion events being explored in the current studies. For example, reaching events involve an Agent (who is also the Source) acting intentionally on a Goal, whereas the Motion events being explored in the current studies involve an Actor (Figure object) moving from a Source to a Goal. In these events, it is not clear whether the Actor is also an Agent, and whether it should be construed as having intentions towards the Goal. Given these differences, it is an open question whether infants encode Goals in Motion events. Furthermore, whether infants encode Sources in any type of event is yet to be explored. Thus, Experiments 1-3 investigate whether infants encode Goals and Sources in Motion events, and Experiment 4 then explores whether these components are asymmetrically represented.

---

According to Jackendoff (1990), Actors are defined as “doers of the action” and they usually satisfy the linguistic test, “What NP did was…” (p. 126). Actors may take on one or more agentive properties (see Footnote 4 for a list of agentive properties as described by Dowty). For example, Actors may be volitional Actors, therefore expressing want or intent, or Actors may be neutral with respect to volition. Thus, Actors may be ambiguous with respect to volition. As Jackendoff explains, “generally it seems that any Actor, if animate, is subject to this ambiguity unless the verb specifically selects for a volitional Agent, as do for
2.1 General Methodology: Experiments 1-4

These experiments used a Visual Familiarization Paradigm similar to one that has been used by several researchers (e.g., Woodward, 1998; O’Hearn, 2002).

Participants. Infants were recruited through the Maryland Department of Health and Mental Hygiene (DHMH). Both Johns Hopkins University and the DHMH approved this method of recruitment. When parents and infants visited the lab, parents were asked to sign an informed consent that was also approved by both Johns Hopkins University and DHMH. At the end of the experiment, infants received a t-shirt in appreciation for their participation.

Apparatus. An infant sat in a high chair located 32 inches in front of a small puppet stage. The stage was 32 inches wide, 12.5 inches high, and 14.5 inches deep. The walls and floor of the stage were covered in off-white material. An overhead light, hidden from the infant’s view, lit the stage. The stage was encapsulated in a 38.5 inch wide by 68 inch high structure that was also covered in off-white material. A small video-camera was mounted just above the stage and a small slit in the material made it possible for the camera to record the infant’s looking patterns. This camera projected to a monitor located behind the stage. A trained observer monitored the infant’s looking patterns on this monitor. A curtain was attached to the front of the stage and when raised, it revealed the stage for the infant to view. During the experiment, a parent sat next to the infant with her back facing the stage.

instance, buy and look” (p. 128). ‘Reach’ would also seem to be an action selecting for a volitional Agent, whereas the action used in the current experiments (slide) seems subject to ‘volitional ambiguity’.
Design and Procedure. There were seven familiarization trials, one inter-trial, and six test trials. At the start of each trial the curtain was raised, the infant viewed a Motion event, and then the curtain was lowered. The experimenter signaled the beginning and end of each trial by saying “Look, (baby’s name), Look!”.

An infant’s looking time at the stage was recorded by the trained observer, who watched the infant on the video-monitor and pressed a key on a computer keyboard whenever the infant looked at the stage. A computer program calculated the infant’s looking time (Mac Xhab; Pinto, 1994). When the infant looked away from the stage for two continuous seconds, the computer program beeped, signaling the experimenter to proceed to the next trial.

Looking time was the dependent measure for every experiment.

2.2 Experiment 1: Goal Encoding at 12-months

2.2.1 Method: Experiment 1

---

8 In order to control for any experimenter bias an audio control was used where the experimenter recorded “Look, (baby’s name), Look!” onto an audio file on a computer before the infant arrived. Then, during the experiment, the experimenter pressed a button when it was the appropriate time for this recording to play.

9 We decided to test 12-month-old infants because a pilot experiment found that 10-month-old infants did not show evidence of encoding the Goal in Motion events. One possible reason for this is that the ability to encode Goals in Motion events is something that is acquired (or emerges) over the course of development, and 10-month-old infants have not yet reached this developmental milestone. This possibility receives some support when considering Woodward’s (1998) findings for reaching events. Woodward found that 6-month-old infants selectively encoded the Goal object of an animate actor’s reach. However, although 5-month-olds showed a similar pattern, the findings were not statistically significant for this younger age group. Woodward interpreted these findings as suggesting that infants’ knowledge of Goals in reaching events may change between 5 to 6 months. In later work, Woodward, Sommerville, & Gaarjardo (2001) explain that this change may be due to infants’ familiarity with different types of actions. For example, perhaps by 6 months infants are familiar with reaching events and have learned that Goals are important in these events when an animate actor does the reaching. Following this interpretation, it is also possible that infants’ knowledge of Goals in Motion events also develops, albeit at a different rate than Goals in reaching events.
Participants. Participants were sixteen 12-month-old infants (8 males, 8 females; Mean age = 12 months, 6 days; Range: 11 months, 15 days to 12 months, 24 days). One infant was excluded because of fussiness.

Stimuli. The stimuli were Motion events that included two Goal objects (red block and green bowl), a Figure object (toy duck), and a Motion (simple slide) (see Figure 2.1 for a depiction of the stimuli and the procedure). In all the events the Goal objects were located on the right of the stage (for half the infants) or on the left of the stage (for half the infants), and in the middle of the stage (i.e., neither front nor back). The Figure’s initial position was always in the corner of the stage; the positions were counterbalanced for front/back and left/right across infants. Note that if the Figure’s initial position was one of the left corners, the Goal objects were located on the right side of the stage, and vice versa.

Procedure. Infants were familiarized to the Figure moving to one of two Goal objects (onto the red block or into the green bowl). After familiarization, while the curtain was lowered, the experimenter switched the locations of the two Goal objects. During the inter-trial, infants viewed the two Goal objects in their new locations. During three test trials, infants saw the Figure object move to a Different Goal object as in familiarization, but in the Same Location; henceforth, Different Goal/Same Location. In another three test trials, infants saw the Figure object move to the Same Goal object as in familiarization, but in a Different Location; henceforth, Same Goal/Different Location. The type of familiarization event (onto a red block / into a green bowl) was counterbalanced across infants. The presentation of the two types of test trials was alternated and presented in a counterbalanced order.
Figure 2.1. Schematic of the procedure for Experiment 1 (Goal experiment). In familiarization, the duck moved to one of two Goal objects. During inter-trial, the objects switched locations. In three test trials, the duck moved to a Different Goal/Same Location and in three test trials the duck moved to the Same Goal/Different Location.
Reliability. In order to assess the reliability of the on-line coding, a second observer recoded 100% of the trials for eight infants off-line. Intra-observer agreement was calculated by correlating the mean looking times for all the trials between the two observers. There was a significant correlation, \( r = .99, p < .01 \).

Prediction. If infants selectively track and encode the Goal object during familiarization then they should look longer (indicating that they were “surprised”) at the test trials where the duck slides to the Different Goal/Same Location compared to the Same Goal/Different Location test trials. This prediction was based on the results from previous infant studies suggesting that infants look longer when a hand reaches to a Different Goal/Same Location than to the Same Goal/Different Location (Woodward, 1998; Woodward & Sommerville, 2000).

2.2.2 Results: Experiment 1

Preliminary analyses

The infants’ looking times decreased from the first to seventh familiarization trial (\( Ms = 18.00, 13.26; SEs = 2.58, 2.21 \) for trials one and seven, respectively). The data from the seven familiarization trials were entered into a within subject analysis of variance and revealed a marginally significant effect, \( F(6, 90) = 1.89, p < .10 \), indicating that infants looked less across trials showing they were familiarized.

Primary analyses

Infants showed evidence of Goal encoding. A one-tailed paired t-test showed that, on average, infants looked longer at the Different Goal/Same Location test trials (\( M \))
= 12.35, SE = 1.19) compared to Same Goal/Different Location test trials (M = 10.17, SE = 1.38), t (15) = 4.50, p < .01 (See Figure 2.2). Fourteen out of the 16 infants showed this pattern. This pattern was also confirmed with a Wilcoxon signed ranks test which was performed on the difference between mean looking time at the two differences types of test trials for each infant (z = -3.15, p < .01).

Additional analyses

In addition to the primary analyses, I asked whether any secondary variables significantly interacted with the primary variable of interest (Trial Type: Different Goal/Same Location vs. Same Goal/Different Location). These secondary variables were 1) whether the infant was a male vs. female, 2) whether the duck started at the front vs. back of the stage, 3) whether the duck started on the left vs. right of the stage, 4) whether the infant was familiarized with the duck moving to the closer object vs. the farther object (e.g., in Figure 2.1, familiarization involves the duck moving to the closer object), and 5) whether the infant was familiarized with the duck going into the bowl vs. onto the block.

Five separate Secondary Variable x Trial Type analyses of variances were conducted with the Secondary Variable entered as a between subject variable and Trial Type entered as a within subject variable. The results of the analyses for this Experiment and for Experiments 2-4 will only be reported if the secondary variable significantly interacted with Trial Type. In Experiment 1, none of the secondary variables significantly interacted with Trial Type.

---

10 One-tailed t-tests were used in Experiments 1, 2, and 3 because, based on previous findings (e.g., Woodward, 1998), we predicted that infants would selectively track and encode the Object in preference to the Location. Two-tailed t-tests were used in the remainder of the experiments because there were few, if any, previous findings with which to base the directionality of our hypotheses.
Figure 2.2. Experiment 1: Goal encoding at 12-months. Average looking times (and SEs) at the two different Trial Types.
2.2.3 Discussion: Experiment 1

The findings from Experiment 1 suggest that infants selectively attend to the Goal object during familiarization, and during test they look longer at a change in the Goal object than a change in the Location. This suggests that 12-month-old infants do encode the Goal in Motion events. This result adds to the growing body of literature discussed in Section 1.2.4 suggesting that pre-linguistic infants know about Goals in both Psychological/Mentalistic events and Physical/Non-Mentalistic events. The question we explore in Experiment 2 is whether infants encode the Source in Motion events.

However, before turning to Experiment 2, we would like to consider another possible interpretation of the findings from Experiment 1. It is possible that the infants in the previous experiment were not conceptualizing the event as a multi-part Motion event (i.e., one involving a Figure, Motion, Path, and Goal), but rather were basing their looking patterns on the static end state of the event. In other words, perhaps infants were ‘ignoring’ the Motion and Path of the Figure object and were simply encoding the association between the duck (Figure object) and the bowl/block (Goal object) as observed at the end of the event. If this were the case, then the findings from Experiment 1 do not provide any evidence that infants encode Goals in Motion events, but rather suggest that infants are able to form an association between two objects (duck and bowl/block). Experiment 1a was conducted to address this concern.
2.3 Experiment 1a: Event or Static End State?\(^{11}\)

In order to explore whether infants in Experiment 1 were basing their looking patterns on an event or on a static end state, we carried out a similar experiment in which we removed the ‘event part’ of the event. Thus, only the static end-state was revealed to the infants.

2.3.1 Method: Experiment 1a

Participants. Participants were sixteen 12-month-old infants (9 males and 7 females; Mean age = 11 months, 29 days; Range: 11 months, 20 days to 12 months, 9 days). One infant was excluded because of fussiness.

Stimuli. The stimuli were the same objects as those used in Experiment 1; the Reference objects were a red block and green bowl, and the Figure was a toy duck (see Figure 2.3 for a depiction of the stimuli and the procedure). In all the events the Reference objects were located on the right of the stage (for half the infants) or on the left of the stage (for half the infants), and in the middle of the stage (i.e., neither front nor back).

Procedure. Infants were familiarized to the toy duck either on the red block or in the green bowl. After familiarization, while the curtain was lowered, the experimenter

\(^{11}\) Thanks to Dr. Lisa Feigenson for suggesting this control experiment.
Figure 2.3. Schematic of the procedure for Experiment 1a (Control experiment). In familiarization, the duck was on/in one of two objects. During inter-trial, the objects switched locations. In three test trials, the duck was on/in a Different Object/Same Location and in three test trials the duck was on/in the Same Object/Different Location.
switched the locations of the two objects. During the inter-trial, infants viewed the two objects in their new locations. During three test trials, infants saw the duck on/in a Different Object as in familiarization, but in the Same Location, henceforth Different Object/Same Location. In another three test trials infants saw the duck on/in the Same Object as in familiarization, but in a Different Location, henceforth Same Object/Different Location.

The type of familiarization event (on the red block / in the green bowl) was counterbalanced across infants. The presentation of these two types of test trials was alternated and presented in a counterbalanced order.

Reliability. In order to assess the reliability of the on-line coding, a second observer recoded 100% of the trials for eight infants off-line. Intra-observer agreement was calculated by correlating the mean looking times for all the trials between the two observers. There was a significant correlation, $r = .99$, $p < .01$.

Prediction. If infants in Experiment 1 were simply forming an association between the duck and bowl/block rather than basing their looking patterns on a conceptualization that they had formed involving a Figure, Motion, Path, and Goal, then infants in the current experiment should show the same pattern of looking as they showed in Experiment 1. That is, they should look longer at the test trials where the duck is on/in a Different Object/Same Location compared to the trials where the duck is on/in the Same Object/Different Location.
2.3.2 Results: Experiment 1a

The prediction was *not* supported. A one-tailed paired t-test showed that, on average, infants did not look significantly longer at the Different Object/Same Location test trials ($M = 7.41$, $SE = 1.67$) compared to the Same Object/Different Location test trials ($M = 8.42$, $SE = 2.44$), $t (15) = .85$, $p > .10$ (see Figure 2.4). Furthermore, inspection of individual participant data revealed that only seven out of the 16 infants looked longer at the Different Object/Same Location test trials. This finding was also confirmed with a Wilcoxon signed ranks test which was performed on the difference between mean looking time at the two differences types of test trials for each infant ($z = -.16$, $p > .10$).

2.3.3 Discussion: Experiment 1a

The findings from Experiment 1a suggest that infants in Experiment 1 were not simply forming an association between the duck and bowl/block that they observed at the end of the event, but rather were basing their looking patterns on a conceptualization that they had formed of a multi-part Motion event (i.e., one involving a Figure, Motion, Path, and Goal). Thus, the findings from Experiment 1 do indeed suggest that infants encode the Goal in Motion events.

Note that the findings from Experiments 1 and 1a are also supported by recent research suggesting that infants show evidence of encoding the Goal when the Figure performs some Motions but not others. Specifically, when the Figure object engages in
Figure 2.4. Experiment 1a: Object encoding at 12-months. Average looking times (and SEs) at the two different Trial Types.
rather ‘simple’ Motions such as sliding or hopping, infants show evidence of encoding the Goal, but when the Figure object engages is more ‘complicated’ Motions, such as scooting, infants fail to show evidence of Goal encoding (Wagner, Lakusta, O’Hearn, & Landau, 2005). If infants in these experiments were ignoring the Motion and Path, and were basing their looking patterns on the static end state of the event, then the Manner of Motion should not matter for whether or not infants show evidence of Goal encoding. The fact that the type of Manner of Motion matters, suggests that infants are indeed conceptualizing these events as multi-part Motion events.

2.4 Experiment 2: Source Encoding at 12-months

2.4.1 Method: Experiment 2

Participants. Participants were sixteen 12-month-old infants (8 males and 8 females; Mean age = 12 months, 6 days; Range: 11 months, 26 days to 12 months, 14 days). One infant was excluded because of an error in the experimental procedure.

