The Extent of Children’s Understanding of the Space/Time Metaphor: Mapping between Length and Duration

THESIS

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By
Carolyn Theresa Dahlgren, B. A.
Graduate Program in Psychology

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Master's Examination Committee:
Laura Wagner, Advisor
John Opfer
Vladimir Sloutsky
Abstract

The aim of this study is to explore children’s comprehension of the space/time metaphor, focusing on understanding of extent – ‘long’ and ‘short’ – in the domains of space and time. Exploring the space/time metaphor provides a way to better understand how people think about and potentially share knowledge between these domains. The role of metaphor, using information from one domain to understand another domain, and its impact on cognition extends beyond our proposed investigations of the space/time metaphor; metaphor research can provide insight into how we transfer and extend knowledge between many different domains.

This research project will focus on children’s ability to understand and transfer information between the domains of space and time. We completed a CHILDES analysis (Study 1) of spontaneous production of ‘long’ and ‘short’ by children and parents. We also conducted two experimental studies to further investigate children’s knowledge of ‘long’ and ‘short’. Study 2 ($N = 64$) explored children’s ability to make connections between the domains of space and time and potential directional effects within the metaphor. Using training with either spatial or temporal stimuli, 3- and 5-year-old children were taught a novel word – ‘blicket’ – which was consistently paired with one dimension of extent. Children’s ability to transfer knowledge within the domain of training and to the opposing domain was evaluated. Compared to 5-year-old subjects, 3-
year-old children had difficulty transferring knowledge outside the domain of training when they receive spatial training. Three-year-olds also appeared to have difficulty learning and transferring temporal information. This suggests that the space/time metaphor, and temporal information in general, is not readily apprehended by young children. Both age groups performed better in the spatial training condition for novel word learning, within domain transfer and across domain extension; these results show a directional effect that suggests that, if the space/time metaphor exists, the spatial domain may anchor the metaphor. Study 3 (N = 64) investigated how language influences mapping between space and time. In this study, subjects received non-linguistic training instead of novel word training; there was no specific linguistic item, ‘blicket’, to facilitate learning, transfer and extension of knowledge. Results for the non-linguistic training in study 3 show similar patterns of performance to study 2 where children received linguistic training. This suggests that a linguistic item is not necessary and does not facilitate mapping between space and time.
Vita

2002...........................................High School Diploma with Honors, ACS Cobham International School

2004 – 2005......................................Student Intern, Language Enrichment Pre-
School Program, Phebe Ana Thorne School

2005...............................................Bryn Mawr Summer Science Fellowship,
Bryn Mawr College

2005 – 2006......................................Bryn Mawr Mello Trico Colloquium Fellow,
Bryn Mawr College

2006...............................................B.A. magna cum laude Psychology (minors
in Biology and Educational Studies), Bryn
Mawr College

2006-2009 .........................................Research Assistant and Coordinator,
Program in Education, Afterschool and
Resiliency (PEAR), McLean Hospital/
Harvard University
2008..............................................................Presentation at the National Conference of Science & Technology in Out-Of-School-Time, Chicago, IL

2009 – 2010....................................................University Fellowship, Department of Psychology, The Ohio State University

2010 to present...............................................Graduate Teaching Associate, Department of Psychology, The Ohio State University

2011..............................................................College of Social and Behavioral Sciences (SBS) Fellowship, Department of Psychology, The Ohio State University

2011..............................................................Poster Presentation at the Biennial Meeting of the Cognitive Development Society (CDS), Philadelphia, PA

2011 to present...............................................Assessment Coordinator for General Psychology (P100) Course, Department of Psychology, The Ohio State University

Fields of Study

Major Field: Psychology
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Introduction: What is Metaphor?

Metaphors exist across cultures and languages. Even when metaphors seem to be culturally specific, different linguistic or cultural expressions are founded on shared conceptual representations that span across cultures. The Polish expression, niedojrzale, which translates to unripe in English, can be used to talk about ideas that are not fully thought out or planned. The English metaphoric equivalent is the term half-baked. Even though these expressions differ for the two languages, they are based on a shared conceptual metaphor, IDEAS are FOOD (Deignan, Gabryś, & Solska, 1998). Classical accounts of metaphor typically focused exclusively on language analysis, interpreting figurative language without exploring the underlying foundations of these linguistic expressions (Halliwell, 1998). Some researchers still focus on the role of language in metaphor (Bowdle & Gentner, 1999; Gentner, 1982; Gentner & Jeziorski, 1993). In the past few decades, however, this view of metaphor has been challenged. Metaphor is now thought to extend beyond its linguistic components, tapping into deep conceptual structures that underlie figurative language. The work of Lakoff and Johnson (1980a; 1980b; 1980c; Lakoff, 1993) was some of the first to investigate metaphor beyond literary analysis and to engage in thinking about metaphor at a conceptual level, exploring the cognitive implications of metaphor usage. Lakoff and Johnson suggest that
there are conceptual metaphors – such as UP is MORE or TIME is SPACE – that are so pervasive they may help organize thought. The role of these metaphors is still being explored; researchers are currently investigating how domains of metaphors are connected. Are mappings in metaphors a result of similarities between independent domains which have resulted in corresponding similarities for mental representations of these domains or is there a causal relationship where one domain is utilized to structure another?

The current study investigates the space/time metaphor, exploring whether it offers a coherent structural system that is accessible to children, whether there are directional effects in the linkages between the domains of space and time, and whether lexical items are necessary for mapping within the space-time metaphor. There are many spatial representations of time that infuse a variety of cultures (Gentner, Imai & Boroditsky, 2002) (e.g., clocks, calendars, time lines, musical notation, and many more). There are also connections between space and time found in cultural-linguistic artifacts; for example, there are correspondences between representations of time lines and directionality of writing systems (Santiago, Lupianez, Perez, & Funes, 2007; Fuhrman & Boroditsky, 2010) and mirror writing can change the orientation of time lines (Casasanto & Bottini, 2010). Additionally, temporal and spatial language often utilize the same lexical items (Boroditsky, 2000; Gentner et al., 2002). For example the following words can be used in both domains: at, from, to, behind, and many more.
Space:  
At the park  
From here to there  
Behind the tree

Time:  
At midnight  
From dusk to dawn  
Behind schedule

Lexical items that correspond to extent can also be used in both the domains of space and time; ‘long’ and ‘short’ can be used to refer to both spatial objects (e.g., ‘She has short hair’ or ‘The shoelaces are long’) and temporal events (e.g., ‘The days are short in the winter’ or ‘It took a long time to finish’). This phenomenon is not isolated to the English language; there are other languages that share lexical items between the domains of space and time. In Aymara, a language spoken by approximately one million people in Chile, Bolivia and Peru, the words used to spatially represent ‘front’ and ‘back’, nayra and q’ipa, are also used as basic expressions for ‘past’ and ‘future’ (Núñez & Sweetser, 2005).

The aim of this study is to explore children’s ability to spontaneously discover a connection between space and time as well as investigate the influence of language in facilitating space/time understanding and transfer. Does the space/time metaphor exist; do children learn and map information between the domains of space and time? What role does language play; does it influence mapping for the space/time metaphor?

Theories of Metaphor

Metaphors are a pervasive part of language that are commonly used and can be traced across a diverse array of cultures with regularity and coherence. Classically, metaphor has been viewed from a literary perspective, focusing mostly on the aesthetic qualities
and poetic value of figurative speech. In recent decades, researchers have shifted focus within metaphor research and have begun exploring the interconnections between metaphor and the mind. Lakoff and Johnson (1980a; 1980b; 1980c; Lakoff, 1993) point out that, when speaking or listening to an utterance, language is not divided into everyday, literal speech and poetic, figurative speech. Instead, figurative language is readily apprehended and appears to continuously meld with literal speech. Lakoff and Johnson developed the Conceptual Theory of Metaphor which is based on the tenet that metaphor is primarily conceptual and only secondarily linguistic. According to this theory, metaphors should be interpreted, beyond their role as a literary device, as a window into the deeper conceptual recesses of the mind. Conceptual metaphors are the foundation of cognition. The linguistic expressions of metaphor are only one component of this structure, a product of a larger conceptual architecture. By this view, abstract thought is predominantly metaphoric and inferences derived from conceptual metaphors are utilized continuously throughout daily life and facilitate learning and induction.

