Conveying symbolic relations:

Children's ability to evaluate and create informative legends

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Abstract

Symbols are used regularly in our daily lives, but in order for a symbol to serve its intended purpose, its meaning must be conveyed in some way (Myers & Liben, 2012). Across two studies, this research examined 4- to 6-year-olds' understanding of how the relations between symbols and their referents are effectively conveyed using legends. To investigate this issue, a novel task was developed in which it was necessary to convey the arbitrary correspondence between symbols (the shapes on top of a set of boxes) and a set of referents (cards with shapes on them), so that an unknowing other would know which card went inside each box.

Study One was an investigation of children's ability to *evaluate* legends that either effectively or ineffectively conveyed symbol-referent relations. Children's performance was examined in relation to age, the ability to detect ambiguity (Ambiguous Messages and Droodle tasks), and Executive Function skills (Inhibitory Control, Working Memory, Planning tasks). The results provide evidence that both the ability to detect ambiguity and Executive Function uniquely relate to children's ability to evaluate legends.

Study Two investigated a new group of children's ability to *create* a legend to convey symbol-referent pairs, in relation to the same cognitive skills considered in Study One. In addition, to examine the impact of exposure to effective legends, half of the children who did not create an effective legend were then presented with legends created by the experimenter, while the other half served as the baseline group. Children who received this exposure, relative to those in the baseline group, significantly improved their legend creations and transferred this improvement to a new set of stimuli. This study found evidence that ambiguity detection was related both to legend creation on children's first attempt, and children's ability to improve following exposure. However, Executive Function performance did not relate to legend production. Taken together, these studies provide insight on factors that relate to children's developing understanding of how symbol meanings are effectively conveyed, and argue for the important role of being able to detect ambiguity.

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Chapter One: Introduction

In our daily lives we convey and receive information using a variety of symbols, such as written language, numbers, maps, musical notation, etc. Such symbols allow us to share information with others and with our future selves (e.g., making notes or diagrams to be used later). Goodman (1976) emphasizes the communicative nature of symbols and argues that nothing intrinsically serves as a representation. For example, a cloud in the sky that appears to take the form of a rabbit was not deliberately created with that intention, and therefore is not *symbolic* of a rabbit (Rochat & Callaghan, 2005). DeLoache (2004) holds a similar view and defines a *symbol* as "something that someone intends to represent something other than itself"(p. 66). Her definition of symbol includes all representations regardless of the level of resemblance between the representation and what it stands for (i.e., its referent). According to this view, the term 'symbol' can be used for representations that resemble their referents, such a photographs, as well as those that have an arbitrary relation to their referents, such as written words. Peirce (1868) makes more fine-grained distinctions, and uses the term *symbol* to refer only to the latter, and uses *icon* (or iconic representation) for those representations that refer as a result of resemblance. Although the term *symbol* is used in different ways, in different bodies of research, I will use the term as DeLoache (2004) does (in keeping with the terminology used in current developmental psychology research).

Common across many definitions is that a symbol is something created with the intention to represent something. Goodman (1976) highlights how even symbols that appear to be literal representations, such as photographs, represent the referent based on the creator's intention (e.g., the limits of the frame that the photographer chooses to capture). In cases where a representation is arbitrarily linked to its referent, the referring relation is not self-evident and, as such, it must be conveyed in some way (Myers & Liben, 2012). Therefore, to serve as a symbol and convey information, it is necessary for: (1) the symbol creator to intend a referring relation; and (2) the symbol user to be informed of that referring relation. Importantly, for a symbol to be informative, the referring relation must be conveyed *effectively*; in other words, the relation between a given symbol, or set of symbols, and their respective referents must be conveyed in way that is clearly interpretable by a user. Without this, symbols will fail to serve their intended purpose. Young children's ability to evaluate and create ways to convey such relations is the focus of this research.