Stimuli. The stimuli were the same as those used in Experiment 1, but this time the Motion events included Sources (red block or green howl) rather than Goals (see Figure 2.5 for a depiction of the stimuli and the procedure). As in Experiment 1, in all the events, the Source objects were located on the right of the stage (for half the infants) or on the left of the stage (for half the infants), and in the middle of the stage (i.e., neither front nor back). The Figure’s ending position was always in the corner of the stage; the positions were counterbalanced for front/back and left/right across infants. Note that if
Schematic of the procedure for Experiment 2 (Source experiment). In familiarization, the duck moved from one of two Source objects. During inter-trial the objects switched locations. In three test trials, the duck moved from a Different Source/Same Location and in three test trials the duck moved from the Same Source/Different Location.
the Figure’s ending position was one of the left corners, the Source objects were located on the right side of the stage, and vice versa.

**Procedure.** Infants were familiarized to the Figure moving from one of two Source objects (off of the red block or out of the green bowl). After familiarization, while the curtain was lowered, the experimenter switched the locations of the two Source objects. During the inter-trial, infants viewed the two Source objects in their new locations. During three test trials, infants saw the Figure object move from a Different Source object as in familiarization, but in the Same Location, henceforth Different Source/Same Location. In another three test trials infants saw the Figure object move from the Same Source object as in familiarization, but in a Different Location, henceforth Same Source/Different Location.

The type of familiarization event (off a red block / out of a green bowl) was counterbalanced across infants. The presentation of these two types of test trials was alternated and presented in a counterbalanced order.

**Reliability.** In order to assess the reliability of the on-line coding, a second observer recoded 100% of the trials for eight infants off-line. Intra-observer agreement was calculated by correlating the mean looking times for all the trials between the two observers. There was a significant correlation, \( r = .99, p < .01. \)

**Prediction.** If infants selectively track and encode the Source object during familiarization, then they should look longer at the Different Source/Same Location test trials compared to the Same Source/Different Location test trials.
2.4.2 Results: Experiment 2

Preliminary analyses

The infants’ looking times decreased from the first to seventh familiarization trial ($M_s = 17.26, 12.42$; $SE_s = 1.19, 2.17$, for trials one and seven, respectively). The data from the seven familiarization trials were entered into a within subject analysis of variance and revealed a significant effect, $F(6, 90) = 2.64, p < .05$, indicating that infants looked less across trials showing they were familiarized.

Primary analyses

Infants did not show evidence of Source encoding. A one-tailed paired t-test showed that, on average, infants did not look significantly longer at the Different Source/Same Location test trials ($M = 9.69$, $SE = 1.16$) compared to the Same Source/Different Location test trials ($M = 9.73$, $SE = 1.31$), $t(15) = .04, p > .10$ (see Figure 2.6). Furthermore, inspection of individual participant data revealed that only 7 out of the 16 infants showed the predicted pattern of looking (i.e., longer looks at the Different Source/Same Location test trials). This finding was also confirmed with a Wilcoxon signed ranks test which was performed on the difference between mean looking time at the two differences types of test trials for each infant ($z = -.21, p > .10$).

Additional analyses

As in Experiment 1, none of the secondary variables significantly interacted with Trial Type.
Figure 2.6. Experiment 2: Source encoding at 12-months. Average looking times (and SEs) at the two different Trial Types.
2.4.3 Discussion: Experiment 2

The findings from Experiment 2 suggest that infants do not selectively attend to the Source object during familiarization and during test they do not look longer at a change in the Source object than a change in the Location. Thus, infants of this age do not show evidence of encoding the Source object in Motion events. This finding differs from the finding reported in Experiment 1 where 12-month-old infants did show evidence of encoding the Goal object. Thus, taken together, the results from Experiments 1 and 2 suggest that 12-month-old infants may represent Goals and Source asymmetrically. This lends support to the broader hypothesis that a Goal/Source asymmetry does exist in the non-linguistic spatial cognitive system.

The finding from Experiment 2 raises the question of whether 12-month-old infants will ever show evidence of encoding the Source in Motion events. It is possible that the Source is such an unimportant part of the event that 12-month-old infants will never track and encode it during familiarization. Or, perhaps infants would track and encode the Source if it were made more salient. Exploring these two possibilities is essential to understanding the nature of 12-month-old infants’ Motion event representations. Do infants at this young age conceptualize the Source in Motion events? This possibility was tested in Experiment 3.
2.5 Experiment 3 ‘Super’ Source Encoding at 12-months

The aim of Experiment 3 was to explore whether 12-month-old infants would encode the Source object in a Motion event when the Source object was made more salient. This was done in three different ways: Increased physical salience of Source objects (by making them bigger, brighter, and more exciting), increased amount of time that the Figure object (duck) spent at the Source at the beginning of the event, and decreased distance traveled by the Figure object so that the Figure object and Source were closer together throughout the entire event (these changes are described in more detail in the Method section below). These three changes were designed to increase the likelihood that 12-month-old infants would encode the Source object in Motion events.

2.5.1 Method: Experiment 3

Participants. Participants were twenty-four 12-month-old infants (14 males, 10 females; Mean age = 12 months, 2 days; Range: 11 months, 18 days to 12 months, 13 days). Six infants were excluded (3 fusses out, 2 errors in the experimental procedure, and one infant was influenced by the parent).

Stimuli. The stimuli were the same as those used in Experiment 2, but this time, in order to make the Source objects more physically salient, one Source object was a big metallic blue block with sparkly pipe cleaners attached to its sides and the other Source object was a big orange bowl with puffs, bows, and sequins stuck to it (see Figure 2.7 for a depiction of the stimuli and the procedure).
Figure 2.7. Schematic of the procedure for Experiment 3 (‘Super’ Source experiment). In familiarization, the duck moved from one of two salient Source objects. During inter-trial, the objects switched locations. In three test trials, the duck moved from a Different Source/Same Location and in three test trials the duck moved from the Same Source/Different Location.
Procedure. The procedure was also the same as that used in Experiment 2 with the following exceptions. In order to increase the time the Figure stayed at the Source object at the beginning of the event, the duck stayed waggling at the Source an additional 6.5 seconds after the experimenter said, “Look (baby’s name), look!”\footnote{Six and a half seconds was chosen because this was the average length of time that the infants in Experiment 1 looked at the Goal object once the duck reached the Goal object.} Also, in order to have the Figure object be closer to the Source object throughout the entire trial, rather than have the duck hop off/out of the Source object and slide to the corner of the stage, the duck hopped off/out of the Source object and slid to the middle of the stage.

Reliability. In order to assess the reliability of the on-line coding, a second observer recoded 100\% of the trials for twelve infants off-line. Intra-observer agreement was calculated by correlating the mean looking times for all the trials between the two observers. There was a significant correlation, $r = .99$, $p < .01$.

Prediction. If infants selectively track and encode the Source object during familiarization, then they should look longer at the Different Source/Same Location test trials compared to the Same Source/Different Location test trials.

2.5.2 Results: Experiment 3

Preliminary analyses

The infants’ looking times decreased from the first to seventh familiarization trial ($Ms = 19.35, 11.29; SEs = 1.63, 1.36$, for trials one and seven, respectively). The data from the seven familiarization trials were entered into a within subject ANOVA and
revealed a significant effect, $F(6, 138) = 7.43, p < .01$, indicating that infants looked less across trials showing they were familiarized.

**Primary analyses**

Unlike the results from Experiment 2, infants showed evidence of Source encoding. A one-tailed t-test showed that, on average, infants looked longer at the Different Source/Same Location test trials ($M = 13.80, SE = 1.59$) compared to the Same Source/Different Location test trials ($M = 11.78, SE = 1.31$), $t(23) = 1.85, p < .05$ (see Figure 2.8). Eighteen out of the 24 infants showed this pattern. This pattern was also confirmed with a Wilcoxon signed ranks test which was performed on the difference between mean looking time at the two differences types of test trials for each infant, $(z = -2.00, p < .05)$.

**Additional analyses**

In this experiment, one secondary variable significantly interacted with Trial Type. This secondary variable was whether the infant was familiarized with the duck starting in the bowl and then moving out of the bowl vs. the duck starting on the block and then moving off the block. A 2 (Secondary variable: Out of Bowl vs. Off of Block) x 2 (Trial Type: Different Source/Same Location vs. Same Source/Different Location) mixed analysis of variance showed a significant interaction, $F(1, 22) = 5.60, p < .05$. Simple effect contrasts revealed that only the infants who were familiarized with the duck moving out of the bowl discriminated between the two different types of test events, $p < .01$. This finding is notable and is discussed further in the discussion below.
Figure 2.8. Experiment 3: ‘Super’ Source encoding at 12-months. Average looking times (and SEs) at the two different Trial Types.
2.5.3 Discussion: Experiment 3

The results from Experiment 3 suggest that infants do encode the Source object in Motion events when the Source objects are made more salient. This finding differs from the finding reported in Experiment 2 where 12-month-old infants did not show evidence of encoding a ‘non-salient’ Source object. Furthermore, the additional analyses in Experiment 3 revealed that only the infants who were familiarized with the duck moving from \textit{out} of the bowl showed evidence of Source encoding (i.e., they looked longer at the Different Source/Same Location vs. Same Source/Different Location test trials). Infants who were familiarized with the duck moving from \textit{off} of the block did not show this pattern. Thus, it appears that the spatial relationship of the duck relative to the Source object (whether it was \textit{in} it and then moved \textit{out} of it or whether it was \textit{on} it and then moved \textit{off} of it) mattered for whether or not infants selectively tracked and encoded the Source object. This result is consistent with recent research suggesting that ‘in’ is a privileged spatial relation for pre-linguistic infants in that it is one of the first to be conceptualized and appears earlier than ‘on’ (Cassasola & Cohen, 2002).\textsuperscript{13} Hence, the results from Experiments 2 and 3 suggest that it takes special circumstances for Source objects to be encoded.

\textit{Why} did infants show evidence of encoding salient Sources in Experiment 3, but not ordinary Sources in Experiment 2? Specifically, what mechanism(s) is(are) responsible for these different patterns of results? One likely possibility is attention. Compared to the infants in Experiment 2, perhaps the infants in Experiment 3 allocated
more attention to the Source objects when viewing the event, thus leading them to encode the Source object. In order to explore this possibility we took a closer look at infants’ looking patterns throughout the experiment. Specifically, for both Experiments 2 and 3 we reviewed the infant video-recordings and counted how many times infants looked back at the Source object once the duck started moving away from the object. Assuming that where one looks is a good measure of where one attends, we reasoned that if attention plays a role in Source encoding, then the infants in Experiment 3 should have looked back at the Source objects more frequently than did infants in Experiment 2. This is exactly what we found. On average, infants in Experiment 3 looked back at the Source objects twice as many times as did the infants in Experiment 2 (Mean number of look backs at the Source object = 1.14 and .57 for Experiments 3 and 2, respectively).

Although this is a course measure, it is suggestive evidence that attention may have played a significant role in infants’ encoding of the Source in Experiment 3, but not in Experiment 2. And, more generally, it suggests that attentional allocation may play a critical role in determining which event components individuals encode.

The results from Experiments 1 and 3, showing that 12-month-old infants encode both Goals and Sources (albeit ‘salient’ Sources) in Motion events, puts us in a position to directly test whether infants of this age represent Sources and Goals asymmetrically. That is, when shown a Motion event that contains both a (salient) Source and a (ordinary) Goal, which component will 12-month-old infants prefer to track and encode? If infants selectively track and encode the Goal in preference to the Source then this would provide strong evidence for asymmetric Goal/Source encoding in pre-linguistic infants, and this,

---

13 Note that ‘in’ may be privileged in the sense that the perceptual changes that occur when something emerges ‘out of’ something else are more salient than the perceptual changes that occur when something
in turn, would support the broader hypothesis that the asymmetry between Sources and Goals extends to the non-linguistic spatial cognitive system.

### 2.6 Experiment 4 ‘Super’ Source vs. Goal Encoding at 12-months

#### 2.6.1 Method: Experiment 4

*Participants.* Participants were twenty-four 12-month-old infants (10 males, 14 females; Mean age = 11 months, 29 days; Range: 11 months, 18 days to 12 months, 11 days). Five infants were excluded (3 fussed out and 2 errors in the experimental procedure).

*Stimuli.* The stimuli were Motion events that included the two ‘salient’ Source objects from Experiment 3 (salient block and salient bowl) and the two ‘ordinary’ Goal objects from Experiment 1 (red block and green bowl). The Figure object (toy duck) and Motion (simple slide) were the same as those used in the previous experiments (see Figure 2.9 for a depiction of the stimuli and the procedure). In this experiment, the Source objects were located on the right of the stage (for half the infants) or on the left of the stage (for half the infants), and in the middle of the stage (i.e., neither front nor back). The Goal objects were located in the corner of the stage; the positions were counterbalanced for front/back and left/right across infants. Note that the Source and Goal objects were always positioned on opposite sides of the stage.

emerges ‘off of’ something else (see Gibson & Pick, 2000).
Figure 2.9. Schematic of the procedure for Experiment 4 ('Super' Source vs. Goal experiment). In familiarization, the duck moved from one of two salient Sources to one of two Goals. During inter-trial the objects did not switch locations. In three test trials, the duck moved from the Same Source/Different Goal and in three test trials the duck moved from a Different Source/Same Goal.
Procedure. Infants were familiarized to the Figure moving from one of two Source objects (off of the ‘salient’ block or out of the ‘salient’ bowl) to one of two Goal objects (onto the ‘ordinary’ block or into the ‘ordinary’ bowl). Unlike the previous experiment, during inter-trial, the objects’ locations were not switched; i.e., all objects remained in the same position throughout the entire experiment. During three test trials, infants viewed the Figure object moving from the Same Source object as in familiarization but to a Different Goal object, henceforth, Same Source/Different Goal. In another three test trials infants viewed the Figure object moving from a Different Source object as in familiarization but to the Same Goal object, henceforth, Different Source/Same Goal.

The type of familiarization trial (off of salient block onto ordinary block / off of salient block into ordinary bowl / out of salient bowl onto ordinary block / out of salient bowl into ordinary bowl) was counterbalanced across infants. The presentation of the two types of test trials were alternated and presented in a counterbalanced order.

Reliability. In order to assess the reliability of the on-line coding, a second observer recoded 100% of the trials for twelve infants off-line. Intra-observer agreement was calculated by correlating the mean looking times for all the trials between the two observers. There was a significant correlation, $r = .98$, $p < .01$.

Prediction. If infants prefer to track and encode the Goal in preference to the Source during familiarization, then infants should look longer at the Same Source/Different Goal test trials compared to the Different Source/Same Goal test trials.
2.6.2 Results: Experiment 4

Preliminary analyses

The infants’ looking times decreased from the first to seventh familiarization trial \((Ms = 26.62, 16.85; SEs = 2.65, 1.77, \text{ for trials one and seven, respectively})\). The data from the seven familiarization trials were entered into a within subject analysis of variance and revealed a significant effect, \(F (6, 138) = 2.18, p < .05\), indicating that infants looked less across trials showing they were familiarized.

Primary analyses

Infants showed evidence of a Goal bias. A two-tailed paired t-test showed that, on average, infants looked longer at the test trials where the duck slid to the Same Source/Different Goal test trials \((M = 19.85, SE = 2.42)\) compared to the Different Source/Same Goal test trials \((M = 15.33, SE = 1.15)\), \(t (23) = -2.63, p < .05\) (see Figure 2.10). Eighteen out of the 24 infants showed this pattern. This pattern was also confirmed with a Wilcoxon signed ranks test which was performed on the difference between mean looking time at the two differences types of test trials for each infant \((z = -2.49, p < .05)\).