Metaphor is used to develop a better understanding of the world by generating new – or using pre-existing – connections between different domains. The Conceptual Theory of Metaphor states that metaphor involves understanding one domain in terms of another, mapping a source domain onto a target domain. Information from a base domain (also called a vehicle by some theorists) is used to define a target domain (also known as a topic). In the Conceptual Theory of Metaphor, base domains are more concrete while target domains are more abstract. Metaphors offer a way to better understand an abstract domain by utilizing corresponding knowledge from a better understood, more concrete
base domain. According to Lakoff and Johnson, the domains within a metaphor are asymmetrical and partial. The base domain anchors understanding of the target domain and only a select, relevant set of properties are shared between the two domains. Using the example of the metaphor ‘Love is a journey’, Lakoff and Johnson state that the target domain of ‘love’ is defined by a set of properties mapped onto it from the base domain of ‘journey’. Knowledge about some of the physical properties of journeys (they take a long time, you start in one place and end in another, as you move along you get closer to your goal, sometimes there are unexpected detours, etc.) can be used to understand some of the more ethereal components of love.

Metaphors provide structure to concepts by taking known information from a concrete domain and utilizing it to organize a more abstract domain. Essentially, metaphors build structure, yet how does a person build an initial reservoir of information and develop understanding of concepts that are the bases of metaphors? Lakoff and Johnson argue that there are basic, conceptual metaphors, such as UP is MORE or TIME is SPACE, which derive from experiencing the world. These primary conceptual metaphors organize cognition and provide the foundation for other metaphors. For the UP is MORE metaphor, we have experiences – for example, blocks being stacked up into a tower – and, from these experience, we develop an understanding that higher towers contain more blocks. A relationship between height and quantity is formed. For TIME is SPACE, we experience objects existing in physical space for a duration of time. An object’s temporal existence is marked by its presence or absence in space, forming a relationship between the two domains. According to Lakoff and Johnson, conceptual metaphors like UP is
MORE and TIME is SPACE can be built up into more complex metaphors creating a hierarchy of conceptualizations. For example, instantiations of TIME is SPACE can be seen in language – in utterances like ‘This is the moment’ or ‘How much time will it take?’ – where time is treated as a physical substance. TIME is SPACE can also be invoked in more complex metaphors like TIME is A MOVING OBJECT (e.g., ‘The years go by’, where time is construed as an object – ‘years’ – that is in motion), TIME is A CONTAINER (e.g., ‘He finished the race in ten minutes’, where the span of time – ‘ten minutes’ – is interpreted as an object that can hold items such as the ‘the race’) or TIME is A RESOURCE (e.g., ‘Don’t waste your time’, where time is viewed as a valuable commodity, an object that should not be ‘wasted’). All of these complex metaphors are built on the premise that time can be treated as a physical object, TIME is SPACE, but add new dimensions to the representation of time by mapping further components from the space domain.

Other metaphor research supports the idea that metaphor is fundamentally grounded in and arises from experience. For some researchers, supporters of the Embodiment Account, body experiences create the foundation of conceptual metaphors. Gibbs, Costa Lima, and Francozo (2004) describe how poetic expressiveness in metaphoric language arises from everyday sensations and actions of the body. Simple, perceptual experiences are not sufficient to build conceptual metaphor; instead, these experiences must be embodied, rooted physically in the body. During re-occurring sensorimotor activity, ‘image schema’ are created and become organizing structures for experiences of the body. According to Gibbs, these ‘image schemas’ form the basis of metaphor. In one
study by Gibbs and colleagues, acting out body movement that corresponded with a metaphor – for example, making a shoving motion while interpreting the metaphor ‘push an argument’ – primed comprehension of that metaphor (Wilson & Gibbs, 2007). In another study, Gibbs, Costa Lima and Francozo (2004) found correlations for emotional experiences of hunger and desire that were associated with metaphoric language describing these feeling in both English and Portuguese. They claimed that metaphors, like DESIRE IS HUNGER, have pervasive, universal patterns which emerge to show that body activity gives rise to metaphoric thought and language.

Continuing his work, Gibbs (2006) proposed the Embodied Simulation Theory where he states that, to make sense of abstract metaphoric expressions, individuals do not look up encoded meanings of attributes or relations between these concepts. Instead, individuals undergo embodied simulation to understand metaphoric concepts. Gibbs conceives of abstract concepts as ‘disembodied’ and believes that people automatically construct a simulation of their bodies performing action to understand metaphors about these abstract, disembodied concepts.

Some researchers are critical of the embodiment view, stating that it not a requirement for metaphor processing. The speed of processing for metaphor is too fast for embodied simulation. Studies of reaction time for metaphor comprehension suggest that matching between domains must occur but simulations of embodiment are not required (Gentner & Wolf, 2000; Wolf & Gentner, 2000). There is evidence, however, of embodiment of metaphors, though it is still debated whether embodiment a prerequisite or product of
conceptual metaphors. Metaphor embodiment can be seen in a study conducted by Casasanto and Dijkstra (2010) where moving marbles in an apparatus corresponded with the emotion valence of memory. When subjects moved marbles upwards, they retrieved more positively-valenced memories; when they moved marbles downwards, they retrieved more negatively-valenced memories. Miles, Nind and Macrae (2010) also showed links between the body and conceptual thought. They instructed their subjects to remain still while imagining past and future events but subtle shifts in subjects’ body positions were measured and corresponded to representation of time. When imagining future events, subjects shifted their body position so they leaned forward. When thinking about events from the past, subjects moved their bodies to lean back. Changes in body position seemed to embody a mental timeline. The impact of embodiment on learning can be seen in a study of 7-and 10-year-old children practicing music. Children in an embodied metaphor learning condition performed more accurately and were better able to verbally articulate movement-sound sequences compared to children who were in learning conditions that did not instantiate embodied metaphor (Antel, Droumeva, & Corness, 2008).

Experience may provide the grounding for conceptual development, however, these experiences do not need to be grounded in the body. According to the Metaphor Structuring View (Boroditsky, 2000), perceptual interactions with the world build understanding of relations between objects and events. Experiencing this relational knowledge provides the initial underlying structure for metaphor. When describing the Metaphor Structuring View, Boroditsky explains why base domains tend to be concrete
and target domains tend to be abstract. Concrete domains can be experienced easily, a person is able to perceive and interact with concrete stimuli and begin to apprehend them through experience. Abstract domains are too ephemeral, too disconnected from the perception to be comprehended solely through physical experience. Thus, abstract domains can only be understood by mapping structures onto them from concrete domains. Base domains anchor metaphors and create asymmetries. Boroditsky illustrates through the IDEAS are FOOD metaphor. It is easy to understand phrases like ‘half-baked ideas’ or an ‘idea you can really get your teeth into’ but no one believes that ideas are objects that can physically be eaten or that thinking too much can make a person fat. Understanding IDEAS are FOOD metaphors comes from knowledge of the relationship between food and hunger (developed through concrete, physiological experiences) utilized to describe and understand the relationship between ideas and intellectual needs. According to this view, there must be an asymmetry between base and target domains – base domains anchor metaphors. To support this view, Boroditsky points out that reversed metaphors lose meaning and become incomprehensible.

*Alternatives to Metaphor*

Some researchers have critiqued the Conceptual Theory of Metaphor. Keysar and Bly (1995, 1999) suggest that conceptual metaphors are constructed as post-hoc explanations of patterns in language; they are not the result of deep conceptual connections – despite the perception that this is the case – but simply due to familiarity of conventional use. In research conducted on idioms, Keysar and Bly found that groups of participants could
learn the true meaning of an unfamiliar idiom (‘The goose hangs high’ means “Things look good”) just as readily as they learn the opposite meaning (‘The goose hangs high’ means “Things look bad”). After learning the meaning of the idiom both groups reported that the meaning they learned – whether it was correct or, in fact, the opposite meaning – was transparent and the non-learned meaning was not. Keysar and Bly argued that this indicates that perceptions of idioms – and by extension metaphors – are based on conventionality rather than a deeper conceptual motivation. Further research conducted by Keysar and colleagues (Keysar, Shen, Glucksberg, & Horton, 2000) has explored interpretation of nonconventional language and suggested that, for nonconventional expressions, conceptual mapping is used to interpret and understand these utterances.