To date, only two published studies have examined children's understanding of the way in which we convey the relations between a set of symbols and their referents. These studies, by Myers and Liben (2008, 2012; discussed in depth below), had 5- to 9-year-olds decide which symbols they would use to represent intended referents, and then convey this information in a legend. This required the children to first create the symbol-referent pairings (e.g., using different symbols to represent different referents), and then create a way to convey those relations. My focus is not on children's generation of symbol-referent pairings, but is on children's emerging understanding of how relations between symbols and their referents should be conveyed. Therefore, a novel task was developed to examine that specific skill.

Overarching Research Goal

The main goal of the reported research was to investigate young children's understanding of how to convey symbol-referent relations to an unknowing other (by evaluating and creating legends). While there are a number of ways one might do this, I employed a device commonly used for this purpose: a legend (like that which typically accompanies a map). Although maps often pose difficulties for young children, as evidenced by 4- and 5-year-olds' inability to extract spatial information from such representations (e.g., Liben & Downs, 1993; Liben & Yekel, 1996), legends themselves allow for a relatively simple way to communicate symbol-referent pairings. A legend explicitly informs the symbol-user of what the symbols stand for by listing each type of symbol with its corresponding referent. Therefore, legends (independently of maps) were considered ideal for investigating children's understanding of how symbolic relations are conveyed. The use of such legends also allowed for an investigation of factors that relate to this understanding. The identification of these factors, such as cognitive skills and exposure to effective legends, was an additional goal of thesis. Despite a relative abundance of research on children's symbolic understanding, research has not specifically addressed these issues.

Four- to 6-year-olds were the target age group for this investigation, given that previous work has demonstrated rapid development in symbolic understanding during this period (e.g., DeLoache, 1995, 2000), as well as significant improvements in the cognitive skills expected to relate to this ability (Detection of Ambiguity and Executive Function; these developments will be defined in Goal Two). To investigate this age group's emerging understanding of what makes an effective legend, I developed the

Legend Evaluation Task and Legend Creation Task. A description of the Legend Tasks and the demands children are faced with when evaluating and creating legends will highlight why the chosen cognitive skills were expected to play a role. The tasks used in both studies were designed to measure children's developing understanding of what makes an effective legend, as demonstrated by their ability to evaluate legends as effective and ineffective (Study One), as well as their ability to create an effective legend to convey information to an unknowing other (Study Two).

In both of my studies, children were shown three boxes that each had a different symbol on top (e.g., square, circle, and triangle). Inside each, there were three identical cards that were unique to that box (e.g., pictures of crescent moons inside the box with the square, stars inside the box with the circle, and clouds inside the box with the triangle). The symbols on the boxes were arbitrarily related to the shapes on the cards that went with them; therefore, the relation between the symbols and their referents was not obvious from visual inspection. As a result, the relations between the symbols on the boxes and the shapes inside had to be conveyed (via a legend). Children watched as the cards were taken out of the boxes so that they could look at them. They were told that after they were done, someone else (an unknowing other) would need to put the cards back into their original boxes, and needed something to 'help them put the cards back in the right boxes'.

Using this simple scenario, I created a constrained situation wherein three symbols each corresponded to a different referent. The symbol system (i.e., the relation between the symbols and their referents) was straightforward and consisted of a one-to-one-mapping between each symbol and its corresponding referent (see Goodman, 1976 for a detailed discussion of the rules governing well-crafted symbols systems). The system was designed to be easily interpretable so that legends could be considered based on whether or not they conveyed the symbol-referent pairs, without having to deal with a situation in which the symbol-referent pairings themselves were problematic. Note that this task makes significantly different demands than in Myers and Liben's (2008, 2012) studies (mentioned above), in which children had to come up with the symbol system (which may or may not be well-crafted) and then convey it using something like a legend.

Goal One. My first goal was to investigate 4- to 6-year-olds' developing understanding of legends, and the way in which they convey information about symbol-referent relations. To this end, I examined children's understanding of how symbol-referent relations are conveyed by having them evaluate legends made by someone else (Study One), and by having them create legends to help another (Study Two).