Additional analyses

None of the secondary variables significantly interacted with the primary variable.
Figure 2.10. Experiment 4: ‘Super’ Source vs. Goal encoding at 12-months. Average looking times (and SEs) at the two different Trial Types.
2.6.3 Discussion: Experiment 4

Experiment 4 directly tested whether 12-month-old infants prefer to track and encode the Goal in preference to the Source in Motion events. The results suggest that infants do indeed represent Sources and Goal asymmetrically – specifically, they show a Goal bias. Infants looked significantly longer at the test trials where the duck ended up at a different Goal compared to the test trials where the duck started out at a different Source. The presence of a Goal/Source asymmetry in pre-linguistic infants supports the broader hypothesis that this asymmetry extends beyond language to non-linguistic event representations.

2.7 General Discussion

The findings from Experiments 1-4 suggest that 12-month-old infants are able to encode the Goal in Motion events (Exp. 1). Infants of this age do not show evidence for encoding the Source (Exp. 2) unless the Source objects are made sufficiently salient (Exp. 3). Finally, when shown an event that contains both a (ordinary) Goal and (salient) Source, 12-month-olds prefer to track and encode the Goal in preference to the Source.

These results provide useful information about the conceptual foundations of spatial language. First, they suggest that 12-month-old infants encode Goals in Motion events. This finding is consistent with previous research showing that infants know about Goals in Psychological/Mentalistic events and Physical/Non-Mentalistic events (see Section 1.2.4). Furthermore, the current results suggest that infants also encode the
Source in Motion events, given that the Source is made sufficiently salient. The fact that pre-linguistic infants show evidence of representing Sources and Goals in Motion events is significant given that infants start *linguistically marking* these reference objects by 14-21 months of age (Choi & Bowerman, 1991). Thus, it appears that infants are able to non-linguistically represent Sources and Goals prior to marking them in language. These findings set the stage for future research to explore whether the linguistic categories of ‘Source’ and ‘Goal’ mirror the non-linguistic categories of ‘Source’ and ‘Goal’, and what role language may play in determining the nature of non-linguistic Source/Goal representations.

The finding that 12-month-old infants represent Sources and Goals asymmetrically not only yields information about how pre-linguistic infants represent these reference objects with respect to each other, but it also supports the broader hypothesis that the Goal/Source asymmetry observed in language extends to non-linguistic Motion events representations in general. That is, Sources and Goals appear to be hierarchically organized not only in language, but also in non-linguistic spatial cognition. Chapter 3 seeks converging evidence for this finding, and explores, in more detail, in what ways this asymmetry may come to exist and the extent to which this bias characterizes cognition.
CHAPTER 3: STUDY 2: GOAL/SOURCE ASYMMETRY IN ADULTS AND 4-YEAR-OLD CHILDREN

The first two experiments in this chapter test the hypothesis that the Goal/Source asymmetry found in language extends to the non-linguistic Motion event representations of adults and 4-year-old children. Support for this hypothesis would provide converging evidence for the findings reported in Study 1. Next, the remaining experiments (Experiments 6a and 6b and 7a and 7b) explore the nature of asymmetric Goal/Source encoding by investigating under what conditions Goals are encoded in preference to Sources. Experiments 6a and 6b explore whether Goals are encoded better than Sources under conditions where the intentionality in the event is manipulated by having the Figure object look back at the Source as it moves towards the Goal. Experiments 7a and 7b further explore the role of intentionality, as well as other conceptual factors, by testing whether Goals and Sources are asymmetrically encoded in the representations of Physical/Non-Mentalistic events – events falling under a different core cognitive domain than the Motion events previously discussed. Together, the findings from the experiments in this chapter aim to explore further whether Goals and Sources are hierarchically organized in spatial cognition and provide insight about the nature of a non-linguistic Goal bias.
3.1 Experiments 5a/5b: Non-Linguistic Goal/Source Asymmetry

3.1.1 Experiment 5a: Adults

3.1.1.1 Method: Experiment 5a

Participants. Participants were fourteen Johns Hopkins undergraduates who were recruited through the Psychology department’s subject pool. Before participating in the experiment, each participant signed an informed consent. Both the method of recruitment and informed consent were approved by Johns Hopkins University.

Stimuli. The stimuli were 74 Manner of Motion events. The events were comprised of a Figure undergoing some Motion from a Source object to a Goal object (see Figure 3.1). The events were 2.5 seconds long and all event components remained on the screen throughout the entire event. Source and Goal objects were real life objects, such as a table, chair, and basket. Motions were spinning, walking, hopping, running, rolling, lunging, crawling, skipping, and dancing. Figures were women and men. All events were videotaped. In half of the events the Source object was located on the left side of the scene and the Goal was located on the right side (hence the Figure moved from left to right), and in the other half of the events the Source object was located on the right side of the scene and the Goal was located on the left side (hence the Figure moved from right to left).
Figure 3.1. Clip from one of the events used in Experiments 5a and 5b. In this event the Figure (man) is hopping from the Source (table) to the Goal (ladder). Note that the actual stimuli used in the experiments were movies, not static clips.
There were 37 trials and each trial consisted of a pair of events. Trials fell into one of the following three categories: the pair of events was exactly the Same (N = 9), the pair of events had Different Sources (N = 9), or the pair of events had Different Goals (N = 9). In order to increase the difficulty of the task, there were also 10 filler trials where the pair of events had Different Figures (N = 5) or Different Motions (N = 5). In order to control for the saliency of the change, all Source changes and Goal changes were identical. That is, if there was a Source change pair where a TV was replaced by a cart, there was also a Goal change pair where a TV was replaced by a cart.

Procedure. This experiment used a method that builds on findings from change blindness studies suggesting that individuals fail to notice all the information contained in a scene (see Simons, 2000 for a review). I will call this method Detecting Changes. In this method, each trial began with participants viewing the first event, then the screen went black for 10 seconds, and then participants viewed the second event. After viewing the second event, participants were asked to judge whether the events were the same or different (by circling ‘same’ or ‘different’ on their test sheet), and to judge how confident they were in their decision (by circling a number one to five on their test sheet: one was least confident, five was most confident). Also, if participants indicated ‘different’ they were asked to indicate (on their test sheet) how the two events differed. That is, they were asked to name the component in the first event and the component in the second event.

In order to prevent linguistic encoding, participants were asked to verbally shadow a sequence of numbers and words that were played from the computer. This

---

14 Special thanks to Dr. Helene Intraub for her extremely helpful suggestions on the Detecting Changes Method.
method of verbal interference has been used successfully in previous studies of spatial encoding (e.g., Hermer-Vasquez, Spelke, & Katsnelson, 1999). Furthermore, in order to increase the complexity of the task, participants were asked trivia questions during the 10 second delay between each event in the pair. Pilot data suggested that this manipulation was necessary in order to prevent adults from performing at ceiling in this task.

Before the experiment began, the participants received practice trials. There were four practice trials that included pairs of Non-Manner of Motion events, such as a teddy bear sitting on the table and a girl clapping. In two of the practice trials the events were the same and in two of the practice trials the events were different. The procedure during practice was exactly the same as that used for the real experiment (verbal shadowing, trivia questions, etc.). Experiments 6a and 7a used the same practice trials.

**Prediction.** If adults have a non-linguistic bias to encode Goals, they should be better at detecting the Goal changes than Source changes. Specifically, they should be more likely to judge an event as ‘different’ when there was a Goal change than when there was a Source change.

3.1.1.2 Results: Experiment 5a

**Preliminary Analyses**

In order to explore how well participants performed on this task, overall proportion correct was compared to chance performance (.50). This analysis revealed that overall proportion correct ($M = .78, SE = .03$) was significantly greater than chance, $t$

---

15 Chance performance was .50 because for each item participants had two choices - same or different.
(13) = 8.14, p < .01, suggesting that participants were able to perform this task. A further analysis showed that the events that had a change were not significantly more difficult than the events that had no change (M for Change events = .77, SE = .04, M for No Change events = .83, SE = .03; t (13) = -1.09, p > .10).

**Primary Analyses**

Figure 3.2 shows that participants were better at detecting Goal changes than Source changes. This pattern was confirmed by a two-tailed t-test comparing the proportion of correct responses for Goal and Source change trials, t (13) = -2.74, p < .05. The next analysis examined individual participant data. Figure 3.3 plots each participant’s performance as a function of number of Goal change trials correct minus the number of Source change trials correct. Thus, participants who received a score of zero got an equal number of Goal and Source change trials correct, participants who received a positive score had a ‘Goal bias’ (got more Goal change trials correct), and participants who received a negative score had a ‘Source bias’ (got more Source change trials correct). As shown in Figure 3.3, 10 of the 14 adults had a Goal bias. A Wilcoxon signed ranks test was performed on these difference scores and confirmed that adults showed a Goal bias when encoding these events (z = -2.39, p < .05).

**Additional analyses**

Additional analyses examined how well adults encoded all four of the event components (Goal, Source, Figure, and Motion) with respect to each other. Adult although interesting, the results of these additional analyses in this experiment, and in all subsequent experiments, should be considered with caution. The current experiments were designed specifically to explore Source versus Goal encoding. These experiments were not specifically designed to test how well the Figure and Motion components are represented with respect to Source and Goal, and thus, the salience of the Figure and Motion changes were not properly controlled. In other words, one cannot be sure that the Figure and Motion changes were equally salient to the Goal and Source changes.
Figure 3.2. Experiment 5a: Average proportion correct (and SEs) of Goal and Source change trials for adults.
Figure 3.3. Experiment 5a: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 adults).
were better at encoding some event components compared to others. This observation was confirmed with a within subjects analysis of variance on proportions of correct responses for Goal, Source, Figure, and Motion, \( F(3, 39) = 13.86, p < .01 \). Contrasts revealed that adults judged more of the Goal (\( M = .75, SE = .06 \)), Figure (\( M = .96, SE = .03 \)), and Motion (\( M = .94, SE = .03 \)) changes correctly than Source changes (\( M = .59, SE \) = .09): \( F(1, 13) = 7.51, p < .05 \) for Goal vs. Source; \( F(1, 13) = 16.50, p < .05 \) for Figure vs. Source; \( F(1, 13) = 17.78, p < .05 \), for Motion vs. Source. Adults also judged more Figure and Motion changes correctly than Goal changes: \( F(1, 13) = 10.88, p < .05 \) for Figure vs. Goal; \( F(1, 13) = 10.23, p < .05 \) for Motion vs. Goal. Adults did not significantly differ in their judgments of Figure vs. Motion changes, \( F(1, 13) = 1.00, p > .10 \).

**Qualitative Analyses**

In addition to the quantitative analyses, two qualitative analyses were conducted in order to further explore asymmetric Goal/Source encoding. The first analysis explored whether a Goal/Source asymmetry would also be reflected in how well participants named the Goal and Source objects in the events. Recall that during the experiment, if participants judged that the two events were different they were asked to name (on their answer sheet) the original object (i.e., the object in the first event) and the changed object (i.e., the object in the second event). Thus, for every Goal and Source change trial judged correctly (i.e., when participants circled ‘different’), participants wrote the names of the Source and Goal objects. If a Goal/Source asymmetry also characterizes the quality of participants’ Source and Goal object representations, then they should produce more
correct names of the Goal objects (for the Goal change events), than correct names of the Source objects (for the Source change events).

In order to test this prediction, for each participant I looked at the Source change trials that were correct (i.e., the trials that had a Source change and the participant said ‘different’) and the Goal change trials that were correct (i.e., the trials that had a Goal change and the participant said ‘different’). Then, for these correct Source and Goal trials, I examined how often participants correctly named the original object and changed object. A second coder scored 20% of the utterances; reliability was 97%. Planned comparisons were performed on the proportion of correct responses for Source and Goal, for when the objects were the original objects and the changed objects. The means and results of these comparisons are reported in Table 3.1 (first row – Experiment 5a). As can be seen in Table 3.1, neither of these comparisons yielded significant effects, suggesting that a Goal/Source asymmetry was not reflected in the quality of participants’ Goal and Source object representations.

The second qualitative analysis examined participants’ confidence ratings in order to explore whether a Goal/Source asymmetry would be reflected in this measure. Recall that for each response, participants were asked to rate (on their answer sheet) how confident they were in their same or different judgment (1 = least confident and 5 = most confident). In this analysis, for each participant, I looked at the Source change trials that were correct (i.e., the trials that had a Source change and the participant said ‘different’) and the Goal change trials that were correct (i.e., the trials that had a Goal change and the participant said ‘different’). Then, for these correct Source and Goal trials, a mean confidence rating was obtained.
Table 3.1. Mean proportion (and SEs) of correctly named Source and Goal objects for the Source and Goal change trials that were correct.

<table>
<thead>
<tr>
<th>T</th>
<th>Source</th>
<th>Goal</th>
<th>t-test</th>
<th>Source</th>
<th>Goal</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>.13 (.07)</td>
<td>.17 (.04)</td>
<td>$t(11) = -.73, p &gt; .10$</td>
<td>.52 (.10)</td>
<td>.60 (.08)</td>
<td>$t(11) = -1.00, p &gt; .10$</td>
<td></td>
</tr>
<tr>
<td>.33 (.07)</td>
<td>.28 (.08)</td>
<td>$t(13) = 1.47, p &gt; .10$</td>
<td>.66 (.08)</td>
<td>.55 (.08)</td>
<td>$t(13) = 1.85, p = .09$</td>
<td></td>
</tr>
<tr>
<td>.31 (.05)</td>
<td>.43 (.05)</td>
<td>$t(23) = -2.10, p &lt; .05$</td>
<td>.61 (.05)</td>
<td>.66 (.05)</td>
<td>$t(23) = -.94, p &gt; .10$</td>
<td></td>
</tr>
</tbody>
</table>

Note. All comparisons were paired 2-tailed t-tests.

Note. The remainder of the responses that were not correct names fell into the following categories: incorrect names (Original object Source = .41, Original object Goal = .50, Changed object Source = .17, Changed object Goal = .24), blank responses (Original object Source = .27, Changed object Source = .15, Changed object Goal = .06), and other responses (e.g., responses were ambiguous; Original object Source = .15, Original object Goal = .06, Changed object Source = .16, Changed object Goal = .10).

The analyses for this experiment were conducted on 12 subjects’ responses because two subjects did not get any of the Source change trials correct.
The results showed that the mean confidence ratings were nearly identical for the correct Source change trials ($M = 4.16, SE = .21$) and the correct Goal change trials ($M = 4.15, SE = .18$); $t(11) = .02, p > .10$. This result suggests that a Goal/Source asymmetry was not reflected in participants’ confidence ratings.

3.1.1.3 Discussion: Experiment 5a

Participants encoded Goals and Sources asymmetrically. Specifically, adults judged more of the Goal changes correctly than the Source changes, suggesting that Goals are encoded better than Sources in non-linguistic Motion event representations. This finding converges with the findings of Study 1 and supports the hypothesis that Goals and Sources are hierarchically represented in spatial cognition. Furthermore, it is interesting to note that participants in this experiment judged more Figure and Motion changes correctly than Source and Goal changes, suggesting that the Figure and Motion may be salient components of the event, hence encoded well by participants.

Qualitative analyses revealed that participants’ identifications of the Source and Goal objects in the events did not show a Goal/Source asymmetry. That is, participants were just as good at naming a Goal object compared to a Source object. This finding suggests that although Sources are encoded less well than Goals, when they are encoded, the representation of a Source seems to be just as good as the representation of a Goal.