Murphy (1996) has also notably critiqued the Conceptual Theory of Metaphor. He said that the theory is too vague and does not offer enough insight into how the process of mapping between base and target works. Murphy suggested that, instead of using information from a concrete base domain to structure or organizing an abstract target domain, metaphors may arise due to pre-existing similarities in the domains. According to the Structural Similarity View, there is no causal relationship between base and target domains, instead they are structured independently and associated based on similarities. Research findings of asymmetries within metaphors, however, seem to refute this claim. If connections between domains are solely based on similarity, there should be no directional effects where one domain exerts more influence over another. Metaphor research has found a variety of asymmetries such as those found in studies on line length and tone duration judgments (Boroditsky, Fuhrman, & McCormick, 2011; Bottini &
The Conceptual Theory of Metaphor, the Embodiment View of Metaphor, and the Metaphor Structuring View all are founded on the view that there are metaphoric mappings between domains. Lakoff and Johnson state that TIME is SPACE is a basic conceptual metaphor, however, other research questions the existence of the space/time metaphor. According to ‘A Theory Of Magnitude’, ATOM (Walsh, 2003), space and time (along with number) have a single representation in the brain and mind. The ATOM theory hypothesizes that time, space and number are part of a generalized magnitude system located in the inferior parietal cortex. The Approximate Number System (ANS) account (for a review, see Canton, Platt, & Brannon, 2009) for representing number also aligns with this view. Number is represented as a mental magnitude and additional, non-numeric magnitudes – for example, time, space, order, brightness, and others – may use the same magnitude mechanism. At the heart of these theories, there is the belief that time and space (and quantity) are interrelated and that all three operate on shared principles of accumulation to represent magnitude.

There is neurological research that supports the ATOM and ANS views; space and time (along with number) seem to inhabit the same area of the brain. Basso and colleagues (Basso, Nichelli, Frassinetti, & Pellegrino, 1996) compared a normal control subject to a
subject with a brain lesion in the right side of the cerebral cortex. The normal control subject demonstrated no errors when judging the temporal duration of visually presented stimuli. The subject with the brain lesion, however, demonstrated overestimation of the duration of stimuli that were presented in the visual field that corresponded to the damaged part of the brain. Basso and colleagues hypothesized that reduced visuo-spatial processing, due to the lesion, sped up internal measure of time and caused duration to be judged as longer. Parietal lesions can also impair numerical ability (Dehaene, Molko, Cohen, & Wilson, 2004).

The ATOM view of space/time challenges the idea of the space/time metaphor. If time and space have a single representation in the brain, there is no mapping between the two domains because the domains are indistinguishable. If the domains of space and time are not truly distinct, there is no metaphor. If this is the case, impairments of space and time due to damage to the parietal cortex should co-exist (along with numeric deficits) and these abilities should be equally compromised. Research has been conducted, however, which supports the existence of the space/time metaphor; there are directional interference effects for judgments of conflicting space and time information. Research suggests that one domain, the spatial domain, is more dominant than the other, a view that could not exist if the domains were not distinct.

Is One Domain Dominant?

Merritt, Casasanto & Brannon (2010) compared adult human and Rhesus Monkey performance on non-verbal spatial and temporal bisection tasks. For the experiment,
subjects were trained to classify spatial (lines of varying length) or temporal (tones of varying duration) stimuli as either long or short. Stimuli during the training session were unambiguous and could be classified as long or short; subjects were able to pass this training phase. After completing training, subjects were shown ambiguous stimuli that were bisections, half the value (duration or length), of stimuli they experienced during training. Subjects were asked to classify these intermediate stimuli as long or short. In this testing phase, cross-modal information was presented; tones of varying length were played during line length judgment and lines of varying length were shown during tone duration judgment. Humans had difficulty ignoring irrelevant spatial information when performing temporal judgment tasks but did not show interference of temporal information in spatial judgment tasks. Rhesus monkeys, however, had difficulty ignoring irrelevant information for both spatial and temporal tasks. This finding from the Rhesus monkey research supports the ATOM conceptualization (Walsh, 2003) of space and time. Monkeys may have a single, analog magnitude representation of time, space, and number. The human data, however, supports the metaphoric representation of space and time, not the ATOM model. These results suggest that space is anchoring the space-time metaphor. If space and time were represented or processed by a single mechanism, there should not be the asymmetry seen in human performance.

Other studies have explored whether a spatial bias exists in human representations of space and time. In study of Dutch adults, Bottini and Casasanto (2010) showed subjects words of the same letter length that referred to objects of different spatial length (binder compared to pencil). Subjects were asked to estimate how long – temporal duration –
each word was presented on the screen. In another condition of the study, participants saw nouns corresponding to temporal events of different length (decade compared to season) and had to estimate the spatial length – number of letters – of each word. There was an asymmetrical pattern of results supporting the theory that space is the dominant domain of the space/time metaphor. Spatial nouns referring to short/long objects had shorter/longer estimates of duration when presented on the screen. Temporal nouns referring to different events, however, showed no difference in estimates of words’ spatial lengths.

Casasanto, Fotakopoulou & Boroditsky (2010) found evidence to support a space bias earlier in development. They showed children, aged 4-5 and 9-10 years of age, videos of animals moving for different amounts of time and different lengths of distance traveled. One snail went a longer distance but took a shorter time. Another snail traveled a longer time but moved a shorter distance. Casasanto and colleagues then asked the children to make spatial and temporal judgments about which animal traveled the longer distance and which traveled the longer time. The children had difficulty ignoring irrelevant spatial information compared to irrelevant temporal information. The researchers suggested that, due to their experimental design, it was easier to reference spatial information and that this could possibly account for the result that space anchors the space/time metaphor. In their initial experiment, spatial judgments could have been more easily apprehended because they could be determined by attending to the final positions of the animals. Children could refer back to the pictures and utilize spatial information about distance traveled; one animal had a stopping position further from the starting point. There was
no such immediate, concrete reference for temporal information, travelling time, because the event was complete. In another experiment, Casasanto and colleagues (2010) controlled for the continued visual presence of spatial information by using videos of jumping animals as stimuli, removing the spatial reference cues. One snail in the video jumped a higher distance while the other snail jumped for a longer time. Both animals ended in the same position that they started so children could not simply reference the final location of the animals to make spatial and temporal judgments. Even with the revised experimental design, children still had difficulty ignoring irrelevant spatial information but not irrelevant temporal information.

Research has shown that there is a connection between space and time that exists in infancy. Srinivasan and Carey (2010) simultaneously present spatial (lines) and temporal (tones) stimuli to 9-month-old infants. In one condition, the extent of the spatial and temporal information was congruent. Long lines were paired with long durations of a tone and short lines were paired with short tone durations. In another condition, spatial and temporal information was incongruent. Short stimuli in the spatial or temporal domain were paired with long stimuli in the opposing domain. Srinivasan and Carey found that infants were better at distinguishing between familiar and novel stimuli when they were in the congruent condition compared to the incongruent condition. This suggests that, at 9 months, there is a connection between space and time. In the incongruent condition, where extent for space and time was in conflict, there were interference effects.
Study 1: CHILDES Analysis of ‘Long’ and ‘Short’ for Space and Time

If TIME is SPACE is a basic, conceptual metaphor – as hypothesized by Lakoff and Johnson – or if a common magnitude mechanism exists – as posited in the ATOM model – children should be able to easily navigate between these domains and naturally make connections between space and time. Language should not be necessary to make these connections because the metaphor should exist before language is acquired. Alternatively, the domains of space and time may be linked, but not in a way that is intuitive for children. If this is the case, children will not spontaneously make connections between space and time and, instead will learn based on evidence provided in their environment. By this view, differences in input are of vital importance and children may need evidence to connect linguistic items of a metaphor with domains of use. Our first study explored use of lexical items of extent – ‘long’ and ‘short’ – in each domain of the space/time metaphor for children and parents. The study investigated whether children produce the words ‘long’ and ‘short’ in both domains and whether children receive parental input that uses ‘long’ and ‘short’ with both spatial and temporal referents. The study was an analysis of child and parent speech conducted using corpora from the Child Language Data Exchange System, CHILDES (MacWhinney, 2000).
Eilers, Oller and Ellington (1974) investigated how English-speaking children attach meaning to lexical items for extent, including acquisition of the terms ‘long’ and ‘short’. Using a forced choice research design they asked children, aged 2- to 3-years, questions that explored whether the children understood the meaning of dimensional adjectives (i.e., ‘Which is the big horse?’ or ‘Which is the little horse?’). They found a pattern underlying how children learn lexical items for extent. ‘Big and little’ were learned before ‘long and short’. ‘Long and short’ were, in turn, acquired before ‘wide and narrow’. This order effect in acquisition corresponded to order of semantic generality. Children acquired dimensional adjectives starting at the level with the most dimensions (big and small) before distinguishing between more specific features (long and short then wide and narrow). Additionally, analysis also showed that children made more errors on unmarked pairs (big, long, wide) than on marked ones (little, short, narrow).