Goal Two. My second goal was to investigate the cognitive skills that relate to children's emerging understanding of legends (Study One and Study Two). The specific cognitive skills investigated were Detection of Ambiguity and Executive Function. Detection of Ambiguity is the ability to recognize when information may be interpreted in more than one way (Nilsen & Graham, 2012; Nilsen, Graham, Smith, & Chambers, 2008), and therefore not necessarily as it was intended. Executive Function is an overarching term used to refer to the cognitive processes that are implicated in conscious control of thoughts and actions (e.g., Carlson, 2005; Zelazo & Müller, 2002) and problem solving (e.g., Zelazo, Carter, Reznick, & Frye, 1997).

To consider how Detection of Ambiguity and Executive Function contribute to performance, it is necessary to consider what demands children must deal with to succeed on my Legend Tasks. To be successful in identifying effective and ineffective legends (Study One), children must consider whether the information provided by each legend conveys the information it is supposed to (i.e., which symbol stands for which referent), in a way that lends itself to a single interpretation. This is also the case when the child creates the legend (Study Two). In other words, children must be sensitive to whether the information captured in the legend is unambiguous so that the legend-user will be clear about the legend-creator's specific intent. This highlights the need for Detection of Ambiguity.

The other cognitive skill expected to relate to performance on my Legend Tasks was Executive Function. This umbrella term commonly includes Inhibitory Control, Working Memory, and Planning ability (e.g., Hughes, Ensor, Wilson, & Graham, 2010; Sonuga-Barke, Dalen, Daley, & Remington, 2002; Welsh, Pennington, & Groisser, 1991). Inhibitory Control is the ability to inhibit or suppress an automatic (prepotent) response (e.g., Blair, Zelazo, & Greenberg, 2005; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Working Memory is the dynamic ability to hold information in mind while processing it (Baddeley, 1990). Finally, Planning is the ability to formulate a series of steps that must be taken to achieve a goal or solve a problem (Hayes-Roth & Hayes-Roth, 1979). Each of these skills will be discussed in more detail in Chapter Three.

The predicted role of these skills was motivated by the specific demands with which children are faced in the Legend Tasks. For example, children know which card belongs in which box; however, they must *inhibit* this knowledge and consider the perspective of an unknowing other when evaluating or creating legends. In the Legend Tasks, children must also rely on Working Memory to remember the task details, and keep the symbol-referent relations in mind while evaluating or creating a legend that conveys them on paper. Lastly, in order to be successful on the tasks, children need to plan ahead and consider what someone who has never seen the boxes before will need in order to pair each symbol with its correct referent.

Goal Three. The third goal motivating my research was to determine whether children's ability to convey symbolic relations could be improved by exposure to effective legends (Study Two). More specifically, the second study began by identifying children who were unable to spontaneously create an effective legend, and exposing them to effective legends, to see if that would help them improve the effectiveness of the legends they create. Eskritt and McLeod (2008) conducted a similar investigation, examining the impact of training on 9- to 11-year-olds' note-taking skills in a memory game. Participants in their study significantly improved after watching the experimenter demonstrate how to make functional notes. This finding suggests that children may have some understanding of how notations are made, and that with minimal intervention they can learn what information to include when making their own notations (Eskritt & McLeod, 2008). The current project continued this investigation with younger participants, using a simpler scenario, and examined the role of exposure for children's creation of legends.

Overview of Chapters

The next chapter (Chapter Two) will review research relevant to both of the studies reported in this thesis. I will present the limited research on children's understanding of legends, and then discuss research on symbolic understanding more generally. This review will identify aspects of symbolic understanding that pose difficulties for children, which were taken into consideration when designing the tasks used in the current project. Chapter Three will present a more in-depth discussion of the cognitive skills predicted to relate to children's ability to evaluate and create legends, including a review of common tasks used to measure these skills in the age group of interest. In Chapter Four, I will present Study One on children's evaluation of legends, followed by Chapter Five in which I will present Study Two on children's creation of legends. Finally, Chapter Six contains a general discussion of the two studies, along with concluding thoughts and ideas for future research.