The fact that both adults (in the current experiment) and infants (in Study 1) show a Goal bias when non-linguistically encoding events suggests that a Goal/Source asymmetry may be a fundamental aspect of the way non-linguistic event representations
are structured. That is, these representations may be structured such that conceptual Goals are ranked higher than conceptual Sources, an asymmetry which is then reflected in language. If a Goal/Source asymmetry is a fundamental aspect of event cognition, then we may expect individuals at any point in development to encode Goals and Sources asymmetrically. Experiment 5b explores this possibility by testing 4-year-old children.

3.1.2 Experiment 5b: Children

3.1.2.1 Method: Experiment 5b

Participants. Participants were fourteen 4-year-old children (4 males and 10 females; Mean age = 4 years, 6 months; Range: 4 years, 1 month to 4 years, 11 months). The children were recruited through the Landau Lab’s subject pool. Before participating in the experiment, each participant’s parent signed an informed consent. Both the method of recruitment and informed consent were approved by Johns Hopkins University. At the end of the experiment, children received a small toy in appreciation for their participation.

Stimuli and Design. The stimuli and design were the same as those used in Experiment 5a.

Procedure. The procedure was the same as that used in Experiment 5a, with the following three exceptions. After viewing an event pair, children were only asked if the events were the same or different. Children were not asked to name the objects for ‘different’ trials and were not asked to judge how confident they were in their decision. In
addition, children were not asked trivia questions during the 10 second delay period. Rather, during that time, the experimenter would say to the child, “Remember, remember, remember, don’t forget, don’t forget”. Pilot testing revealed that asking the children trivia questions, albeit simple trivia questions, resulted in children giving long winded answers that disrupted the likelihood of their watching the second event in the pair. Children also received a different pre-training from the adults. Children received five practice trials which included pairs of Motion events, similar to, but not identical to, the events that were used as test stimuli. In one practice trial the events were the same, and in four practice trials the events were different. Specifically, there was one Goal change, Source change, Figure change, and Motion change. As in Experiment 5a, the procedure during practice was exactly the same as that used for the real experiment.

**Prediction.** If children have a non-linguistic bias to encode Goals, they should be better at detecting the Goal changes than Source changes. Specifically, they should be more likely to judge an event as ‘different’ when there is a Goal change than when there is a Source change.

### 3.1.2.2 Results: Experiment 5b

**Preliminary analyses**

To explore how well children performed on this task, overall proportion correct was compared to chance performance (.50). This analysis revealed that overall proportion correct ($M = .60$, $SE = .03$) was significantly greater than chance, $t (13) = 3.19$, $p < .01$, suggesting that children were able to perform this task. A further analysis showed that
the events that had a change were not significantly more difficult than the events that had no change ($M$ for Change events $= .60$, $SE = .04$, $M$ for No Change events $= .59$, $SE = .05$; $t (13) = .10, p > .10$).

**Primary analyses**

Similar to adults, children were better at detecting Goal changes than Sources changes (see Figure 3.4). This observation was confirmed by a two-tailed t-test comparing the proportion of correct responses for Goal change trials and Source change trials, $t (13) = -2.94, p < .05$. As in Experiment 5a, individual participant data were also examined and plotted in Figure 3.5. Nine of the 14 children showed a Goal bias. A Wilcoxon signed ranks test was performed on these difference scores and confirmed that children showed a Goal bias when encoding these events ($z = -2.36, p < .05$).

**Additional analyses**

A within subjects analysis of variance on proportions of correct responses for Goal, Source, Figure, and Motion revealed that children were better at encoding some event components than others, $F (3, 39) = 9.52, p < .05$. Contrasts revealed that children correctly judged more of the Goal ($M = .65$, $SE = .06$) and Figure ($M = .80$, $SE = .07$) changes than Source changes ($M = .48$, $SE = .04$): $F (1, 13) = 8.62, p < .05$ for Goal vs. Source; $F (1, 13) = 21.38, p < .05$ for Figure vs. Source. Children also judged more Goal and Figure changes correctly than Motion changes ($M = .53$, $SE = .06$): $F (1, 13) = 5.99, p < .05$ for Goal vs. Motion; $F (1, 13) = 10.74, p < .05$ for Figure vs. Motion. Children did not significantly differ in their judgments of Source vs. Motion changes, $F (1, 13) = .90, p > .10$, and Goal vs. Figure, $F (1, 13) = 3.83, p > .05$. 

96
Figure 3.4. Experiment 5b: Average proportion correct (and SEs) of Goal and Source change trials for children.
Figure 3.5. Experiment 5b: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 children).
3.1.2.3 Discussion: Experiment 5b

Children, like adults, encoded Goals and Sources asymmetrically. They too judged more of the Goal change trials correctly than the Source change trials, suggesting that they also encode Goals better than Sources when non-linguistically representing Motion events. In addition, children judged more Goal and Figure changes correctly than Motion changes, a pattern which was not observed with adults. Although this finding must be considered with caution (see Footnote 16), it may suggest that for children, the Motion component is not encoded as well as other event components (Goal and Figure).

3.2 General Discussion: Experiments 5a/5b

The fact that infants (Study 1), children, and adults all show a Goal bias when non-linguistically encoding a Motion event suggests that a Goal/Source asymmetry is a fundamental characteristic of the way individuals non-linguistically represent events throughout development. That is, Goals and Sources seem to be hierarchically organized such that Goals outrank Sources in spatial cognition. This hierarchy is then reflected in language in many different forms (see Section 1.2.5). Thus, the presence of a non-linguistic asymmetry provides one example of how non-linguistic conceptual representations serve as a basis for linguistic structure and a support for language learning.

Armed with evidence that individuals represent Goals and Sources asymmetrically when non-linguistically encoding Motion events, the remainder of this
thesis seeks to explore the nature of this asymmetry in spatial cognition. In Experiments 6a/6b we consider the possibility that attention may be playing a role in asymmetric Goal/Source encoding and explore whether the intention embodied in the event may drive attention to the Goal in preference to the Source. In Experiments 7a/7b, we continue to explore the role of intentionality, as well as other conceptual factors, by investigating whether a Goal bias extends to individuals’ representations of Physical/Non-Mentalistic events – events that are not intentional.

### 3.3 Experiments 6a/6b: The Nature of a Goal/Source Asymmetry\(^\text{17}\)

In these experiments we begin to explore why Goals are encoded in preference to Sources. What factors are involved in asymmetric Goal/Source encoding? One likely possibility is attention. Perhaps Goals are encoded better than Sources because individuals attend more to the Goal than to the Source when encoding an event. This explanation seems especially likely when considering findings from change blindness studies. Change blindness is the inability to spot changes in the visual details of objects and scenes (Simons, 2000). That fact that this phenomenon occurs so robustly provides strong evidence “against the idea that our brains contain a picture-like representation of the scene that is everywhere detailed and coherent” (Rensink, 2000, p. 17; see also Hochberg, 1986). Rather, Rensink (2000) suggests that in order for a stable object representation to be formed, focused attention must be allocated to the object in a scene. Thus, perhaps individuals in Experiments 5a and 5b often failed to detect the Source.

\(^{17}\text{Many thanks to Dr. Amy Shelton for suggesting these experiments.}\)
change in the events because they rarely focused their attention on the Source object. The aim of Experiment 6a and 6b was to create events where individuals would allocate more attention to the Source object, thus perhaps increasing the likelihood that the Source object would be encoded.

But how could we get individuals to attend more to the Source object? What conceptual factors drive attention to the Goal in preference to the Source? One possibility is intention. Consider the following Motion event: a person walks from a chair to a desk. Note that in this event the Figure object is animate and is walking away from the chair (Source) to the desk (Goal), while looking at the desk (Goal). Many would agree that this is a very natural event, people usually look to where they are headed; i.e., they look at the Goal (if they didn’t, they would bump into the object!). But what is interesting about this event for the current study is that where one looks is often a good indicator of one’s intentions (e.g., Woodward, 2003). People usually look at the Goal because they intend to go to the Goal. Given this, it is possible that the intentionality of the Figure object (as cued, for example, by the direction of his eye gaze) may play a significant role in a bias to encode Goals in preference to Sources.

In order to test this possibility, for Experiments 6a and 6b we manipulated the intentionality of the Figure object, by having the Figure look back at the Source, rather than at the Goal, as he went from the Source to the Goal. Adults, young children, and even infants are able to follow the eye gaze of another individual and often use another individual’s gaze to direct their own attention (Butterworth & Jarrett, 1991; D’Entremont, Hains & Muir, 1997; Hood, Willen, & Driver, 1998; Scaife & Bruner, 1975). Given this, we reasoned that individuals may be more likely to attend to the Source object in events
where the Figure object gazes continuously back at the Source while moving from the Source to the Goal, thus signaling that he intends to move away from the Source rather than towards the Goal. We explored this possibility with adults in Experiment 6a and with 4-year-old children in Experiment 6b.

3.3.1 Experiment 6a: Adults

3.3.1.1 Method: Experiment 6a

Participants. Participants were fourteen Johns Hopkins undergraduates who were recruited through the Psychology department’s subject pool. Before participating in the experiment, each participant signed an informed consent. Both the method of recruitment and informed consent were approved by Johns Hopkins University.

Stimuli. The stimuli were 74 Manner of Motion events and were very similar to those in Experiment 5a. They also depicted a Figure object moving from a Source object to a Goal object. However, unlike the events in Experiment 5a, as the Figure moved from a Source object to a Goal object, the Figure looked back continuously at the Source object as he moved to the Goal object (see Figure 3.6). As in Experiment 5a, the events were 2.5 seconds long and all event components remained on the screen throughout the entire event. The Source and Goal objects were exactly the same as those used in Experiment 5a. The Motions and Figures were very similar to those used in Experiment 5a (Motions were walking, hopping, running, lunging, crawling, skipping, and dancing, and Figures were men and women). All events were videotaped. In half the
Figure 3.6. Clip from one of the events used in Experiments 6a and 6b (‘Look Back’). In this event the Figure (man) is hopping from the Source (table) to the Goal (ladder), while looking back at the Source. Note that the actual stimuli used in the experiments were movies, *not* static clips.
events the Source object was located on the left side of the scene and the Goal was located on the right side (hence the Figure moved from left to right), and in the other half of the events the Source object was located on the right side of the scene and the Goal was located on the left side (hence the Figure moved from right to left).

Design. The design was the same as that used in Experiment 5a. The Source and Goal changes were also exactly the same as those in Experiment 5a.

Procedure. The procedure was the same as that used in Experiment 5a.

Prediction. If attention, and perhaps intention, plays a role in a Goal bias, then the asymmetry between Sources and Goals should disappear, or maybe even reverse, under conditions where the Figure moves from the Source to the Goal while looking back continuously at the Source.

3.3.1.2 Results: Experiment 5a

Preliminary analyses

To explore how well participants performed on this task, overall proportion correct was compared to chance performance (.50). This analysis revealed that overall proportion correct ($M = .82, SE = .03$) was significantly greater than chance, $t (13) = 10.45, p < .01$, showing that participants were able to perform this task. A further analysis showed that the events that had a change were not significantly more difficult than the events that had no change ($M$ for Change events = .81, $SE = .03$, $M$ for No Change events = .86, $SE = .05$; $t (13) = -.84, p > .10$).
Primary analyses

Figure 3.7 shows that Goals and Sources did not differ as to how well they were encoded. This observation was confirmed by a two-tailed t-test comparing the proportion of correct responses for Goal and Source change trials, $t(13) = -0.50, p > .10$. Individual participant data further confirmed this pattern (see Figure 3.8). Only six of the 14 adults showed a Goal bias. A Wilcoxon signed ranks test was performed on these difference scores and confirmed that adults did not encode Goals and Source asymmetrically ($z = -0.74, p > .10$).

Additional analysis

To examine how well adults encoded all four of the event components a within subjects analysis of variance was conducted on the proportion of correct responses for Goal, Source, Figure, and Motion. This analysis revealed no significant differences as to how well the event components were encoded ($M$s = .83, .82, .81, .74; $SE$s = .04, .05, .04, .06 for Goal, Source, Figure, and Motion respectively; $F(3, 39) = 1.16, p > .10$).

Qualitative Analyses

As in Experiment 5a, two qualitative analyses were performed to further explore the possibility of a Goal/Source asymmetry. The first qualitative analysis examined how participants named the Source and Goal objects, and the second analysis examined participants’ confidence ratings. Although the quantitative analyses presented above do not provide evidence for asymmetric Goal/Source encoding, it is possible that an asymmetry may be evident in these additional measures. The coding and analyses for
Figure 3.7. Experiment 6a, ‘Look Back’: Average proportion correct (and SEs) of Goal
and Source change trials for adults.
Figure 3.8. Experiment 6a ‘Look Back’: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 adults).
these additional analyses were the same as those in Experiment 5a. A second coder scored 20% of the utterances; reliability was 100%.

In the first qualitative analysis, planned comparisons were performed on the proportion of correct names of Source and Goal, for when the objects were the original objects (i.e., objects in the first event) and the changed objects (i.e., objects in the second event). The means and results of these comparisons are reported in Table 3.1 (second row – Experiment 6a). As can be seen, when the objects were the changed objects, there was a marginal effect, suggesting that Sources were correctly encoded more often than Goals - a pattern which certainly does not reflect a Goal bias.

As in Experiment 5a, the second qualitative analysis examined the participants’ confidence ratings in order to explore whether a Goal/Source asymmetry would be reflected in this measure. The results showed that the mean confidence ratings did not significantly differ for the correct Source change trials ($M = 4.24$, $SE = .14$) vs. the correct Goal change trials ($M = 4.03$, $SE = .18$); $t (13) = 1.71$, $p > .10$. This result suggests that participants’ confidence ratings did not reflect asymmetric Goal/Source encoding.

3.3.1.3 Discussion: Experiment 6a

Unlike the findings of Experiment 5a, adults did not encode Goals and Sources asymmetrically. That is, when viewing Motion events that involved a Figure moving from a Source to a Goal but looking back continuously at the Source, adults did not significantly differ as to how well they encoded the Source and Goal objects. Thus, for
adults, the direction the Figure’s eye gaze influenced whether Sources and Goals would be asymmetrically encoded, suggesting that attention and intention play a role in a Goal bias. Experiment 6b explored whether this would also be the case for four-year-old children.

3.3.2 Experiment 6b: Children

3.3.2.1 Method: Experiment 6b

Participants. Participants were fourteen 4-year-old children (3 males and 11 females; Mean age = 4 years, 6 months; Range: 4 years, 1 month to 4 years, 11 months). The children were recruited through the Landau Lab’s subject pool. Before participating in the experiment, each participant’s parent signed an informed consent. Both the method of recruitment and informed consent were approved by Johns Hopkins University. At the end of the experiment, children received a small toy in appreciation for their participation.

Stimuli and Design. The stimuli and design were the same as those used in Experiment 6a.

Procedure. The procedure was the same as that used in Experiment 5b with the exception that the stimuli for the practice trials included Motion events where the Figure moved from the Source to the Goal, but continuously looked back at the Source as she moved to the Goal. As in Experiment 5b, there was a practice trial for each event type.
(Same, Source change, Goal change, Figure change, and Motion change). None of the practice events were identical to the test events.

_Prediction_. If attention, and perhaps intention, plays a role in a Goal bias, then the asymmetry between Sources and Goals should disappear, or maybe even reverse, under conditions where the Figure moves from the Source to the Goal while looking back continuously at the Source.