This study by Eilers and colleagues provides insight into the acquisition of lexical items of extent but does not differentiate between children’s ability to comprehend extent words for spatial and temporal referents. The Eilers study provides a basis for this project to study extent in the space/time metaphor. Two- and 3-year-old children demonstrated understanding of the lexical items ‘long’ and ‘short’ but it is unclear whether they use these items in both the spatial and temporal domain.

Since children at age 3 demonstrated understanding of ‘long’ and ‘short’ (Eilers et al, 1974), we chose to begin our CHILDES analysis by looking at spontaneous production and usage of these lexical items in 3-year-olds. In this study, we analyzed child use of ‘long’ and ‘short’ at ages 3 and 5 along with parent input at these ages. Transcripts of
child and parent speech from the American English corpora available in CHILDES were selected to investigate usage of ‘long’ and ‘short’ in the domains of space and time. Our exploration focused on language data from four studies using files from five children: Abe (Kuczaj, 1977), Adam, Sarah (Brown, 1973), Matt, (Weist, Pawlak, & Hoffman, 2009; Weist & Zevenbergen, 2008), and Naomi (Sachs, 1983). Looking at all data within the CHILDES corpora, these children were selected because extensive transcripts of speech during spontaneous play and interactions with caregivers were available for these children at 3- and 5-years of age. Data from many studies has been uploaded into the CHILDES database but not all of the studies explored interactions between parents and children. Studies that did not record parent data were excluded from analysis. From the studies that were selected, transcripts of the children at 3 years of age (transcripts from age 2;5 up to 3;6) and 5 years of age (transcripts from age 4;7 up to 5;6) were analyzed to investigate how children use the words ‘long’ and ‘short’ and the concurrent parental input they received for these lexical items. Table 1 lists the number of transcript files analyzed for each child for this study.

<table>
<thead>
<tr>
<th>Child</th>
<th>Number of Transcripts Analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age 3 (2;6 to 3;6)</td>
</tr>
<tr>
<td>Abe</td>
<td>94 transcripts</td>
</tr>
<tr>
<td>Adam</td>
<td>25 transcripts</td>
</tr>
<tr>
<td>Matt</td>
<td>18 transcript</td>
</tr>
<tr>
<td>Naomi</td>
<td>25 transcripts</td>
</tr>
<tr>
<td>Sarah</td>
<td>47 transcripts</td>
</tr>
</tbody>
</table>

Table 1. Corpora files used for CHILDES analysis of ‘long’ and ‘short’
When coding the transcripts, every utterance of ‘long’ and ‘short’ produced by the children or parents was analyzed. Each utterance was assessed to determine whether the word was used to refer to a spatial or temporal item. Utterances of ‘long’ or ‘short’ that referenced a physical object were coded as a spatial usage of the word while utterances that referenced events or the passage of time were coded as a temporal usage of the word. For example, when Abe said, “That’s a long snake,” the referent for ‘long’ was the spatial object ‘snake’. Abe’s statement, “You took so long when you were playing baseball,” was coded as a usage of ‘long’ in reference to the temporal domain. If it was not immediately clear from the context of the utterance whether the referent for ‘long’ or ‘short’ was spatial or temporal, the next three exchanges or sentences following the ambiguous utterance were analyzed to determine how the word was used.

Usages of ‘long’ and ‘short’ were only included in the analysis when the child or parent demonstrated a clear reference to some object in space or period of time. Usages of ‘long’ and ‘short’ in colloquial expressions, like Sarah’s usage of “So long!” to say “Good bye”, were excluded from our investigation. Superlatives were included as instances of using ‘long’ or ‘short’ in the analysis. When Abe said, “That’s my fishing pole, it’s longest,” his use of ‘longest’ was coded as an instance of ‘long’ used in reference to the spatial domain. Repetitions of a word in a single sentence were coded as separate, unique instances of using the words only if the repetitions of the word were non-adjacent and had separate referents. For example, “It had one long thing and one long thing and one short thing and that’s like a rhinoceros,” (Abe) were coded as two instances of ‘long’ in the spatial domain and one instance of ‘short’ also referencing the
spatial domain. On the other hand, when Abe was wrestling with his father and said, 
“I’m holding on to your long, long legs!” Abe’s usage of ‘long, long’ was coded as a single instance of usage of ‘long’ in reference to the spatial domain.

*Results of CHILDES Analysis of ‘Long’ and ‘Short’*

Data from the CHILDES analysis, see figures 1 and 2, show that parents (175 tokens when child is age 3, 58 tokens when child is age 5) and children (171 tokens at age 3, 98 tokens at age 5) use of the words ‘long’ and ‘short’. Additionally, ‘long’ and ‘short’ are also used with spatial and temporal references.

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**Figure 1.** Use of ‘long’ and ‘short’ in spatial and temporal domains by 3-year-old children and their parents
Patterns of word usage for 3-year-old children show use of ‘long’ and ‘short’ did not match parental input; chi-square analysis on frequency of usage for children and parent use of words was significant, $\chi^2 (4) = 37.201$, $p = .031$, showing that expected frequency for child usage of extent items was different from parent usage. Child usage of ‘long’ in ‘short’ in the spatial and temporal domain does not reflect the input from parents. At age 5, however, children used the items in either domain with regard to parental input.

Patterns of word usage for 5-year-old children matched parental input; chi-square analysis on frequency of usage for children and parent showed no significant difference
between child and parent use of ‘long’ and ‘short’ in the spatial or temporal domain, \( \chi^2 (4) = 12.365, p = .089 \).

At age 3, two of the five children studied did not use ‘long’ or ‘short’ in the temporal domain, only using these lexical items in the spatial domain. This could illustrate child preference for using spatial referents; it may be a reflection of spatial dominance. One of the parents only uses spatial referents for ‘long’ and ‘short’ for a child at age 3 and age 5, suggesting that there may be biases in the input, however, comparing across children spatial (51%) and temporal (49%) referents were used approximately equally when parents spoke with 3-year-old-children. Approximately two thirds (68%) of tokens were temporal and only a third (32%) were spatial when parents spoke to 5-year-old children. These patterns suggest there isn’t an overabundance of spatial uses for the words in the input children receive. An alternative explanation for why some 3-year-olds did not use ‘long’ or ‘short’ for time is, perhaps, these 3-year-old children lack understanding of the domain of time. By age 5, children may have enough knowledge of time to use ‘long’ and ‘short’ in the temporal domain, so their use of the words matches their environmental input.
Experiments: Studies 2 and 3

Prior research has shown a connection between space and time and uncovered interference effects when spatial and temporal stimuli are presented concurrently (Srinivasan & Carey, 2010; Casasanto & Boroditsky, 2008; Bottini & Casasanto, 2010; Casasanto & Bottini, 2010; Casasanto et al., 2010). The ATOM model suggests that space and time are represented via a common mechanism. Both the Conceptual Metaphor and the ATOM views account for the presence of interference between space and time judgment. Only the Conceptual Metaphor view, however, supports directional effects where space anchors the space/time metaphor. According to the Conceptual Theory of Metaphor, the domain of time is more abstract while the domain of space is more concrete, this suggests that knowledge about space could be used and mapped onto the domain of time; the spatial domain anchors the space/time metaphor. The purpose of study 2 was to explore the state of the space/time metaphor, investigating the connection between the two domains of space and time. The goals of this study were to 1) determine whether the space/time metaphor is accessible to children and 2) uncover potential directional effects within the space/time metaphor. A second study experimental study (study 3) explored whether having a linguistic item impacts mapping in the space/time metaphor.
Participants for this experiment were 3- and 5-year-old children. There were 64 participants in study 2; 32 children in the 3-year-old group (age range from 35.9 to 51.1 months with mean age 42.1 months, 18 male and 14 female subjects) and 32 children in the 5-year-old group (age range from 51.2 to 77.0 months with mean age 63.3 months, 13 male and 19 female subjects). Parents were asked whether participating children were developing normally; children with parental reports of developmental delays were not included in the study. Data was collected in laboratory space at two universities and dedicated university research space at a prominent science museum.

Stimuli for the study were divided into two classes: spatial stimuli and temporal stimuli, see table 2.