Chapter Two: What Is Known About Children's Symbolic Understanding

Numerous researchers have investigated young children's emerging ability to deal with symbols. From such work, we know that by 3 to 4 years of age, most children can consider the intentions of a symbol's creator when interpreting a representation (e.g., Bloom & Markson, 1998; Hartley & Allen, 2014). However, children's understanding of symbols is far from complete and young children often make errors. For example, 3-year-olds often expect symbols to share physical properties with their referents, expecting pictures of ice cream to be cold (Beilin & Pearlman, 1991) and pictures of popcorn to spill if the photo is tipped over (Flavell, Flavell, Green, & Korfmacher, 1990).

Research has also established that the ability to deal with arbitrary symbols undergoes significant development during the preschool years. For example, Bialystok, Shenfield, and Codd (2000) investigated young children's understanding of written words as arbitrary symbols and demonstrated that 4-year-olds tend to expect the names of large objects to be larger (i.e., longer) than the names of smaller objects (e.g., compare *train* and *caterpillar*), but that there are significant improvements by age 5. Other research has shown similar improvements while investigating children's understanding of numbers as symbols. For example, Zhou and Wang (2004) found that children demonstrate improvements from age 4 to 5 when using conventional number symbols to represent small quantities (as opposed to making unrelated notes, pictographic representations of the items to be counted, or marks for each individual item rather than the total count). Evidence for development into the early school years comes from Myers and Liben (2008) who demonstrated that even older children (5- to 10-year-olds) continue to improve in their understanding of symbols, becoming increasingly able to select a symbol created with intentional purpose over a similar one created for an aesthetic purpose.

We know that, as they develop, children become increasingly able to deal with arbitrary symbols. However, we know very little about children's understanding of how the relation between such symbols and their referents should be conveyed. This is important because arbitrary symbols are only informative when symbol-creators communicate the referring relations in some way, such as through a legend. Thus, I will begin by reviewing the only published studies to date that have investigated children's understanding of how symbol-referent relations are conveyed by having the participants evaluate and create legends – both by Myers and Liben (2008, 2012).

Research Investigating Children's Understanding of Legends

Myers and Liben (2008) developed the *make-a-map* task to investigate children's ability to record locations on a map by using symbols, and then create a legend that would convey what their chosen symbols represent (this was presented among other tasks, which will be briefly described below). In this task, 5- and 6-year-olds were told that the experimenter would be hiding four blocks and four toy cars in a room and that they would have to indicate the locations on a map, using the provided symbols, to help the 'next child' find them. The symbols children selected from were a set of 16 stickers (4 patterns in 4 colours), none of which resembled any feature of the hidden items. This design resulted in a situation such that, regardless of a participant's choices for the symbol/sticker-referent pairs, a legend would be needed to convey which symbol stood for which referent (ostensibly for the next child). Participants were further told that the next child would be limited to searching in only four locations for *either* the blocks or the cars. This design allowed the researchers to investigate whether participants would differentiate between the items when selecting symbols as representations of them, and whether they would effectively convey their choices to the child who would be using them.

They found that 63% of children developed a symbol system that differentiated between the two types of items by using one type of sticker for the blocks, and another for the cars. Of particular interest for the present study was children's ability to *convey* the symbol system to an unknowing other by creating a legend to accompany their map. In total 73% of children made a legend (sometimes in response to prompts), of which 86% were deemed effective in communicating the symbol-referent relations (i.e., 63% of the entire sample). Legends that were considered effective were classified as one of two types: (1) categorical legends, which displayed each type of referent and the corresponding symbol, 56%; and (2) redundant legends, which displayed each individual item and the corresponding symbol, 44%. It is worth noting that for a legend to be deemed *effective*, Myers and Liben did not require that the creator differentiate among the items in their symbol system, as long they differentiated between them in some other way, such as labeling the hiding locations. Therefore, children who drew images of the hidden items alongside the sticker placed on the map were considered effective legend makers because they conveyed the pairing of the symbol (the sticker) with its referent (the hidden item). Though considered effective legend creators, it is not clear whether all of these children fully understood the purpose of the sticker on the map or whether they were simply labeling the hiding locations.