3.3.2.2 Results: Experiment 6b

_Preliminary analyses_

To explore how well children performed on this task, overall proportion correct was compared to chance performance (.50). This analysis revealed that overall proportion correct ($M = .60, SE = .03$) was significantly greater than chance, $t (13) = 4.12, p < .01$, suggesting that children were able to perform this task. A further analysis showed that the events that had a change were not significantly more difficult than the events that had no change ($M$ for Change events = .60, $SE = .04$, $M$ for No Change events = .62, $SE = .04$; $t (13) = -.27, p > .10$).

_Primary analyses_

Figure 3.9 illustrates the proportion of correct responses for the Goal and Source change trials. A two-tailed t-test conducted on these data yielded no significant difference, $t (13) = -1.39, p > .10$, suggesting that Goals and Sources did not differ much as to how well they were encoded. Examination of the individual participant data showed that eight of the 14 children showed a bias to encode Goals (see Figure 3.10). A
Figure 3.9. Experiment 6b, ‘Look Back’: Average proportion correct (and SEs) of Goal and Source change trials for children.
Figure 3.10. Experiment 6b ‘Look Back’: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 children).
Wilcoxon signed ranks test performed on these difference scores showed the Goals and Sources were not encoded asymmetrically \( (z = -1.34, p > .10). \)

Further inspection of Figure 3.10 reveals that a group of children (specifically, participants 5, 6, 8, 9, and 10) seemed to continue to show a Goal bias, despite the looking back manipulation. In order to further explore this, a two-tailed paired t-test was performed on the proportion of correct responses for Goal and Source change trials for these participants. The results suggest that Goals and Sources were asymmetrically encoded \( (M = .82, .38; SE = .04, .06, \text{ for Goal and Source change trials, respectively}; t(4) = -8.94, p < .01) \), suggesting that a Goal bias did indeed persist for these children despite the look back manipulation.\(^{18}\)

**Additional analyses**

A within subjects analysis of variance on the proportion of correct responses for Goal, Source, Figure, and Motion suggests that some event components were encoded better than others, \( F(3, 39) = 4.35, p < .05. \) Contrasts revealed that children judged more Goal \( (M = .70, SE = .06) \), Source \( (M = .58, SE = .07) \), and Figure \( (M = .63, SE = .06) \) changes correctly than Motion changes \( (M = .43, SE = .07) \): \( F(1, 13) = 9.25, p < .05 \) for Goal vs. Motion; \( F(1, 13) = 4.59, p = .05 \) for Source vs. Motion; \( F(1, 13) = 11.38, p < .05 \) for Figure vs. Motion. Children did not significantly differ in their judgments of Goal vs. Source \( (F(1, 13) = 1.92, p > .10) \), Goal vs. Figure \( (F(1, 13) = .59, p > .10) \), and Source vs. Figure \( (F(1, 13) = .59, p > .10) \).

\(^{18}\) Similar to adults in Experiment 6a, and the primary analysis above, when a two-tailed t-test was performed on the data from the remaining nine participants, a Goal/Source asymmetry was not found \( (M = .63, .69; SE = .08, .07, \text{ for Goal and Source change trials, respectively}; t(8) = .76, p > .10) \), suggesting that the look-back manipulation was effective for most children.
3.3.2.3 Discussion: Experiment 6b

Similar to the adults in Experiment 6a, children did not encode Goals and Sources asymmetrically. That is, when viewing Motion events that involved a Figure moving from a Source to a Goal but *looking back continuously* at the Source, children did not show a significant bias for encoding Goal objects compared to Source objects. Thus, it appears that, for (most) children, the direction the Figure’s eye gaze also influenced whether Goals and Sources would be asymmetrically encoded, suggesting that attention and intention play a role in Goal bias.

Before concluding this section, recall that although most children did not encode Goals and Source asymmetrically (thus, reflecting the adult pattern in Experiment 6a), a small group of children did continue to show a Goal bias (see Figure 3.10). Given that even infants are able to follow another individual’s eye gaze (Butterworth & Jarrett, 1991; D’Entremont, Hains & Muir, 1997; Hood, Willen, & Driver, 1998; Scaife & Bruner, 1975), why would 4-year-old children continue to show a Goal bias despite the Figure looking back at the Source?

One possibility is that a child’s knowledge of eye gaze may be enriched over development. As Woodward (2003) describes “a mature understanding of eye gaze is the product of a long process of development” (Woodward, 2003, p. 297). For example, although even infants as young as 2- to 6-months can follow an individual’s gaze, it is not until 9- to 12-months that infants understand that there is a relationship between a person’s gaze and the object of her gaze (Woodward, 2003). Then, further down the developmental pathway, gaze following becomes important for joint attention (e.g.,
Tomasello, 1995) and making inferences about another person’s epistemic state (e.g., O’Neill, 1996). Given this protracted period of development, it does not seem too surprising that some 4-year-olds in the current study may have continued to show a Goal bias despite the Figure looking back at the Source. Perhaps the ‘look back’ manipulation was not a strong enough cue for these children and/or perhaps these children have not yet developed a mature understanding about the link between eye gaze and intentionality. Future research should explore these possibilities.

3.4 General Discussion: Experiments 6a/6b

The results of Experiments 6a and 6b suggest that attention and intention play a key role in Goals and Sources being asymmetrically encoded. When the Figure object moved from the Source to the Goal while looking back continuously at the Source, neither adults (Exp. 6a) nor children (Exp. 6b) showed a reliable Goal/Source asymmetry. These results differ from the findings of Experiment 5a and 5b, where both adults and children showed a clear Goal bias. In Experiments 7a and 7b, we further explore the role of intentionality in asymmetric Goal/Source encoding.

3.4.1 ‘Look Forward’ vs. ‘Look Back’ Experiments

Before turning to Experiments 7a and 7b, we take a slight detour to ask in what way the asymmetry diminished from Experiments 5a and 5b (Look Forward at Goal) to Experiments 6a and 6b (Look Back at Source). For example, did individuals’ detection
of the Source changes improve? Or did individuals’ detection of the Goal changes worsen? We are able to explore these questions by reexamining the mean proportion of correct Source and Goal changes in Experiments 5a/5b and 6a/6b. As shown in Figure 3.11, for adults and children, the mean proportion of correct Source change trials increased from Experiments 5a/5b (Look Forward at Goal) to Experiments 6a/6b (Look Back at Source). Whereas, the mean proportion of correct Goal change trials did not decrease, in fact it slightly increased, from Experiments 5a/5b (Look Forward at Goal) to Experiments 6a/6b (Look Back at Source).

For adults, these observations were confirmed with a 2 (Experiment: Look Forward/Look Back) x 2 (Reference object: Goal/Source) mixed analysis of variance. The results showed a significant interaction, $F(1, 26) = 4.60, p < .05$, suggesting that Sources and Goals were encoded asymmetrically in the Look Forward experiments, but not the Look Back experiments. There was also a significant main effect of Reference Object, $F(1, 26) = 6.93, p < .05$, suggesting that Goals were judged correctly more often than Sources overall. Furthermore, two separate one way analyses of variances showed that the proportion of Source correct was greater for Experiment 6a (Look Back) than for Experiment 5a (Look Forward), $F(1, 27) = 5.58, p < .05$. The proportion of Goal correct did not differ between the two Experiments, $F(1, 27) = 1.71, p > .05$. 
Figure 3.11. Panel A. Average proportion correct (and SEs) of Source and Goal changes for adults in Experiments 5a (‘Look Forward’) and 6a (‘Look Back’). Panel B. Average proportion correct (and SEs) of Source and Goal changes for children in Experiments 5b (‘Look Forward’) and 6b (‘Look Back’).
Similar statistical results were found with children when the data from the five children that continued to show a Goal bias were removed. A 2 (Experiment: Look Forward/Look Back) x 2 (Reference object: Goal/Source) mixed analysis of variance showed a significant interaction, $F(1, 21) = 5.67, p < .05$. Furthermore, two separate oneway analyses of variances showed that the proportion of Source correct was greater for Experiment 6b (Look Back) than for Experiment 5b (Look Forward), $F(1, 22) = 6.59, p < .05$. The proportion of Goal correct did not differ between the two Experiments, $F(1, 22) = .05, p > .05$.

Thus, these results suggest that the asymmetry diminished in Experiments 6a/6b because individuals’ encoding of the Source improved, not because individuals’ encoding of the Goal worsened. Thus, when shown Motion events involving a Figure moving from a Source to a Goal *while continuously looking back at the Source*, children and adults now encode the Source and also continue to encode the Goal.

The fact that the Goal/Source asymmetry did not reverse in Experiment 6a/6b suggests that the relative importance of Goals is sustained even under conditions where the Figure object is not looking at the Goal. Thus, despite the ‘looking back’ manipulation, the Goal remained important enough such that it did not drop below the Source in a conceptual structural hierarchy. There are several possible reasons why this may be the case. First, perhaps the forward self-propelled movement of the Figure object towards the Goal indicated that some of the Figure object’s intentions were still directed towards the Goal. Another possibility is that no matter how much attention is allocated to the Source, the encoding of the Goal will not suffer simply because the Goal is the end
point of the event. I return to this issue in the Chapter 4 where I discuss in more detail what factors may play a role in determining how an event’s components are hierarchically structured.

Given that the Goal/Source asymmetry did not reverse in Experiments 6a and 6b, one may think that participants performed better overall in these experiments. However, this was not the case. Overall proportion correct was remarkably similar for both experiments (for adults overall proportion correct was .78 in Experiment 5a and .82 in Experiment 6a, for children overall proportion correct was .60 in both experiments). However, what did differ between experiments was how well participants encoded the Figure and Motion components. Specifically, participants encoded the Figure and Motion more poorly in Experiments 6a and 6b, where the Figure looked back at the Source, compared to Experiments 5a and 5b, where the Figure looked ahead at the Goal (for adults, mean Figure correct was .96 in Experiment 5a vs. .81 in Experiment 6a, for children, mean Figure correct was .80 in Experiment 5b vs. .63 in Experiment 6b; for adults mean Motion correct was .94 in Experiment 5a vs. .74 in Experiment 6a, for children, mean Motion correct was .53 in Experiment 5b vs. .43 in Experiment 6b). This observation may suggest that adults and children may have certain amount of attention for encoding an event’s components, and when one event component captures more attention than usual (e.g., Source in Experiments 6a and 6b), the ability to encode other event components suffers.
3.5 Experiments 7a/7b: Goal vs. Source Encoding in Physical Events

Humans are endowed with domain specific systems of knowledge such as knowledge of language, knowledge of physical objects, and knowledge of number. Each system of knowledge applies to a distinct set of entities and phenomena…More deeply, each system of knowledge is organized around a distinct body of core principles (Carey & Spelke, 1994, p. 169).

This quote illustrates the idea that cognition is not one monolithic system, but rather is structured into separate core cognitive domains. The issue I address next in this thesis is whether a Goal/Source asymmetry is a phenomenon specific to one core cognitive domain, or whether it applies to multiple domains, thereby being a more general characteristic of cognition. As will be seen, exploring this issue will shed further light on what conceptual factors may play a role in asymmetric Goal/Source encoding.

The two domains I will focus on in this chapter are the domains of psychology and physics. I refer to events falling under the domain of psychology as Psychological/Mentalistic events and I refer to events falling under the domain of physics as Physical/Non-Mentalistic events. The domain of psychology involves reasoning about sentient, mental, animate beings and their behaviors, while the domain of physics involves reasoning about physical, inanimate, material objects and their behaviors. Much research has shown that adults, children, and even infants reason about objects and events falling under these two domains in fundamentally different ways.

For instance, recall from Section 1.2.4.1, Woodward found (1998) that 6-month-old infants were surprised when a human arm, but not a mechanical rod, reached for a new Goal object. Also Meltzoff (1995) found that 18-month-old infants imitated an
intended goal-directed act when an animate actor performed the action, but not when an inanimate actor did so. Furthermore, Johnson, Slaughter, and Carey (1998) found that infants treated a novel object as an agent (i.e., an entity with a mental state) only if the object either acted contingently with the infant, had a face, or possessed both of these characteristics. Specifically, when the novel object had one or both of these characteristics, 12-month-old infants would follow the novel object’s eye gaze, suggesting that they attributed perception and attention to the object. Infants did not follow the object’s gaze when the object did not have at least one of these characteristics. Finally, Premack and Premack (1997) found that infants attributed positive or negative value to a geometric object (e.g., viewed it as a ‘helper’ or ‘hinderer’) if the object acted intentionally—that is, if it was self-propelled and engaged in goal-directed movement. These are just a few of the many examples illustrating that even infants reason about objects in psychological and physical events differently.

The distinction between psychological and physical events is also illustrated by the way individuals talk about events. For example, a seminal study by Heider and Simmel (1945) used participants’ verbal descriptions as a measure of how they perceived events. The events in this study depicted geometric objects moving around a screen as if the objects were animate and engaged in either playful or belligerent behavior. Most adults perceived these events as meaningful and intentional, as illustrated by the way they described the scenes; participants described the actions with psychological/mental verbs such as ‘plan’, ‘want’, ‘try’, and ‘chase’ and described the geometric objects as people having psychological traits, such as ‘belligerent’, ‘mean’, and ‘playful’. Interestingly, one participant, who presumably did not perceive these events as psychologically
meaningful, described the scenes without using any mentalistic language. Rather this participant described the objects’ actions with non-mentalistic verbs, such as ‘move’ and ‘come’ and described the geometric objects as ‘large solid triangle’ and ‘circle’. The stark contrast in the way participants described the events illustrates the distinction between the psychological and physical domains (see Wellman & Phillips, 2001, for a discussion about how children also talk about psychological and physical events differently).

Given this structuring of cognition, one question that arises is whether the hierarchical structuring of Goals relative to Sources is a general characteristic of cognition, extending beyond one cognitive domain. Thus far, the Motion events explored in the current studies seem to fall naturally under the Psychological/Mentalistic domain. In the case of the infant experiments, the events involved an animate-like toy duck moving towards and/or away from an object, and in the case of Experiments 5a/5b and 6a/6b in the present study, all the events involved an animate person moving from one object to another. Note that the Figure object in these events, whether it was a stuffed duck or person, possessed many defining cues of ‘agenthood’ (e.g., morphological features such as eyes and face, asymmetry along one axis, goal-directed movement, and self-propelled movement; see Johnson, 2000 for a review of the notion of mentalistic agent). Given that these Motion events fall under the Psychological/Mentalistic domain, it remains an empirical question whether Goals and Sources in other types of events would also be asymmetrically encoded.

Experiments 7a and 7b explored this question by testing whether individuals would show a Goal bias when non-linguistically encoding Physical/Non-Mentalistic
events – events involving inanimate objects acting unintentionally. If a Goal/Source asymmetry is a general structural characteristic of cognition then individuals should show a Goal bias when encoding these events, similar to the way they asymmetrically encoded the Goals and Sources in Experiments 5a and 5b. But if conceptual factors, such as intentionality, play a role in a Goal/Source asymmetry (as suggested by the results of Experiments 6a/6b), then individuals may not encode Sources and Goals asymmetrically, since Physical/Non-Mentalistic events do not involve intention. We tested this possibility with adults in Experiment 7a and with children in Experiment 7b.

3.5.1 Experiment 7a: Adults

3.5.1.1 Method: Experiment 7a

Participants. Participants were twenty-four Johns Hopkins undergraduates who were recruited through the Psychology department’s subject pool. Before participating in the experiment, each participant signed an informed consent. Both the method of recruitment and informed consent were approved by Johns Hopkins University.