<table>
<thead>
<tr>
<th>Domain</th>
<th>Space</th>
<th>Long</th>
<th>Short</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td>7 inch pencil</td>
<td>2.5 inch pencil</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 inch pipe cleaner</td>
<td>3 inch pipe cleaner</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 inch yarn</td>
<td>3 inch yarn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>paper &amp; marker</td>
<td>paper &amp; marker</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>buzzer (played for 8 seconds)</th>
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<td></td>
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<td>flash light (played for 1 second)</td>
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<td></td>
<td>pig light (played for 8 seconds)</td>
<td>pig light (played for 1 second)</td>
</tr>
<tr>
<td></td>
<td>touch light (played for 8 seconds)</td>
<td>touch light (played for 1 second)</td>
</tr>
</tbody>
</table>

Table 2. Spatial and temporal stimuli that vary along extent
The spatial stimuli included sets of items such as pencils or pipe cleaners. Each set of spatial stimuli included two items that varied along one dimension of space, extent. One item of each set was long and the other was short. The contrast between short and long items in each set was of a large enough magnitude that differences of extent were easily perceptible. For example, in the set of pencils, the long pencil was approximately 7 inches length and the short pencil was approximately 2.5 inches in length. Additionally, a note pad and marker were also used to assess children’s knowledge of space. In tasks using the note pad and marker, children were asked to draw lines and, thereby, illustrate their spatial knowledge of extent.

The temporal stimuli for the study were items, such as lights or noise makers, which could be played for varying lengths of time. When the temporal stimuli were presented to participants, the only dimension that differed for each presentation was the amount of time the light or noise was played for the children. Again, the two items in each set were presented with sufficient contrast in extent that allowed them to be easily discriminable. Stimuli presented for a long time were played for 8 seconds, while a short presentation of a stimulus lasted 1 second. Participants also completed production tasks using the temporal stimuli. During these tasks, children were asked to play the lights or noise makers to illustrate their temporal knowledge of extent.

Study 2: Procedure

The study had 2 stages: a novel word training stage and an evaluation stage to assess understanding and extension of the novel word to domains that were different from initial
presentation of the word. The domains studied were space and time; the extent classifications were long and short. The study lasted approximately 5 to 7 minutes.

**Novel Word Training**

During the training stage, children were introduced to a novel word, ‘blicket’, in reference to one dimension of extent (long or short) using stimuli that were either temporal or spatial. Participants were introduced to the novel word three times and each utterance of the novel word was followed by presentation of a stimulus. For example, an experimenter training a child in the spatial domain where the novel word was paired with long stimuli would say, “This is the blicket pencil [show child long pencil] and this is the pencil that is not blicket [show child short pencil].”

Pilot testing showed that 3-year-old subjects required an addendum to training – a 1 to 2 minute free-play and familiarization stage – to give them an opportunity to explore all of the experimental stimuli (both spatial and temporal) and introduce them to the experimenter before the study began. During this familiarization, children were encouraged to interact with the researcher and to handle all of the stimuli before starting novel word training.

Conditions were counterbalanced, half of the participants (16 children in each age group) experienced novel word training with spatial stimuli while the other participants (16 children in each age group) were trained using temporal stimuli. Extent Meaning –
whether the novel word ‘blicket’ was paired with long stimuli or short stimuli – was also counterbalanced.

*Evaluation Stage*

After completion of the novel word training, the children completed a series of tasks to assess their understanding and usage of the novel word, ‘blicket’. There were 12 trials across 4 stages to assess learning and mapping: Novel Word Learning, Within Domain Extension, Across Domain Transfer, and a control test of Knowledge of Extent. Each stage of the evaluation had 3 trials where subjects were asked to complete forced-choice tasks, yes/no questions, or production tasks (see table 3 for examples).

| Example Scripts |  
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Forced Choice Task | “Can you give me the blicket pencil?” | [Subject selects one of two pencils] |  
| Yes/No Question | “Is this the more blicket pipe cleaner?” | [Experimenter points to one of two pipe cleaners, subject responds ‘yes’ or ‘no’] |  
| Production Task | ”Can you play the buzzer blicket?” | [Subject plays the buzzer.] |  

Table 3. Scripts for different types of trials for evaluation in Study 2

In the forced-choice tasks, the participants were asked to give the experimenter the item that was (or had been played) ‘blicket’ or to give the item that was (or had been played) ‘not blicket’. During yes/no questions, the researcher pointed to one stimuli and asked participants if the item was blicket. Finally, the participants were asked to show how to
‘do it blicket’ and how to ‘do it not blicket’ in production tasks. Participants had to produce instances of both ‘blicket’ and ‘not blicket’ so experimenters could compare each production to assess whether the task was performed correctly. Responses were coded as correct if they were able to successfully perform the tasks according to the novel word training they received.

**Novel Word Learning**

The first three tasks evaluated whether children learned the novel word and could use this knowledge to correctly answer questions using the same stimuli from training. There were two forced-choice tasks and one yes/no question. Each of the three tasks used the same stimuli that were utilized during the training stage.

**Within Domain Extension**

The next three tasks explored whether children were able to transfer novel word knowledge to new stimuli from the same domain. Participants who were trained in the spatial domain were asked to apply their knowledge to new spatial stimuli while participants trained in the temporal domain had to extend their knowledge to new temporal stimuli. There was one forced-choice task, one yes/no question, and one production task in the within domain extension assessment.

**Across Domain Transfer**

Participants were asked to shift novel word knowledge and its relation to extent (long or short) to a new domain. Participants trained in the spatial domain were asked to assess
applications of the novel word with temporal stimuli. Conversely, participants trained with temporal stimuli completed tasks which used stimuli from the spatial domain. There were two forced-choice tasks and a single production task to explore children’s ability to transfer novel word knowledge to new domains.

Knowledge of Extent

After completing tasks designed to explore children’s use of the novel word both within and across domains, children were assessed on their general knowledge of extent. This was a control task and was completed at the end of the experiment so it did not influence early performance by directing child attention to extent. Participants completed three tasks to demonstrate their knowledge of the words ‘long’ and ‘short’: two forced-choice tasks and one production task. Both of the forced-choice tasks explored understanding of extent in the spatial domain. The production task explored children’s understanding of extent in the temporal domain.

Study 2: Results

A repeated measure ANOVA test was used to explore within subject factors (performance during the four evaluation stages: learning of novel word, within domain extension, across domain transfer, and knowledge of lexical items for extent) and between subject factors (age group, 3- and 5-years; training, spatial or temporal; and meaning of novel word, long or short). There was no main effect for Meaning, so whether ‘blicket’ referenced ‘long’ or ‘short’ extent was collapsed for t-tests to examine

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whether performance was above chance based on the different types of training (spatial or temporal novel word training).

For the repeated measures ANOVA, there was a main effect for evaluation stage, $F(3) = 18.025, p < .001$, and an interaction between evaluation stage and training, $F(3) = 4.559, p = .005)$. Children had different performance for the evaluation stages and these differences were mediated by the training – spatial or temporal – that they received. There was also a main effect of age group, $F(1) = 31.973, p < .001$; older children performed better than younger children. And also, there was a main effect of training, $F(1) = 5.596, p = .021$; children who received spatial training had higher scores during evaluation compared to children who received temporal training. No other effects were significant.

Comparing the mean correct score for each stage of the evaluation phase, t-tests revealed that 5-year-old children trained with spatial stimuli were above chance for each stage: novel word learning (at ceiling, there were no incorrect responses), transfer within domain of training (at ceiling, there were no incorrect responses), across domain extension, $t(15) = 2.117, p = .051$, and knowledge of linguistic items, $t(15) = 13.024, p < .001$, see figure 3.
These results reveal that, by age 5, children are able to successfully learn and transfer information between the domains of space and time. T-test results for the 3 year-old age group show above chance performance for novel word learning, $t(15) = 13.024, p < .001$, and transfer within the domain of training, $t(15) = 2.666, p = .018$, but for across domain extension, when 3 year-olds needed to transfer knowledge learned with spatial stimuli to temporal stimuli, performance dropped to chance, $t(15) = 0.565, p = .580$. Three-year-old children were not able to successfully transfer knowledge of extent learned in the spatial domain to temporal objects. This failure is even more striking when contrasted with the successful performance of the 3 year-old age group for questions on knowledge of linguistic items ‘long’ and ‘short’, $t(15) = 3.955, p < .001$. 