Although children's success on this task would suggest that they are at least somewhat skilled at creating effective legends, it is important to note that children participated in five tasks in this study, all of which were presented in a fixed order with the make-a-map task coming after two other map tasks, which may have influenced their ability to create an effective legend. In the task just previous to this one, the *use-a-map task*, children were presented with a legend that they used to locate the objects in the room. Thus, it is possible that children's success on the make-a-map task was influenced by the exposure to a legend in the prior task. Further, the children who created redundant legends were classified as 'effective', despite most of their legends consisting of pictures, letters, or words drawn directly onto the mapped room. While they did create an effective way to indicate the locations of the hidden objects, it is not clear that these count as legends in the more traditional sense of a device used to convey symbol-referent pairings (as they may have been pairing the referent with the location, as opposed to the symbol). If only those who explicitly conveyed the symbol-referent relations were considered to be effective, success rates would have been much lower (35% of the sample).

Another goal of Myers and Liben (2008) was to identify other factors that contributed to children's ability to use and create maps. They found that children's performance on the use- and make-a-map tasks was significantly related to children's ability to identify the intentions of a symbol's creator on the *map-intent* task. In this task, children had to select between a map with dots added to make it look 'pretty' and one with dots added to indicate the location of objects. In addition to identification of a symbol creator's intention, Myers and Liben wanted to investigate the contributions of general cognitive ability, which they did through the inclusion of a Piagetian number conservation task. This task measured children's ability to recognize that two equal rows of chips remain equal in number even after the chips in one row are spread out across a greater distance. Myers and Liben did not find a relation between this measure and their map tasks, however this does not imply that cognitive skills do not contribute to map task performance, but rather it is possible that this task did not measure the relevant cognitive skills. Astle, Kamawar, Vendetti, and Podjarny (2013) found evidence that Executive Function skills relate to children's performance on a task similar to Myers and Liben's use-a-map task. As was mentioned above (and will be reviewed in depth in Chapter Three), these skills were also identified as having a potential role in children's understanding of effective legends, as was investigated in this thesis.

Continuing this line of work, Myers and Liben (2012) investigated 6- to 9-year-olds' understanding of the need to convey symbol meanings to an unknowing other in their *map production* task. They did this by introducing children to a series of items that were hidden in a room, and then providing children with the opportunity to mark the hiding places on a corresponding map. They wanted to see if children could make a legend to accompany their map in order to convey where the items were hidden.

This task began with the experimenter presenting a large, transparent box containing about 40 objects. There were different types of objects (e.g., balls, slinkies, tubes, etc.) and there were different coloured objects of each type. Children watched as the experimenter selected 12 objects from the box (3 of each type) and hid them in a room, while distractor items similar to the hidden objects remained visible in the box. Participants were then oriented to a map of that room and told to use stickers to indicate the locations of the hidden objects. Children were assigned to one of two conditions: (1) the *arbitrary* condition, in which the stickers varied in colour and pattern but did not resemble the hidden objects or the distractor items in the box; and (2) the *iconic* condition, in which the stickers resembled the hidden objects *and* also resembled the distractor items. Therefore, in both the arbitrary and iconic conditions, a legend was required to convey the symbol-referent relations.

On their own, children had to come up a symbol system to use with their map, and then place the appropriate stickers in the appropriate locations. Following their placement, all children were asked a series of questions about what another user of their map would need to know to locate the hidden items. Specifically, the researchers were interested in whether children understood that the user would need to know: (1) which objects were hidden; (2) what symbol stood for each type of object; and (3) where the objects were hidden. Children's performance was also scored based on whether or not they produced a legend to accompany their map, and whether it conveyed the information listed in points (1) and (2) above. It is important to note that although the researchers asked probing questions alluding to the need to include a legend, children were not specifically asked to do so.