Stimuli. The stimuli were 64 Physical/Non-Mentalistic Motion events. The events were comprised of an inanimate Figure undergoing some Motion from a Source object to a Goal object (see Figure 3.12). The Source and Goal objects were real life objects, such as a cup, folder, and remote control. The Motion was either blowing or

---

19 Note that initially, as in the other experiments, we had a sample size of 14 adults. However, with this sample size we observed a small trend in the data suggesting asymmetric Goal/Source encoding (M Source = .69, SE = .06, M Goal = .77). Given this trend, we collected data from 10 more adults. However, as
Figure 3.12. Clips from two of the events used in Experiments 7a and 7b (Physical Events). In the first event the Figure (paper) blew from the Source (container) to the Goal (candle). In the second event the Figure (pen) rolled from the Source (camera) to the Goal (eyeglass case). Note that the actual stimuli used in the experiments were movies, not static clips.

reported in Section 3.5.1.2, the results remained the same. Thus, the lack of a significant Goal/Source asymmetry does not appear to be related to sample size.
rolling. The Figure objects were inanimate objects that could be easily blown (e.g., tissue, leaf, paper) and inanimate objects that could roll easily themselves (e.g., pen, battery, film case). The videos were constructed such that the inanimate object started at the Source object and then either blew or rolled to the Goal object. The blowing and rolling were accomplished by having a hidden hairdryer initiate the Figure’s movement, which produced the effect of an external wind causing the movement. The events were constructed in this manner in an effort to remove any animacy or intentionality that might be perceived in the event.\textsuperscript{20} As in the previous two experiments, the events were 2.5 seconds long and all event components remained on the screen throughout the entire event. All events were videotaped. In half of the events the Source object was located on the left side of the scene and the Goal was located on the right side (hence the Figure moved from left to right), and in the other half of the events the Source object was located on the right side of the scene and the Goal was located on the left side (hence the Figure moved from right to left).

Design. There were 32 trials and each trial consisted of a pair of events. Sixteen trials depicted ‘blowing’ and 16 trials depicted ‘rolling’. Trials fell into one of the following three categories: the pair of events was exactly the Same (N = 8, 4 ‘blowing’ and 4 ‘rolling’), the pair of events had Different Sources (N = 8, 4 ‘blowing’ and 4 ‘rolling’), or the pair of events had Different Goals (N = 8, 4 ‘blowing’ and 4 ‘rolling’). In order to increase the difficulty of the task, there were also 8 filler trials where the pair

\textsuperscript{20} In order to confirm that participants would not construe these events as intentional we had an additional five adults describe the events. We reasoned that if individuals construed these events as intentional, they would be likely to describe these events using mentalistic language, similar to the language used by the adults in Heider & Simmel’s study (1945). The results showed that adults did not use any mentalistic language when describing the events; e.g., adults mostly described the events as “the (inanimate object’s name) rolled” or “the (inanimate object’s name) blew”.

125
of events had Different Figures (N = 8, 4 ‘blowing’ and 4 ‘rolling’). In order to control for the saliency of the change, all Source changes and Goal changes were identical. That is, if there was a Source change pair where a remote was replaced by a cup, there was also a Goal change pair where a remote was replaced by a cup.

Procedure. The procedure was the same as that used in Experiment 5a and 6a.

Prediction. If adult’s non-linguistic bias to encode Goals extends to Physical/Non-Mentalistic events, then they should be better at detecting Goal changes than Source changes. Specifically, they should be more likely to judge the event as ‘different’ when there was a Goal change than when there was a Source change.

3.5.1.2 Results: Experiment 7a

Preliminary analyses

In order to explore how well participants performed on this task, overall proportion correct was compared to chance performance (.50). This analysis revealed that overall proportion correct (M = .80, SE = .02) was significantly greater than chance, t (23) = 13.39, p < .01, suggesting that participants were able to perform this task. A further analysis showed that the events that had a change were not significantly more difficult than the events that had no change (M for Change events = .78, SE = .03, M for No Change events = .86, SE = .04; t (23) = -1.62, p > .10).
Primary analyses

Figure 3.13 shows that there was a small difference in how well the Goal and Source were encoded with respect to each other. A two-tailed t-test conducted on proportion of correct responses for Goal and Source change trials revealed that this difference was not significant, $t(23) = -1.47, p > .10$. As in the previous two experiments, individual participant data were also examined (see Figure 3.14). Only half of the adults showed a Goal bias. A Wilcoxon signed ranks test was performed on these difference scores and showed that adults did not show a Goal bias when encoding these events ($z = -1.27, p > .10$).

Additional analysis

In order to explore how well adults encoded the three event components with respect to each other, a within subjects analysis of variance was conducted on the proportions of correct responses for Source, Goal, and Figure. This analysis revealed that there were no significant differences among the event components, $F(2, 46) = 2.10, p > .10$.

Qualitative Analyses

As in Experiments 5a and 6a, two qualitative analyses were performed to further explore the possibility of a Goal/Source asymmetry. The first qualitative analysis examined how participants named the Source and Goal objects and the second analysis examined participants’ confidence ratings. Although the quantitative analyses presented above do not provide evidence for asymmetric Goal/Source encoding, it is possible that
Figure 3.13. Experiment 7a, ‘Physical Events’: Average proportion correct (and SEs) of Goal and Source change trials for adults.
Figure 3.14. Experiment 7a ‘Physical Events’: Difference scores (# Goal correct - # Source correct) for each participant (N = 24 adults).
an asymmetry may be evident in these measures. The coding and analyses for these additional analyses were the same as those in Experiments 5a and 6a. A second coder scored 20% of the utterances; reliability was 97%.

In the first qualitative analysis, planned comparisons were performed on the proportion of correct names of Source and Goal objects, when the objects were the original objects (i.e., objects in the first event) and the changed objects (i.e., objects in the second event). The means and results of these comparisons are reported in Table 3.1 (third row – Experiment 7a). As can be seen, when the objects were the original objects, Goal objects were correctly named significantly more often than Source objects, perhaps suggesting a Goal/Source asymmetry.

As in the previous two experiments, the second qualitative analysis examined the participants’ confidence ratings in order to explore whether a Goal/Source asymmetry would be reflected in this measure. The results showed that the mean confidence ratings were again very similar for the correct Source change trials ($M = 4.22, SE = .09$) and the correct Goal change trials ($M = 4.28, SE = .10$); $t(23) = -.67, p > .10$. Thus, participants’ confidence ratings do not suggest asymmetric Goal/Source encoding.

3.5.1.3 Discussion: Experiment 7a

Participants did not encode Goals and Sources asymmetrically. That is, when viewing Motion events that involved an inanimate Figure blowing or rolling from a Source to a Goal, adults did not significantly differ as to how well they encoded the Source and Goal objects. However, it is noteworthy that participants’ Source and Goal
identifications revealed a slight Goal bias, suggesting that, although certainly not robust, there may be a tendency for adults to asymmetrically encode the Goals and Sources in the Physical/Non-Mentalistic events. Future work should further explore the quality of Goal and Source representations in these kinds of events.

3.5.2 Experiment 7b: Children

In this section we explored whether four-year-old children would show a Goal/Source asymmetry when representing Physical/Non-Mentalistic events. Although an asymmetry was not observed with adults in Experiment 7a, it is possible that young children will represent Goals and Sources asymmetrically in Physical/Non-Mentalistic events. Perhaps the asymmetry between Sources and Goals is one that starts out as a general bias – characterizing many different kinds of event representations - and then narrows as one develops and has more experience with different kinds of events. We explored this possibility with 4-year-old children below.

3.5.2.1 Method: Experiment 7b

Participants. Participants were fourteen 4-year-old children (8 males and 6 females; Mean age = 4 years, 8 months; Range: 4 years, 3 months to 4 years, 11 months). The children were recruited through the Landau Lab’s subject pool. Before participating in the experiment, each participant’s parent signed an informed consent. Both the method of recruitment and informed consent were approved by Johns Hopkins
University. At the end of the experiment, children received a small toy in appreciation for their participation.

**Stimuli and Design.** The stimuli and design were the same as those used in Experiment 7a.

**Procedure.** The procedure was the same as that used in Experiments 5b and 6b. As in Experiments 5b and 6b, children received five practice trials that included pairs of events. In this experiment the events were Physical Motion events, similar to, but not identical to, the events that were used as test stimuli. In one practice trial the events were the same, and in three practice trials the events were different. Specifically, there was one Goal change, one Source change, and one Figure change. As in Experiments 5b and 6b, the procedure during practice was exactly the same as that used for the real experiment.

**Prediction.** If children’s non-linguistic bias to encode Goals extends to Physical/Non-Mentalistic events, then they should be better at detecting Goal changes than Source changes. Specifically, they should be more likely to judge the event as ‘different’ when there was a Goal change than when there was a Source change.

### 3.5.2.2 Results: Experiment 7b

**Preliminary analyses**

In order to explore how well children performed on this task, overall proportion correct was compared to chance performance (.50). This analysis revealed that overall proportion correct ($M = .69, SE = .03$) was significantly greater than chance, $t(13) =$
6.24, \( p < .01 \), suggesting that children were able to perform this task. A further analysis showed that the events that had a change were not significantly more difficult than the events that had no change (\( M \) for Change events = .71, \( SE = .04 \), \( M \) for No Change events = .70, \( SE = .07 \); \( t (13) = .16, p > .10 \)).

Primary analyses

Similar to adults, children did not differ much in how well they encoded the Goal and Source objects (see Figure 3.15). This observation was confirmed with a two-tailed t-test performed on the proportion of correct responses for Goal and Source change trials, \( t (13) = -1.20, p > .10 \). Individual participant data also support this pattern with only 8 of the fourteen children showing a Goal bias (see Figure 3.16). A Wilcoxon signed ranks test was performed on these difference scores and showed that children did not show a Goal bias when encoding these events (\( z = -1.12, p > .10 \)).

Additional analyses

In order to explore whether there were any significant differences as to how well children encoded all three of the event components, a within subjects analysis of variance was conducted on the proportions of correct responses for Goal, Source, and Figure. This analysis yielded a significant effect, \( F (2, 26) = 6.92, p < .01 \). Contrasts revealed that children correctly judged more of the Goal (\( M = .79, SE = .05 \)) and Source (\( M = .72, SE = .05 \)) changes than Figure changes (\( M = .57, SE = .07 \)): \( F (1, 13) = 7.0, p < .05 \) for Source vs. Figure; \( F (1, 13) = 10.12, p < .01 \) for Goal vs. Figure. Children did not significantly differ in their judgments of Goal and Source changes, \( F (1, 13) = 1.44, p > .10 \).
Figure 3.15. Experiment 7b, ‘Physical Events’: Average proportion correct (and SEs) of Goal and Source change trials for children.
Figure 3.16. Experiment 7b ‘Physical Events’: Difference scores (# Goal correct - # Source correct) for each participant (N = 14 children).
3.5.2.3 Discussion: Experiment 7b

Similar to the adults in Experiment 7a, children did not encode Goals and Sources asymmetrically when representing Physical/Non-Mentalistic events. This result differs from the findings of Experiment 5b, where children showed a significant Goal/Source asymmetry.

In addition, unlike the findings of Experiment 5b, children encoded the Figure object less well than the Source and Goal objects. This may suggest that when Figure objects are inanimate they are encoded less well than Reference objects. However, one should note that the inanimate Figure objects in the Physical were much smaller than the animate, human Figures in the previous experiments. Thus, the poor encoding of the Figure object may be a result of the Figure object being less physically salient, rather than having to do with its conceptual status as an inanimate object.

3.6 General Discussion: Experiments 7a/7b

The results of Experiments 7a and 7b show that the asymmetry between Goals and Sources does not extend to Physical/Non-Mentalistic events – events including inanimate objects acting unintentionally. This was observed for adults in Experiment 7a and for 4-year-old-children in Experiment 7b. This finding suggests that the bias to encode Goals over Sources may be a domain-specific phenomenon; that is, one restricted to events falling under the psychological domain. If correct, then the hierarchical
structure of Goals and Sources may characterize the way individuals reason about the behaviors of sentient, mental, intentional, animate beings, but does not play a role in individuals’ reasoning about the behaviors of physical, inanimate objects.

CHAPTER 4: GENERAL SUMMARY AND CONCLUSIONS

Previous research in linguistics, psycholinguistics, and cognitive psychology suggests that, in language, Goals and Sources are represented asymmetrically. Specifically, there is a bias to encode Goals in preference to Sources. This linguistic phenomenon appears to be broad and robust; it has been observed in many different populations, across many different kinds of events, in many different languages, and in many different forms (see Section 1.2.5). The primary aim of this thesis was to explore whether the asymmetry between Sources and Goals is a unique characteristic of the linguistic system, or whether it extends to non-linguistic cognition. The findings from Study 1 and Experiments 5a and 5b of Study 2 suggest that the asymmetry between Goals and Sources does indeed extend to non-linguistic event representations. Given this, the secondary aim of this thesis was to explore the nature of a Goal/Source asymmetry in cognition; specifically, to investigate what factors may play a role in the bias to encode Goals in preference to Sources. The findings from Experiments 6a/6b suggest that attention and intention play a role in asymmetric Goal/Source encoding. The findings from Experiments 7a/7b suggest that a Goal bias does not characterize people’s representations of Physical events, thereby providing further support for the role of intention, as well as other conceptual factors, in a Goal bias.
Section 4.1 briefly reviews the current findings and Section 4.2 provides a discussion considering the phenomenon of a Goal/Source asymmetry in greater detail. Section 4.3 speculates about whether and how the phenomenon of asymmetric Goal/Source encoding may be related to a set of other cognitive phenomena – e.g., boundary extension and representational momentum. The thesis concludes by considering the theoretical implications of a Goal/Source asymmetry in Section 4.4.

4.1 Findings of the Dissertation

Study 1 tested whether a Goal/Source asymmetry extends to non-linguistic cognition by exploring whether and how pre-linguistic (12-months-old) infants represent Goals and Sources in Motion events. All of the experiments in Study 1 used a Visual Familiarization Paradigm. Experiment 1 tested whether infants encode Goal objects in Motion events. In this experiment infants were familiarized to a toy duck moving to one of two Goal objects. After familiarization, the locations of the two Goal objects were switched. During test, infants saw either the duck move to the Different Goal/Same Location or to the Same Goal/Different Location. Infants looked longer when the duck moved to a Different Goal/Same Location, suggesting that they encoded the Goal and found a change in Goal more surprising than a change in Location.

Experiment 2 used the same procedure as Experiment 1 but this time the objects were Sources rather than Goals; i.e., the duck moved away from one of two Source objects. Unlike the infants in Experiment 1, infants in Experiment 2 did not look longer when the duck moved from a Different Source/Same Location than from the Same
Source/Different Location, suggesting that they did not find a change in Source more surprising than a change in Location. These results do not provide any evidence that infants encoded the Source in Motion events. It was not until Experiment 3, when the Source objects were made more salient, that 12-month-old infants showed evidence for encoding the Source in Motion events. Thus, together, the results from Experiments 1-3 provide suggestive evidence that 12-month-old infants may encode Goals and Sources asymmetrically - while infants show evidence of encoding ‘ordinary’ Goal objects, they only show evidence of encoding ‘salient’ Source objects.