Figure 3. Performance by evaluation stage for 5- and 3-year-old children who received novel word training with spatial stimuli
Results for children who received temporal training show that 5-year-old children are, again, above chance for each stage of evaluation: novel word learning, $t(15) = 9.652, p < .001$; transfer within domain of training, $t(15) = 5.842, p < .001$; across domain extension, $t(15) = 3.020, p = .009$; and knowledge of linguistic items of extent (at ceiling, there were no incorrect responses), see figure 4.

![Figure 4](image)

**Figure 4.** Performance by evaluation stage for 5- and 3-year-old children who received novel word training with temporal stimuli

The t-test results for the 3-year-old age group show a different pattern performance for temporal training compared for to the 3-year-old children who were trained with spatial stimuli. Temporally trained 3-year-old subjects showed chance performance for every stage of evaluation – novel word learning, $t(15) = 1.291, p = .216$; transfer within the
domain of training, $t(15) = 0.460, p = .652$; and across domain extension, $t(15) = -0.344, p = .736$ – except knowledge of linguistic items which was above chance, $t(15) = 5.477, p < .001$. Once again, the 3-year-old children proved that they understood the linguistic items ‘long’ and ‘short’ but, after receiving novel word training in the temporal domain, the younger age group could not successfully demonstrate learning of a novel word within the domain of time much less extending the knowledge within or across domains. These results for 3-year-olds add support to the position that the spatial domain may be anchoring the space/time metaphor. The temporal domain seems opaque to young children but, by age 5, children can readily learn within the domain of time and successfully transfer knowledge across domains.

*Study 2: Discussion*

Study 2 examined accessibility of the space/time metaphor and found that 5-year-old children were able to learn novel words and transfer them within and across domains. The space/time metaphor is readily accessible at age 5 and can be utilized to make inferences between domains. Three-year-old children are not able to navigate the space/time metaphor as freely as their older peers. Three-year-old children did not demonstrate that they possess of a coherent, structured understanding of the space/time metaphor. They were not able to transfer from one domain to the other and, after receiving temporal training, they were at chance levels for learning and subsequent extension and transfer tasks. Whether this failure to learn within or transfer to the
temporal domain is a result of lack of access to the space/time metaphor or due to lack of access simply to the domain of time is a question that we explore in later analysis.

Three-year-old children’s knowledge of the linguistic items for extent (tested via both spatial and temporal applications) was above chance in study 2, however, 3-year-olds were not able to learn to use a novel word in the temporal domain. In the CHILDES analysis, we showed that 3-year-old children use ‘long’ and ‘short’ in both domains and also receive parental input for both these words with referents for both spatial and temporal items. Use of ‘long’ and ‘short’ for space and time, however, was independent from parent input at age 3. These conflicts between knowledge and use of items of extent for the space/time metaphor prompt questions about the role of lexical items in the space/time metaphor. What drives the development of the space/time metaphor and what role does language play in the acquisition of conceptual knowledge and mapping between domains? Study 3 empirically investigates the influence of language and explores whether lexical items facilitate mapping for the space/time metaphor. Do 3- and 5-year-old children succeed on knowledge tasks for ‘long’ and ‘short’ because they have lexical items that aid access to knowledge of extent? Without a linguistic item, will 5-year-old children still succeed in learning and transferring novel knowledge across the spatial and temporal domains? Without a linguistic item, will 3-year-olds still successfully learn from spatial training and extend knowledge within the spatial domain?
Study 3: Methods

The participants in this study were 3- and 5-year-old children. There were 64 participants in study 3; 32 children in the 3-year-old group (age range from 33.9 to 48.0 months with mean age 42.2 months, 10 male and 22 female subjects) and 32 children in the 5-year-old group (age range from 49.0 to 72.4 months with mean age 60.9 months, 14 male and 18 female subjects). Data for study 3 was collected in the same laboratory and museum spaces utilized in study 2. As in study 2, children with developmental delays, as reported by parents, were not included in the study.

Stimuli utilized in Study 3 were the same sets of spatial and temporal items used in study 2, see table 2. The stimuli varied along the dimension of extent – long and short. Sets of spatial stimuli included items that varied in the physical length of the objects. The temporal stimuli varied in the duration each item was presented. There were also stimuli – paper and a marker for space and a buzzer to play for time – that were utilized for production tasks were the subjects had to create instances of ‘long’ and ‘short’ in both the spatial and temporal domains.

Study 3: Procedure

The procedure for study 3 was similar to study 2, however, instead of undergoing novel word training, subjects were trained to learn expressed preferences – based on extent – that the experimenter stated for the stimuli. During preference training, the experimenter consistently stated that she had a preference for one type of stimuli (long or short). After
this preference training, there was an evaluation stage to assess children’s understanding of the experimenter’s stated preference and their ability to extend knowledge of this preference to new domains. Additionally, children’s knowledge of the linguistic items ‘long’ and ‘short’ was also tested, again as a control procedure. Following the method from study 2, space and time were the domains explored and long and short were the extent classifications that were studied. Study 3 lasted approximately 5 to 7 minutes.

Preference Training

For preference training, the experimenter introduced participants to the stimuli and told the children that she preferred one stimulus over the other. The experimenter presented the children with a set of stimuli and told the children, ‘This is the one I like’ while showing the children one stimulus (either long or short). The experimenter also told the participants, ‘This is the one I do not like’ and presented the contrasting stimulus which corresponded to the statement. When stating a preference during the training phase, the experimenter did not use the words ‘long’ or ‘short’ to refer to the stimuli. Half of the participants for each age group received preference training with spatial stimuli; the other half received preference training with temporal stimuli. Conditions were counterbalanced for the type of training each child received and for the dimension of extent that corresponded to stated preference. Half the children received training with experimenter preference for long items; for the other half, preference matched with the short stimuli. In all conditions, the experimenter stated her preference and showed the children the corresponding stimuli three times before proceeding to the evaluation stage.
Evaluation Stage

After the children completed the preference training, there was an evaluation stage to explore whether children learned information about the stated preference during training and whether they could extend their knowledge of this preference to new items from the same domain and to stimuli from other domains. The evaluation stage followed the same format as study 2, consisting of the same 12 assessments for Learning, Within Domain Extension, Across Domain Transfer and Knowledge of Extent. The tasks for study 3 – forced-choice tasks, yes/no questions, and production tasks – were the same tasks used in study 2 except they referenced the experimenter preference training instead of the novel word training (see table 4.)

<table>
<thead>
<tr>
<th>Example Scripts</th>
</tr>
</thead>
</table>
| Forced Choice Task | “Can you give me the pencil I like?”  
[Subject selects one of two pencils] |
| Yes/No Question | “Is this the pipe cleaner I like?”  
[Experimenter points to one of two pipe cleaners, subject responds ‘yes’ or ‘no’] |
| Production Task | ”Can you play the buzzer the way I like?”  
[Subject plays the buzzer.] |

Table 4. Scripts for different types of trials for evaluation in Study 3

For the forced-choice tasks, the experimenter asked the children to indicate which stimuli the experimenter liked (or did not like). During yes/no questions, the experimenter pointed to one stimulus and asked each child whether the object was one that the
experimented liked (or did not like). Finally, for the production tasks, the experimenter asked the children to demonstrate how to ‘do it the way I [the experimenter] like’. The children were also asked to demonstrate how to ‘do it the way I [the experimenter] do not like’. During coding of production tasks, the researchers looked at both demonstrations produced by each child to determine whether the children understood the task. Responses for all trials of the evaluation stage were coded as correct if children’s responses corresponded to the preference training they received.

**Results: Study 3**

A repeated measure ANOVA test was used to explore within subject factors (performance during the four evaluation stages: learning of preference training, within domain extension, across domain transfer, and knowledge of lexical items for extent) and between subject factors (age group, 3- and 5-years; training, spatial or temporal; and meaning of novel word, long or short). There was no main effect for meaning, $F(3) = 1.567, p = .216$, so meaning (whether preference referenced long or short extent) was collapsed for t-tests to examine whether performance was above chance based on the different types of training (spatial or temporal novel word training).

In the repeated measure ANOVA, there was a main effect for evaluation stage, $F(1) = 14.822, p < .001$; an interaction between evaluation stage and training, $F(1) = 5.905, p < .001$; and an interaction between evaluation stage and meaning, $F(1) = 3.926, p = .010$. There were different patterns of performance for the evaluation stages; the differences were influenced by the training subjects received and the meaning that corresponded to the
novel word. The evaluation stage and training interaction mirrors the results from study 2. The addition of the meaning factor in this interaction may be due to child preference for ‘long’ and ‘short’. There was no main effect, however, for meaning. There was a main effect of age group, $F(1) = 20.176, p < .001$; older children performed better than younger children. There was also main effect of training, $F(1) = 10.026, p = .002$ – children who received spatial training performed better than children who received temporal training – and an interaction between age group and training, $F(1) = 5.211, p = .026$. Older children were successful for temporal training but younger children were at chance when they received temporal training. No other effects were significant.