Although 78% of participants verbalized the need for a legend in response to the probes described above, only 66% of all participants actually attempted to produce one, and only 56% made a legend that was effective (i.e., conveyed which objects were selected and what symbol stood for each object). There were age effects for both attempts to produce a legend, and for the creation of a categorical legend (i.e., an efficient legend that linked each given symbol to the type of referent), with older children demonstrating better performance. These results could be interpreted to mean that their younger participants have difficulty knowing what an effective legend should entail, and that therefore it is unreasonable to expect even younger children (such as those in my studies) to have this knowledge. However, instead, I argue that there were features of the task (in terms of design/demands) that are likely to account for the difficulty faced by the participants.

The participants in Myers and Liben's (2012) study were first required to produce the symbol system (pairs of symbols and referents), and place the stickers on the map, before they could convey the symbol-referent relations in a legend. Therefore, children could have done poorly on legend production not because they were unable to create an effective legend, but because the symbol system they developed was ineffective in some way. Put another way, the quality of children's legends is necessarily constrained by the quality of the symbol system they initially established. Given the number of item types that they were required to track, and select symbols for, designing an effective symbol system was no small feat. Further, it is worth noting that although children were asked about the need to create a legend, they were never actually asked to make one. Had children been explicitly asked to make a legend, the researchers may have seen greater success. Thus, the somewhat poor performance of 6- to 9-year-olds in this study is not clear evidence against their ability to understand/create effective legends, but rather it indicates that they are limited in their ability to do so when faced with so many task demands. In order to investigate younger children's emerging understanding, and focus specifically on the ability to convey symbol systems, a different task is needed. Such a task would provide children with a simple, effective symbol system so they do not need to create it, but instead lets them demonstrate their understanding of how that system should be conveyed. Such a task was developed and used in this thesis.

Following the *map production* task, Myers and Liben (2012) examined children's awareness of the usefulness of legends in their *map evaluation* task. In this task, children were asked to choose between two completed maps (each indicating the location of hidden objects). The maps differed in only one way: one included a legend while the other did not. When asked to evaluate which was the 'better map', 86% of participants selected the map with the legend. Explanations of why it was the better map tended to be based on the map denoting what the objects were and where they were hidden (70%) and/or based on explicit reference to the legend (61%). When offering an explanation as to why the legend was valuable, only 39% invoked mental states (indicating a recognition of the user's need to know information) and only 15% made reference to the possibility that there could be many possible symbols for any given referent (i.e., that a user would not necessarily know the symbol-referent correspondence). This suggests that although 6- to 9-year-olds recognize that it is important to include a legend, they are poor at articulating what it is about these legends that make them informative (e.g., that they communicate the relation between symbols and their referents). Thus, their choice may have been governed by the map that looks the most like maps they have encountered before, in contrast to recognizing the communicative value of the legends. Furthermore, although children selected the map with a legend as the 'better' one, there is no evidence that they know when a particular legend is effective versus ineffective. Therefore, my research investigates children's understanding of different types of legends as opposed to the presence or absence of one.

Based on Myers and Liben (2008, 2012), we can draw some tentative conclusions about children's understanding of the communication of symbol-referent pairs. We know that 5- and 6-year-olds can use a map to indicate the locations of hidden objects, and that some of them are able to pair symbols on the maps with the identities of the hidden referents. We know that 6- to 9-year-olds can verbalize the need for a legend when conveying information in a map, and that they can recognize a map is 'better' when it is accompanied by a legend. Despite their knowledge of the need for a legend, we also know that children in this age group have difficulty verbally articulating *why* legends are valuable and can experience difficulty conveying symbol systems that they created.