Experiment 4 directly tested whether 12-month-old infants represent Goals and Sources asymmetrically by showing infants an event that included both (salient) Sources and (ordinary) Goals and asking which component they would prefer to track and encode. Infants were familiarized to a toy duck moving from one of two (salient) Source objects to one of two (ordinary) Goal objects. During test, infants saw either the duck move from the Same Source as in familiarization but to a Different Goal or from a Different Source as in familiarization but to the Same Goal. Infants looked longer when the duck moved from the Same Source but to a Different Goal, suggesting that infants encoded the Goal and found the change in (ordinary) Goal more surprising than the change in (salient) Source. These results show that pre-linguistic infants have a bias to encode Goals in preference to Sources, and thus support the hypothesis that the asymmetry between Sources and Goals extends to the non-linguistic spatial cognitive system.

Experiments 5a and 5b of Study 2 sought converging evidence for a non-linguistic Goal/Source asymmetry by testing whether adults and 4-year-old children encode Goals and Sources asymmetrically when non-linguistically representing Motion events. These
experiments used a non-linguistic Detecting Changes Method in which participants viewed pairs of Motion events that sometimes differed from each other (i.e., events sometimes had a change in Goal, Source, Motion, or Figure). After viewing the second event in each pair, participants were asked if the events were the same or different. Adults (Experiment 5a) and children (Experiment 5b) correctly detected the Goal change significantly more often than the Source change, suggesting that they represented Goals and Sources asymmetrically. These findings provide further support for the hypothesis that a Goal/Source asymmetry extends to the non-linguistic spatial cognitive system.

The presence of a Goal/Source asymmetry in non-linguistic cognition motivated the second aim of this thesis – to explore the nature of asymmetric Goal/Source encoding. Specifically, Experiments 6a and 6b investigated whether attention and intention play a role in the preferential encoding of Goals, and Experiments 7a and 7b further explored the role of intention by testing whether a Goal/Source asymmetry is a general aspect of cognition, extending to Source and Goal objects in the physical domain. All of the experiments used the non-linguistic Detecting Changes Method that was used in Experiments 5a and 5b. Experiments 6a and 7a tested adults, and Experiments 6b and 7b tested 4-year-old children. Further studies are needed to directly explore these questions with pre-linguistic infants.

Experiments 6a and 6b explored whether attention and intention play a role in asymmetric Goal/Source encoding by testing whether participants would continue to show a Goal bias when viewing events that involved a Figure moving from a Source to a Goal while continuously looking back at the Source. Unlike the findings of Experiments 5a and 5b, neither adults (Experiment 6a) nor children (Experiment 6b) differed in their
detection of Goal and Source changes. Thus, attention and intention seem to play a key role in asymmetric Goal/Source encoding. Section 4.2 will discuss how these factors contribute to a Goal bias.

Experiments 7a and 7b further explored the role of intention and other conceptual factors by asking whether a Goal/Source asymmetry extends to Physical/Non-Mentalistic events – events involving an inanimate Figure moving unintentionally from a Source to a Goal. Unlike the findings of Experiments 5a and 5b, neither adults (Experiment 7a) nor children (Experiment 7b) showed an asymmetry. Thus, the asymmetry between Sources and Goals may be a phenomenon specific to events falling under the psychological domain – events involving conceptual factors such as intentionality and animacy.

In sum, the experiments in this thesis suggest that 1) the Goal/Source asymmetry, which has been observed so robustly in language, does extend to non-linguistic event representations, 2) the mechanism of attention plays a role in a Goal bias, and 3) conceptual factors associated with psychological reasoning, such as intentionality and animacy, may play a significant role in explaining the nature of asymmetric Goal/Source encoding. In Section 4.2 below, I provide a more detailed discussion of these findings and in Section 4.3 I speculate about how they may be related to a set of other cognitive phenomena, such as boundary extension and representational momentum.
4.2 Understanding a Goal/Source Asymmetry in Cognition

4.2.1 What is a Goal/Source Asymmetry?

What does it mean to say that a Goal/Source asymmetry extends to non-linguistic Motion event representations? Refer again to Jackendoff’s model of the space/language interface depicted in Figure 1.2. When individuals view an event, they first form a non-linguistic spatial representation of the event. This involves forming a representation of each event component (e.g., Source, Goal, Figure, Motion) and the spatial relationships among them (e.g., FROM-Paths, TO-Paths). Once these spatial representations are formed, they can be mapped into linguistic structure (e.g., semantic, syntactic, phonological) for purposes of language. Previous research suggests that, in language, Sources and Goals are hierarchically organized, such that Goals outrank Sources. For example, when individuals describe Motion events, there is a tendency to map Goals into syntactic structure (in English, the prepositional phrase) in preference to Sources (Lakusta & Landau, 2005). The current findings provide strong evidence that the hierarchical organization of Sources and Goals extends to non-linguistic cognition. That is, Goals also outrank Sources at the level of spatial event representations. This hierarchical structure is then reflected in the linguistic system.

Furthermore, the finding that a Goal/Source asymmetry is observed from infancy to adulthood suggests that this hierarchical organization is a fundamental characteristic of non-linguistic cognition. That is, the hierarchy does not appear to be a consequence of language acquisition, since even pre-linguistic infants encode Sources and Goals.
asymmetrically. Also, the Goal/Source hierarchy does not substantially change as one
develops, since adults also show asymmetric Goal/Source encoding. Thus, the
hierarchical organization of Goals and Sources is a structural characteristic of non-
linguistic event representations throughout development. In addition, the finding from
Experiment 6b showing that some children continue to show a Goal bias despite the
Figure looking back at the Source suggests that a Goal/Source asymmetry may become
enriched over development. For example, perhaps the factors (e.g., attention and
intention, see Section 4.2.2 below) that contribute to preferential Goal encoding may
themselves develop, thus affecting how Sources and Goals are represented with respect to
each other. Future research could further explore this possibility of enrichment.

4.2.2 Factors Involved in Asymmetric Goal/Source Encoding

Fully understanding a cognitive system goes beyond characterizing the
representations of the system and the way those representations are structured. It also
involves characterizing the mechanisms that operate over those representations. Given
this, the discussion that follows will consider what mechanisms play a role in asymmetric
Goal/Source encoding.

4.2.2.1 Memory

Does memory play a role in asymmetric Goal/Source encoding? Consider the way
the Motion events used in the current experiments unfold: the Figure starts out at the
Source object, moves towards the Goal object, and ends up at the Goal object. If people encode the Motion events by tracking the Figure object as it moves from the Source to the Goal, then they would likely encode the Source and Figure first, Figure and Motion second, and Goal and Figure last, thus resulting in the Goal being one of the last objects viewed, hence one of the most recent objects in memory. Thus, it is possible that a Goal bias may actually be a recency effect.

A recency effect is well documented in the memory literature. As Shiffrin (1973) explains,

The recency effect has commonly been attributed to the operation of short-term memory. It is assumed that the items near the end of the list are still in short-term memory when the recall period begins. These are output at once, giving rise to the recency effect, and all additional recall results from retrieval from long-term memory (p. 980).

Given this view, one may argue that the Goal is the ‘item’ near the end of the ‘list’ (list of event components; e.g., Source, Figure, Motion, Goal) and is favored over Sources because it is stored in short-term memory during test, whereas the Source must be retrieved from long-term memory during test (note that ‘test’ would be, for example, same/different judgments as required in the present experiments, or linguistic descriptions, as required in Lakusta & Landau, 2005).

There are several reasons to believe that a Goal bias cannot be explained fully, if at all, as a recency effect. The strongest evidence against this hypothesis is the finding from Experiments 7a and 7b showing that adults and children do not show asymmetric Goal/Source encoding for Physical/Non-Mentalistic events. These events were very similar to the Psychological/Mentalistic events used in Experiments 5a and 5b in that they too involved a Figure object starting out at the Source object, moving towards the
Goal object, and ending up at the Goal object. Thus, if participants encoded the event by tracking the movement of the Figure object, the Goal would be the last, hence the most recent, object the participant encoded. If a Goal bias can be explained as a recency effect, then individuals should have encoded Goals and Sources asymmetrically when viewing these Physical events, just as they did in Experiments 5a and 5b. The fact that a significant asymmetry was not found for the Physical/Non-Mentalistic events suggests that the temporal order of Source-Goal encoding does not fully explain a Goal/Source asymmetry in non-linguistic cognition.

Further evidence against the hypothesis that a Goal bias can be explained as a recency effect comes from preliminary eye-tracking data with infants and adults, suggesting that individuals do not encode events strictly by tracking the Figure object as it moves from the Source to the Goal. Rather, individuals seem to look back at the Source object even after the Figure leaves the Source. This has been observed with both infants and adults and is explained below.

Recall that in Experiment 4 of Study 1 infants viewed events involving a duck moving from one of two Source objects to one of two Goal objects. In order to explore in more detail how infants encoded these events, we referred back to the video-recordings of each infant and counted how many times each infant looked back to the Source object once the duck left the Source and moved towards the Goal. The results from this analysis showed that every infant looked back at the Source at least once after the Figure had left the Source object, suggesting that infants do not always encode the event strictly by tracking the Figure object as it moves from the Source to the Goal. Similar results have been found with adults. Recall that in Experiment 5a, adults viewed events involving a
person moving from a Source object to a Goal object. In order to explore how adults encode these events, we are currently replicating Experiment 5a while monitoring the eye movements of adults using a professional eye-tracking system. Preliminary results suggest that, like infants, adults also do not encode these events strictly by tracking the Figure object as it moves from the Source to the Goal. Rather, adults also looked back at the Source object once the Figure left the Source. Thus, if individuals encode Motion events such that Goals are sometimes encoded prior to Sources, then it seems highly unlikely that the observed Goal bias can be explained simply as a recency effect.

Furthermore, explaining a Goal bias as a recency effect appears to be inconsistent with findings from a seminal study by Shiffrin (1973), suggesting that recency effects (and primacy effects) are usually found only when the items being recalled can be easily verbally encoded. In Shiffrin’s study, complex visual stimuli that could not be easily verbally encoded failed to show primacy and recency effects. Given that the current experiments tested pre-linguistic infants and disrupted linguistic encoding of children and adults (via a verbal shadowing task), it is unlikely that participants verbally encoded our visual stimuli, thus providing further reason to believe that a recency effect cannot explain the observed Goal bias.

Finally, more recent findings suggest that the causal relations in an event, and not only temporal order, affect many aspects of event conception and memory (e.g., Woodward & Sommerville, 2001; Bauer & Mandler, 1989). For example, Woodward & Sommerville (2001) found that infants no longer interpreted a two sequence action as goal-directed if the causal relation between the actions was disrupted, even though the temporal order of the actions was preserved. Also, in a study exploring how 16- and 20-
month old infants remember events, Bauer and Mandler (1989) found that ordered recall was better for novel events when the novel events included causal relations. These findings suggest that when viewing events, even young children conceive of the event as something more than just snapshots of event components strung together in some particular order.

In sum, it seems highly unlikely that a Goal bias can be fully explained as a recency effect in memory. However, one finding from the current study is particularly relevant to this issue and should be noted. Recall that a Goal/Source asymmetry did not reverse in the Look Back Experiments (6a/6b), rather it was reduced. As discussed in Section 3.4 this could be due to the self-propelled forward motion of the Figure object towards the Goal (which is another indicator of the Figure’s intentions) or it could be because the Goal is the end point, and one consequence of being an end point is that it may usually be the most recent object in event memory (recency effect). Future research should further explore whether the recency of the Goal object in memory contributes at all to its status relative to the Source. My hunch is that if it does, the contribution is insignificant (as illustrated in the slight difference in Goal/Source encoding for the Physical events – see Figures 3.13 and 3.15).

4.2.2.2 Attention and Conceptual Factors

As reviewed in Section 4.1, the findings of Experiments 6a and 6b suggest that attention plays a role in the bias to the encode Goals in preference to Sources. In these experiments, we were able to manipulate participants’ attention, by manipulating the
intention in the event. Specifically, when events were created that directed individuals’ attention to the Source (i.e., by having the Figure look back at the Source), the likelihood of encoding the Source increased. The role of attention is also supported by the analysis of infants’ looking patterns for Experiments 2 (Source) and 3 (Super Source) of Study 1 (see Section 2.5.3). Recall that this analysis showed that infants looked back at the Source twice as many times when it was ‘salient’ than when it was ‘ordinary’, suggesting that attention plays a role in determining whether the Source gets encoded.

The finding that attention plays a role in asymmetric Goal/Source encoding raises the interesting question of what factors are driving attention to the Goal in preference to the Source. One possibility is that the Goal is also the end point. Recall that this factor was previously discussed in the context of a recency effect. However, rather than the end point being preferentially encoded because it may be the most recent event component in memory, it is also possible that by being an end point, people allocate more attention to the Goal rather than to the Source. For instance, perhaps individuals make anticipatory eye movements to the Goal over the course of viewing the event. This explanation receives some support when considering another set of cognitive phenomena suggesting that cognition, in general, is ‘anticipatory’ in nature or ‘forward looking’ (see Section 4.3). However, the fact that a Goal/Source asymmetry was not observed for Physical/Non-Mentalistic events suggests that the Goal also being an end point cannot fully explain the Goal bias – other factors must be involved.

Consider again the findings from Experiments 6a and 6b showing that individuals did not show a Goal/Source asymmetry when encoding events in which the Figure object looked back at the Source. The fact that we were able to manipulate participants’
attention to the Source by manipulating the intention in the event suggests that intention plays a key role in asymmetric Goal/Source encoding. This finding is further supported by the results from Experiment 7a and 7b suggesting that individuals do not encode Goals and Sources asymmetrically when they are starting points and end points in Physical/Non-Mentalistic events – events that do not involve intentionality. Thus, the conceptual factor of intention seems to play a key role in determining how Sources and Goals are structurally organized in event representations.

The fact that a Goal/Source asymmetry was observed for Psychological/Mentalistic events in Experiments 5a/5b, but not for Physical/Non-Mentalistic events in Experiments 7a/7b suggests that the hierarchical organization of Goals and Sources characterizes the structure of one cognitive system, but not the other. Specifically, it characterizes the system of knowledge used to reason about events falling under the psychological domain, but not the system of knowledge used to reason about events falling under the physical domain. Given this, we can step back and examine the conceptual factors involved in psychological reasoning that are not involved in physical reasoning to learn more about what factors may be involved in asymmetric Goal/Source encoding.

As discussed in Section 3.5, the domain of psychology involves reasoning about sentient, mental, animate beings, and their behaviors, while the domain of physics involves reasoning about physical, inanimate, material objects and their behaviors. Furthermore, different principles guide reasoning in these two domains. For instance, principles such as self-propelled movement and goal-directed action guide reasoning in the psychological domain (e.g., self-propelled motion: Gelman, 1990; Premack, 1990;
goal-directed behavior: Gergely et al., 1995), whereas the principle of contact guides reasoning in the physical domain (e.g., principle of contact: Leslie, 1982; Leslie & Keeble, 1987).

Given that certain conceptual factors are involved primarily with psychological reasoning and not physical reasoning, and given that a Goal/Source asymmetry may be specific to Psychological/Mentalistic events, it seems likely that the conceptual factors involved in psychological reasoning may also be involved in asymmetric Goal/Source encoding. For instance, consider the principle of goal-directedness. Research has shown that even infants expect psychological entities (such as people), but not physical entities (such as mechanical claws), to be engaged in goal-directed behavior (e.g., Woodward, 1998; Meltzoff, 1995). Perhaps a Goal/Source asymmetry is fundamentally related to the principle of goal-directedness: conceptualizing a behavior as goal-directed may lead one to attend more to the Goal in preference to the Source.