T-tests comparing the mean number of correct responses for the evaluation phase show that 5 year-old children trained with spatial stimuli were above chance for each evaluation stage: preference learning, $t(15) = 23.000, p < .001$; transfer within domain of training, $t(15) = 9.922, p < .001$; across domain extension, $t(15) = 2.255, p = .040$; and knowledge of linguistic items, $t(15) = 16.102, p < .001$, see figure 5.
Older children were able to learn stated preferences that were modeled with spatial stimuli. Five-year-olds could also map this knowledge within the spatial domain and across domains to successfully complete temporal tasks. The mean number of correct responses for the 3-year-old age group was above chance for preference learning (at ceiling, there were no incorrect responses) and transfer within the domain of training, \( t(15) = 4.140, p < .001 \), but not for across domain extension, \( t(15) = 1.464, p = .164 \).

When 3-year-old children were asked to transfer preference knowledge learned with spatial stimuli to temporal stimuli, responding was at chance. Performance of the 3-year-old age group for questions on knowledge for the linguistic items ‘long’ and ‘short’, however, was above chance, \( t(15) = 4.341, p < .001 \). These results correspond to the
findings from study 2, 3-year-old children were not able to successfully transfer knowledge from the spatial domain to the temporal domain.

Looking at children who received temporal training in study 3, 5-year-old children were above chance for correct performance for each stage of evaluation: preference learning, \( t(15) = 3.890, p < .001 \); transfer within domain of training, \( t(15) = 5.155, p < .001 \); across domain extension, \( t(15) = 2.719, p = .016 \); and knowledge of linguistic items (at ceiling, there were no incorrect responses), see figure 6.

Temporally trained 3-year-old subjects, however, showed chance performance for every stage of evaluation – preference learning, \( t(15) = 1.074, p = .300 \); transfer within the
domain of training, $t(15) = 1.291, p = .216$; and across domain extension, $t(15) = -0.460, p = .652$ – except knowledge of linguistic items which was above chance, $t(15) = 5.960, p < .001$. The temporal domain is opaque to 3-year-olds in study 3 as it was in study 2. Three-year-old children were not able to learn preference training or transfer knowledge within the temporal domain or across domains to spatial stimuli. These young children, however, did continue to show that they understood the linguistic items ‘long’ and ‘short’.
Comparing Child Performance in Study 2 and Study 3

A repeated measure ANOVA test was used compare the results of the two experimental studies to explore whether there were differences based on the type of training children received: linguistically-rooted novel word training or nonlinguistically-rooted preference training. The results of this analysis showed that there were no significant differences between the two studies; there was no main effect for study design, $F(1) = .009$, $p = .924$). Additionally, when comparing between studies, other significant results were maintained, as would be expected due to the fact that there was no significant main effect of study design.

The fact that there was no significant difference between novel word training and preference training shows that there are other factors at work, beyond language, that underlie the relationship between the space and time domains. These studies provide support for the view that metaphor is not solely linguistic. If language was inherently and intrinsically connected to metaphor, child performance should be facilitated by the presence of a lexical item to help them learn concepts and map between domains. Performance was not higher for children who received novel word training compared to children who received preference training suggesting that the linguistic components of
metaphor are, indeed, a reflection of conceptual structuring that can be accessed regardless of whether a lexical item is present.

Lakoff and Johnson have suggested that TIME is SPACE is a primary conceptual metaphor; SPACE is TIME is an early-learned metaphor that provides a foundation for other complex metaphors. If a deeply rooted conceptual metaphor was the sole mechanism aligning the domains of space and time, children should readily apprehend and make spontaneous connections between the domains. Transferring knowledge from one domain to another should be easily. According to results of these current experiments, however, the space/time metaphor does not appear to be innate, or at least young children are not able to utilize the metaphor during the task demands of study 2 and 3. Three-year-old children were not able to transfer between the domains of time and space and had difficulty comprehending temporal information. One explanation is that TIME is SPACE is not a basic, primary metaphor; that, perhaps, these primary conceptual metaphors do not exist. The space/time metaphor may exist but time, as an abstract domain, is still being apprehended and young children are not about to learn or transfer information to the temporal domain after brief training. Older children, however, seem to have access to the temporal domain and are successful at the task while younger children are not.

To explore child understanding of the space/time metaphor, especially the temporal domain, we conducted further analysis on data from study 2 and 3 to look at patterns for children who succeed during the learning stage of evaluation compared to children who
did not show learning. Children were coded as passing the learning phase of either study 2 or 3 if correctly answered 2 or 3 questions during the learning stage of evaluation. Children were coded as not passing the learning phase if they only answered 1 question correctly or if they did not answer any questions correctly. Analysis showed the 110 children (85.9%) passed the learning phase and 18 (14.1%) did not pass the learning phase for both age groups in study 2 and 3. Looking within age groups and at training received by children in each study, a pattern emerges that suggests that the critical factor for whether a child passed or did not pass learning was the type of training the child received – spatial or temporal. All cases of children failing to pass the learning stage (answered only 0 or 1 questions correctly) occurred for children who received temporal training. All children, whether aged 3 or aged 5, who received spatial training answered at least 2 questions correctly during the learning phase of evaluation, see table 5.

<table>
<thead>
<tr>
<th></th>
<th>3-Year-Old Children</th>
<th>5-Year-Old Children</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Space Training</td>
<td>Time Training</td>
</tr>
<tr>
<td>Pass Learning</td>
<td>32</td>
<td>18</td>
</tr>
<tr>
<td>Did Not Pass</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Learning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Children who pass or do not pass the learning stage for Study 2 and Study 3 by training

These differences are a result of stimuli used during training – spatial or temporal – rather than due to differences in the linguistic or non-linguistic training, see table 6. A chi-square analysis looking only at number of children who passed the learning phase,
showed that the groups – children in the linguistic study, study 2, or the non-linguistic study, study 3 – were not independent, $\chi^2(3) = .056, p > .05$.

<table>
<thead>
<tr>
<th></th>
<th>3 Year Olds</th>
<th></th>
<th>5 Year Olds</th>
<th></th>
</tr>
</thead>
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<tr>
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<td>Non Linguistic</td>
<td>Linguistic</td>
<td>Non Linguistic</td>
</tr>
<tr>
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<td>9</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Did Not Pass Learning</td>
<td>7</td>
<td>7</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 6. Children who pass or do not pass the learning stage for Study 2 and Study 3 by study condition

Looking within the different age groups for children who received temporal training, using non-parametric Mann-Whitney $U$ tests to compare the performance of 3-year-old children who pass learning with 3-year-old children who did not pass learning, the only significant difference between the groups was in performance on the within domain transfer stage ($U = 181.00, p = .027$). Three-year-old children who passed learning performed better at subsequent within domain transfer compared to 3-year-old children who did not pass learning.

Figure 7 shows performance across the evaluation stages for 3-year-old children who pass and did not pass the learning stage. Three-year-old children who passed learning were above chance for transfer within domain of learning, $t(17) = 2.766, p = .013$, but 3-year-olds who did not pass learning were at chance for within domain transfer, $t(13) = - .806, p = .435$. When asked to transfer to a new domain, both groups performed poorly (transfer mean for 3-year-olds who passed learning = 1.39, transfer mean for 3-year-olds
who did not pass learning = 1.43). Both groups of 3-year-olds, those who passed learning, \( t(17) = -0.514, p = 0.614, \) and those who did not pass learning \( t(13) = -0.285, p = 0.780, \) were at chance levels for across domain extension. Passing learning also did not show an impact on performance for evaluation of knowledge of ‘long’ and ‘short’. Both groups performed well, demonstrating knowledge of the lexical items (knowledge mean for 3-year-olds who passed learning = 2.50, knowledge mean for 3-year-olds who did not pass learning = 2.43). Both groups, those who passed learning, \( t(17) = 6.000, p < .001, \) and those who did not pass learning, \( t(13) = 5.377, p < .001, \) were above chance for performance on evaluation of knowledge for lexical items.