The challenge for future research is to first test which of these conceptual factors play a role in a Goal bias (as was done in Experiments 6a/6b) and then to explain how these factors may interact to produce a Goal bias. For example, would the Source and Goal objects be asymmetrically encoded in an event where an animate, sentient Figure object moved unintentionally from the Source to the Goal (e.g., a person being carried by a tornado from a bench into a pool)? Questions such as these are challenging because they lead us to think about the conceptual factors in the event as if they were independent from each other, when in reality, these factors are likely to be intricately related, not only to each other, but also to a Goal/Source asymmetry.
4.2.3 What are Sources and Goals?

The findings from Study 2 have an important implication for our understanding of how individuals conceptualize Sources and Goals in events. Recall that the use of the term ‘Source’ and ‘Goal’ to refer to starting points and end points in both Psychological and Physical events was motivated by linguistic theory and has been supported by data from language acquisition studies. Linguistic theory uses the terms ‘Source’ and ‘Goal’ in the broad sense based on the linguistic fact that people talk about Sources and Goals in a variety of events using the same linguistic structures (Gruber, 1976; Jackendoff, 1983). Furthermore, language acquisition studies support the broad usage of the terms ‘Source’ and ‘Goal’ with data showing that children have a broad abstract category of Source that encompasses starting points across many different event types (Clark & Carpenter, 1989 - see Section 1.2.2).

However, the current findings suggesting that a Goal bias may be a phenomenon restricted to Psychological/Mentalistic events – events involving conceptual factors such as intention, animacy, and sentience - leads one to seriously reconsider the broad usage of the terms ‘Source’ and ‘Goal’ when talking about non-linguistic event conceptualization. Are Sources and Goals in Psychological/Mentalistic events and in Physical/Non-Mentalistic events truly one in the same? That is, is ‘the chair’ in the events ‘the girl walked from the chair to the desk’ and ‘the tissue blew off the chair onto the desk’ conceptualized as belonging to a single non-linguistic ‘Source’ category? The fact that only one of these Sources (the one in the psychological event) was subject to asymmetric Goal/Source encoding leads one to question the notion of a broad non-linguistic
conceptual category of Source (and similar reasoning applies to the category of Goal). In future research, I plan to ask, do individuals have a broad non-linguistic category of Source and Goal that encompasses starting points and end points across many different domains? Or, are these broad categories uniquely linguistic in nature?

4.2.4 A Paradox?

As previously discussed, the current findings suggest that a Goal bias may be phenomenon restricted to Psychological/Mentalistic events, and may not characterize Physical/Non-Mentalistic event representations. However, research by Lakusta and Landau (2005) suggests that in language, a Goal bias applies to both intentional, Psychological/Mentalistic events (e.g., a girl jumping off a bench onto a book) and unintentional, Physical/Non-Mentalistic events (e.g., a ball rolling out of box into a bag). How could this be? How could a Goal bias characterize Physical event representations in language, but not in non-linguistic cognition? In the discussion below two possibilities will be considered – the Complexity of Events and Attention Hypothesis and the Design of Language Hypothesis.

4.2.4.1 Complexity of Events and Attention Hypothesis

One possibility is that a Goal/Source asymmetry actually would have been observed for the Physical/Non-Mentalistic events in Experiments 7a and 7b if the events and/or the task were more ‘complex’. That is, perhaps a Goal/Source asymmetry emerges
only when an individual’s cognitive system is ‘taxed’, thus leading Sources and Goals to compete for attention. And, perhaps the Physical events in Experiments 7a and 7b did not successfully ‘tax’ individuals’ cognitive systems. Considering together the previous language findings and the current non-linguistic findings lends some support for this possibility.

Landau and Zukowski (2003) showed that, in language, when Motion events included either a Source or a Goal (but not both), adults and five- to seven-year-old children did not show a Goal bias. However, when Motion events contained both Sources and Goals (thus perhaps being more ‘complex’), five- to seven-year-old children did show a linguistic Goal bias (Lakusta & Landau, 2005). In addition, younger children (3–4 year olds) and children with Williams syndrome – groups who probably have limited attentional resources – showed a Goal bias even when the events contained either a Source or a Goal (see Landau & Zukowski, 2003 for the WS findings; see Lakusta, et al., 2004 for the 3- to 4-year-old findings). Furthermore, in the current studies, pilot testing revealed that children and adults were able to encode both Sources and Goals in Psychological/Mentalistic events (i.e., they performed at ceiling) when the Detecting Changes method did not include trivia questions and a ten second delay. However, when the task was made more complex by adding these features, both adults and children showed asymmetric Goal/Source encoding.

Given these results, perhaps a Goal/Source asymmetry was observed for the Psychological/Mentalistic events (Experiments 5a and 5b), but not for the Physical /Non-Mentalistic events (Experiments 7a and 7b), because the Psychological events were more ‘complex’ than the Physical events. Specifically, perhaps the presence of intentionality
in the Psychological events added a level of complexity to the event that resulted in Sources and Goals having to compete for individuals’ attention. If this explanation is correct - if a Goal/Source asymmetry can be fully explained by event ‘complexity’ - then a Goal/Source asymmetry should be observed for Physical/Non-Mentalistic events if the events and/or the task are made more complex (e.g., by speeding up the events or by lengthening the delay after the presentation of the first event).\textsuperscript{21}

Before concluding this section, note that the findings from the Look Back experiments (6a/6b) suggest that a ‘simple’ complexity explanation will not sufficiently explain a Goal bias. Recall that in the Look Back experiments, manipulating the direction of the Figure’s intentions (away from the Source rather than towards the Goal) significantly weakened a Goal bias. If intentionality in an event merely adds a level of complexity, then it is not clear why a Goal bias would weaken when the direction of intention was manipulated. Thus, it seems that a simple complexity explanation will not suffice; something higher level, something conceptual, may be a necessary for explaining a Goal bias.

4.2.4.2 Design of Language Hypothesis

It is also possible that a Goal/Source asymmetry does indeed characterize linguistic, but not non-linguistic, representations of Physical/Non-Mentalistic events. One likely explanation for this is that a linguistic Goal/Source asymmetry is a design

\textsuperscript{21} It is interesting to note that another cognitive phenomenon, representational momentum (also a forward memory bias that is discussed further in Section 4.3), is affected by manipulations of attention. For example, representational momentum increases when another object is present in the stimulus display or
feature of language – a feature that filters information about the Source out of non-linguistic cognition, but retains information about the Goal. And, as discussed in the Section 1.2.5.1, language may filter out Source information because Sources are often considered to be adjuncts, whereas Goals are considered to be ‘true’ arguments of the verb. Landau and Jackendoff (1993) describe a similar ‘filtering’ function of language in their study comparing the language of objects and places. They suggest “there is a tendency for languages to level out geometric detail from both object and place representations” (p. 217). Specifically, although detailed information about an object’s shape (e.g., metric information) is represented non-linguistically (as illustrated, for example, by the fact that individuals are able to precisely reach and grasp objects), neither object names nor spatial prepositions encode this information. Rather, language seems to “filter” and “level out” this information for purposes of being discrete (Landau & Jackendoff, 1993). Thus, similar to the way that object names and spatial prepositions ‘filter out’ information about an object’s shape in order to be discrete, the language of events may ‘filter out’ Source information in order to be economical and only express a verb’s ‘true’ arguments.

In sum, future research should further explore these two hypotheses about why a Goal/Source asymmetry has been observed for Physical events in language, but not in non-linguistic cognition. Exploring these possibilities has implications not only for understanding the existence of a Goal bias, but also for understanding the structure of non-linguistic and linguistic cognition.

when non-visual distracters are introduced in the task, suggesting that when there is less attention available for encoding an event, memory for the event is affected (Hayes & Freyd, 2002).
This section will briefly consider the possibility that a Goal bias may be related to another set of phenomena suggesting that cognition in general is ‘forward looking’; i.e., it is ‘anticipatory’ in nature and exhibits ‘mental extrapolation’. Although examples of such phenomena cross-cut various domains (e.g., speech errors in psycholinguistics, motor errors in action), the present discussion will focus on two phenomena characterizing representations of spatiotemporal events: representational momentum (RM) and boundary extension (BE). As described below, both of these phenomena are errors in that they reflect inaccurate representations of the real world. Yet, the nature of these errors is astounding in that they reflect accurate predictions about the future real world (Intraub, 2002).

Representational momentum is “the tendency for the memory representation of an object to change along the object’s implicit path of motion” (Freyd & Finke, 1984, p. 131). Or, stated differently, representational momentum is “the systematic tendency for observers to remember an event as extending beyond its actual ending point” (Thornton & Hubbard, 2002, p. 1). Thus, representational momentum is a forward memory bias that arises from (accurately) anticipating what comes next.

Boundary extension is also a forward memory bias. In boundary extension “when a photograph is presented and removed, observers misremember the limits of the view – they remember having seen more of the scene, as if the photograph’s boundaries were displaced outward” (Intraub, 2002, p. 94). This error also reflects (accurate) anticipation in that another saccade or head movement by the observer would have revealed the
remaining scene. Thus, both representational momentum and boundary extension illustrate individuals’ tendency to anticipate and ‘mentally extrapolate’; in the case of representational momentum individuals anticipate and extrapolate the Figure’s actual stopping point and in the case of boundary extension individuals anticipate and extrapolate portions of a scene’s spatial layout.

The ways in which representational momentum and boundary extension are related has been a topic of recent investigation. Some researchers propose that these two phenomena are closely related in that they share the same underlying mechanism (e.g., Hubbard, 1996). However, other researchers suggest that these phenomena may be related only generally in that they both reflect the anticipatory nature of cognition (e.g., Intraub, 2002). At the general level, a Goal bias may also reflect anticipatory, forward-looking cognition. When viewing events, individuals may anticipate the Goal and thus attend more to the Goal than the Source, similar to how individuals anticipate the scene’s spatial layout in BE and the Figure’s stopping point in RM. However, after further consideration, it seems that a Goal bias may be related to RM in a more fundamental way. The remainder of this section explores this possibility.

A Goal bias is similar to representational momentum in that it can also be construed as a forward memory bias that is related to the Path of a Figure object. A Goal bias is related to the actual end point of the Figure object, similar to how RM is related to the movement of the Figure object. A Goal bias is a bias to represent a Figure’s end point (Goal) in preference to its starting point (Source); representational momentum is a bias to remember a Figure’s movement as extending beyond its actual end point rather than before its actual starting point. However, one difference between the two phenomena is
that representational momentum has been observed with both static stimuli involving inanimate objects (such as simple geometric objects; e.g., Freyd & Finke, 1984), as well as stimuli involving continuous motion with people (e.g., Thornton & Hayes, 2004). In contrast, as shown in the current experiments, a Goal bias does not seem to pertain to stimuli involving inanimate, unintentional objects.

Given these similarities and differences, it seems possible that representational momentum and a Goal bias may be related in the following way. Perhaps anticipating a Figure’s movement as further along its Path than it actually is (representational momentum), is a necessary condition for a Goal bias. That is, perhaps a Goal bias is actually a consequence of representational momentum. It seems that if one’s construal of an event involves anticipating the future path of the Figure object, then one may more likely to encode the Goal rather than the Source. The fact that a Goal bias does not characterize Physical/Non-Mentalistic event representations suggests that representational momentum is probably not a sufficient condition for a Goal bias. Rather, it is likely that other factors (such as intentionality) also contribute to asymmetric Goal/Source encoding. Of course, much research is needed before the potential relationship between these two phenomena, and boundary extention, can be fully understood.

4.4 Theoretical Implications

The broad goal of this thesis was to shed light on how spatial cognition and language interact; that is, to explore how non-linguistic spatial representations serve as a
basis for language and as a support for language learning. The findings from Study 1 (infant experiments) and Experiments 5a and 5b of Study 2 achieved this goal by showing that the asymmetry between Sources and Goals extends beyond language to non-linguistic Motion event representations. This suggests that the hierarchical structuring of Sources and Goals in non-linguistic spatial cognition serves as the basis for language, thus informing theories exploring the space/language interface.

Furthermore, the results from the infant experiments shed light on how non-linguistic representations serve as a support for language learning. These studies showed that pre-linguistic infants represent Sources and Goals in Motion events prior to marking them in language, and they do so asymmetrically. Thus, the non-linguistic concepts of Source and Goal, and their hierarchical structuring, seem to be in place early to support language learning. These findings also inform theories exploring the space/language interface, as well as theories of development that explore the conceptual foundations of spatial language.

The remainder of the experiments in this thesis explored the phenomenon of a Goal bias in more detail, focusing on the issue of what factors may be involved in asymmetric Goal/Source encoding. The findings from Experiments 6a and 6b suggest that attention and intention play a critical role in Goals being encoded in preference to Sources, and the findings from Experiments 7a and 7b suggest that a Goal bias may be specific to how individuals reason about events falling under the psychological domain. These findings increase our understanding of how individuals conceptualize events and have important implications for how we understand cognition in general.
In sum, the findings from this thesis have important implications for linguistic, psycholinguistic, and psychological research. The results shed light on many aspects of event cognition, as well as raise questions for future research.

**BIBLIOGRAPHY**


Hochberg, J. (1986). Representation of motion and space in video and cinematic displays.


language: Evidence from Williams syndrome. *Journal of Memory and Language.*


categories and the lexicon. Cambridge, UK: Cambridge University press.


CURRICULUM VITA

Laura Lakusta was born in Brooklyn, NY on February 7, 1978. Ms. Lakusta graduated *summa cum laude* from Lehigh University in 2000 with a B.A. in Psychology. While at Lehigh, Ms. Lakusta conducted her research with Dr. Gerald McRoberts, investigating infant speech perception. During her time at Lehigh, Ms. Lakusta spent a semester studying at the University College of London, where she did research with Dr. Annette Karmiloff-Smith. This research investigated the language abilities of children with a genetic disorder called Williams syndrome (WS).

After graduating from Lehigh, Ms. Lakusta entered graduate school at Johns Hopkins University in 2000 and received her M.A. in Psychological and Brain Sciences in 2002. Ms. Lakusta is expected to graduate from Johns Hopkins with a joint Ph.D. in Cognitive Science and Psychological and Brain Sciences.

Ms. Lakusta’s master’s research explored infant language learning mechanisms and was directed by Dr. Rebecca Gomez. The remainder of Ms. Lakusta’s research, including her doctoral work, has been directed by Dr. Barbara Landau. This research has explored the interaction between spatial cognition and language by examining how normally developing infants, children, and adults, and individuals with WS, represent events.

Ms. Lakusta has presented her work at a number of conferences including the Boston University Conference on Language Development, the Society for Research in Child Development, and the International Conference on Infant Studies. Ms. Lakusta has a first-authored publication in the journal, *Cognition*, and has been a co-author on other peer-reviewed journal articles. She has also had articles published in edited volumes.
While at Johns Hopkins, Ms. Lakusta has been the teaching assistant for a number of courses including Language Development, Written Language, and Introduction to Human Learning and Memory. She has also served on the Psychological and Brain Sciences Teaching Assistantship Committee and as a Graduate Student Colloquium Representative.

In the summer of 2005, Ms. Lakusta will be awarded a Ruth. L. Kirchstein National Research Service Award and will begin a position as a post-doctoral fellow at Harvard University under the direction of Dr. Susan Carey.