![Figure 7. Performance by evaluation stage for 3-year-old children based on passing and not passing the learning phase](image_url)
Looking at performance within the 5-year-old age group for children who received temporal training, non-parametric Mann-Whitney $U$ tests were used to compare the performance of 5-year-old children who pass learning with 5-year-old children who did not pass learning. There was a significant difference between the groups in performance on the within domain transfer stage ($U = 231.50, p < .001$) and extension across domain approached significance ($U = 182.00, p = .063$).

Figure 8 shows performance across the evaluation stages for 5-year-old children who passed and did not pass the learning stage. Five-year-old children who passed learning performed better at within domain transfer than 5-year-old children who did not pass learning. They were above chance for transfer within domain of learning, $t(27) = 11.381, p < .001$), while 5-year-olds who did not pass learning were at chance for within domain transfer, $t(3) = -1.000, p = .391$. When asked to extend knowledge to a new domain, 5-year-old children who passed learning did well (extension mean = 2.43) and were above chance for performance on the extension to a new domain phase, $t(27) = 5.590, p < .001$. Five-year-old children who did not pass learning did not perform well (extension mean = 1.00) on extension to a new domain and were not above chance for their performance in this phase, $t(3) = -.707, p = .530$). Both groups of 5-year-olds, were above chance for performance on evaluation of knowledge for lexical items; performance for this stage was at ceiling for this age showing that even children who did not pass the learning phase had knowledge of the lexical items ‘long’ and ‘short’.
Figure 8. Performance by evaluation stage for 5-year-old children based on passing and not passing the learning phase

There is a need for continued research to further explore how understanding of the domains of space and time and connection between the two domains develops. Research suggests a relationship between space and time exists yet the results from the present studies show that 3-year-old children lack the ability to transfer between the domains of space and time. Five-year-old children, overall, were successfully able to learn and transfer knowledge within and between both domains. A subset of 5-year-old children, however, performed similarly to 3-year-old children and also struggled to learn via temporal training. They were not able to learn, transfer, and extend knowledge for the temporal domain.
Discussion

According to study 1, both 3-year-old and 5-year-old children use the words ‘short’ and ‘long’ in the domains of space and time. Similarly, adult input for 3-year-old and 5-year-old children shows that adults use these lexical items in both domains when speaking with children. Results of study 2 and 3 show that 5-year-old and 3-year-old children understand the words ‘long’ and ‘short’, however, young children do not make spontaneous connections between the domains of space and time for lexical items of extent. These results occur whether or not children have a specific linguistic item – ‘blicket’ – to map across the domains. Child performance after novel word training in study 2 was comparable to performance after preference training in study 3; there were no significant differences between the two studies that were solely based on whether children received linguistically-rooted novel word training or nonlinguistic-rooted preference training.

The Conceptual Metaphor Theory advocates for analysis and exploration of metaphor outside of language. These studies we conducted provide support for the view that metaphor is not solely linguistic. If language was inherently and intrinsically connected to metaphor, child performance should be facilitated by the presence of a lexical item to
help them learn concepts and map between domains. Performance was not higher for children who received novel word training compared to children who received preference training suggesting that the linguistic components of metaphor are, indeed, a reflection of conceptual structuring that can be accessed regardless of whether a lexical item is present.

The present research we conducted supports the view that Conceptual Metaphor view that suggests that metaphors are more than language – not a trivial finding since some researchers use the role of language to separate metaphor from analogy (Bowdle & Gentner, 1999; Gentner, 1982; Gentner & Jeziorski, 1993) – it does not, however, provide evidence of a coherent space/time metaphor that is accessible to young children. While it does not seem necessary to have linguistic items for metaphor, 3-year-old children and some 5-year-old children struggle with the space/metaphor. The temporal domain is particularly difficult. These struggle with the space/time metaphor, suggest that TIME is SPACE cannot be a primary, conceptual metaphor, like Lakoff and Johnson posited. Perhaps these primary, conceptual metaphors do not exist and metaphor requires Younger children, and some older children, struggle with the temporal domain. This may, perhaps, be explained due to different representations of time. Work by Gentner and colleagues (2002) suggests that time can be perceived as either ego-moving, where you imagine yourself as walking along a mental timeline, or time-moving, where time is like a flowing river that pass by you. There is also some research to suggest there are cross-cultural differences in representations of time. A study by Casasanto and
colleagues (2004) found that English and Indonesian speakers tended to use linear terms (i.e., ‘long’ and ‘short’) for both space and time while Greek and Spanish speakers tended to share quantity terms (i.e., ‘much’ or ‘little’) between the two domains. Spanish speakers typically do not use ‘largo tiempo’ to state that a ‘long’ time has passed; instead they preferred to use ‘mucho tiempo’ which translates as ‘much’ time has passed. Similarly, in Greek, the words *megalos* or *poli*, which translate to ‘large’ or ‘much’, are used to talk about events that last a long time (Casasanto, 2008). The fact that there are multiple representations of time supports the view that time is abstract and is the target in the space/time metaphor. Children struggling with the space/time metaphor may be developing a representation of time, may switch representations, or have more difficulty within the temporal domain due to the existence of multiple representations of time.

The space/time metaphor does not appear to be innate, or at least young children are not able to utilize the metaphor during the task demands of study 2 and 3. If a deeply rooted, conceptual, primary metaphor was the sole mechanism aligning the domains of space and time, children should make spontaneous connections between the domains and should easily transfer knowledge from one domain to another. Lakoff (1993) has suggested that *TIME is SPACE* is a primary metaphor that is utilized to build more complex metaphors. According to this view, *SPACE is TIME* is an early-learned metaphor that provides a foundation for other complex metaphors. Findings from the current research project, however, bring scrutiny to this account. Three-year-old children were not able to transfer between the domains of time and space and had difficulty comprehending temporal information. One explanation is that *TIME is SPACE* is not a basic, primary metaphor.
Neurobiological research (Basso et al., 1996; Dehaene et al., 2004) shows connections between space and time. This connection between the two domains does not mean, however, that a person is aware of the link or can utilize it to facilitate further inferences.

Another possibility is that the ability to utilize metaphors, even ones that seem basic and rudimentary, is a skill that develops in tandem with cognitive maturation and growth. Children may need additional time to build conceptual knowledge in concrete and accessible domains before they can transfer between domains. This explanation aligns with perspectives on metaphor that tout the importance of experience (e.g., the Metaphoric Structure View, the Embodiment Perspective etc.) but one question remains: What experiential factors could have led to the success of 5-year-old children who have mastered the space/time metaphor? Additionally, does language play a role in general metaphor ability rather than facilitating specific metaphors like TIME is SPACE? Clearly there is a need for further research on metaphor acquisition and development.

So, is metaphor conceptual or is it linguistic? Is there another perspective that best captures how we understand and use metaphor? Bowdle and Gentner (1999) believe that metaphor is a ‘species’ of analogy,’ trading relational information between base and target, in their Career of the Metaphor view. They suggest that metaphors act as lexical extenders and also create new categories of knowledge. Novel metaphoric mappings create new word meanings that refer to the new representations created by mapping between the concepts. For Bowdle and Gentner, metaphor is connected to language. Gentner (1982) differentiates metaphor from analogy by stating that metaphor is
expressive and tied to language while analogies are more like models and are more systematic, abstract, and clearer. We have reviewed some of the challenges to the Conceptual Metaphor Theory but there are also some concerns with limiting metaphor to just language. A modified account of the Career of the Metaphor may be a solution; viewing metaphor as analogy while looking beyond its linguistic form may be the perspective to help guide research and study the process of mapping and making inferences for metaphor.

There is a need for continued research to further explore understanding metaphor, in general, and the space/time metaphor, specifically. How are the domains of space and time connected and how do we develop the abilities to make inference and map between these two domains? A body of literature clearly shows that there is a relationship between space and time that can be seen in humans as early as 9-months of age (Srinivasan & Carey, 2010). Evidence of a relationship between space and time does not, however, entail full knowledge and access to the space/time metaphor. Results from the present study clearly show that 3-year-old children lack the ability to transfer between the domains of space and time. In fact, 3-year-old children were unable to successfully learn novel words or stated preferences within the temporal domain; one half of the space/time metaphor is completely obscured for young children. Five-year-old children, however, were successfully able to learn and transfer knowledge within and between both domains.

There is a need to continue this line of research to further explore how this transition takes place, especially using experimental designs that explore children’s ability to make connections and draw inferences between domains. Gaining the ability to map between
domains, to make metaphors, is an essential skill of learning and acquiring abstract concepts.