As mentioned above, the difficulty these children had with the tasks may have stemmed from other task demands. Further, I was interested in examining earlier-emerging aspects of this skill. Therefore, I developed a task to directly investigate young children's understanding of how symbol-referent relations are conveyed. My task employed a simple, straightforward situation that included a one-to-one mapping between a set of symbols (three of them) and a set of referents. Children were required to evaluate or create a way to communicate the symbol system I designed. In Study One, I presented children with various legends (effective and ineffective) and explicitly asked them to judge each one individually. In Study Two, children were asked to make something that would convey the symbol-referent pairs to an unknowing other. What they produced allowed me to examine what they considered as necessary characteristics when conveying the symbols' meanings. Thus, I was able to investigate early-emerging aspects of this ability, without requiring children to provide sophisticated verbal explanations, create the symbol-referent pairings, or spontaneously produce legends without an explicit request to do so. The role of Detection of Ambiguity and Executive Function was investigated in both studies to consider their relation to children's evaluation and creation of legends.

Though Myers and Liben present the most directly relevant research, there are pertinent findings from other related work. Such research has addressed children's understanding of symbols as intentional (Bloom & Markson, 1998; Hartley & Allen, 2014; Sharon, 2005), as well as their understanding of iconic or conventional representations as a mnemonic tool (Eskritt & McLeod, 2008; Eskritt & Olson, 2012). Although the research does not address children's understanding of how symbol-referent relations are conveyed, it does highlight what we know about children's understanding of symbols. More specifically, this work speaks to children's developing understanding of symbols as a means to convey information and identifies features of symbol tasks that pose difficulties for children. Thus, some of the most relevant aspects of this literature will be reviewed, before turning to a discussion of the cognitive skills that were predicted to relate to children's evaluation and creation of legends.

Children's Understanding of Symbols as Intentional

Existing research demonstrates that children can take intentions into consideration in a representational task. Gelman and Ebeling (1998) found that when drawings were described as having been created intentionally, compared to when they were created accidentally, 2- and 3-year-olds were more likely to label them based on the objects they roughly depicted. Other research found that when 3- and 4-year-olds were presented with drawings, supposedly made by a child with a broken arm, they were able to consider details such as relative size to infer the artist's intention and correctly identify the corresponding referents (despite the drawings lacking any physical resemblance to their referents; Bloom & Markson, 1998; Hartley & Allen, 2014). Along the same line, Preissler and Bloom (2008) found that when 3-year-olds were presented with an ambiguous drawing that looked equally like two unfamiliar objects, they were more likely to indicate that the drawing was of the object the artist was gazing at while creating the representation. Based on this evidence, even young children demonstrate sensitivity to a creator's intentions when interpreting representations.

Sharon (2005) investigated the influence that intention information has on children's symbolic understanding in a representation task. Sharon used DeLoache's scale model task (e.g., DeLoache, 2000; DeLoache & Burns, 1993; Troseth, Bloom Pickard, & DeLoache, 1997) in which children need to treat a scale model as a representation of a larger room in order to locate a hidden object (the two rooms are matched in terms of furniture, layout, etc.). For example, if 'Little Bear' was hidden under a cushion in the little room, children who understand that the little room represents the large room should go and look for 'Big Bear' under the cushion in the big room. Children typically perform quite poorly on this task at around 2.5 years of age, but begin to reliably succeed by age 3 (DeLoache, 2000).

Participants in Sharon's (2005) study were 2.5- and 3-year-olds[1], who were randomly assigned to one of two conditions. Half of the children in each age group completed the standard version of the task while the other half completed the *intentional* version. In the intentional version, the model was described as something that was made

[1] The tasks differed slightly for the two age groups, with the older children's task containing a lower degree of similarity between the model and the room. This was done because previous work had demonstrated that 2.5- and 3-year-olds perform consistently and equally poorly on high- and low-similarity tasks respectively.

to help the child find Big Bear; highlighting that it had been specifically been made to provide information that would help the child. Also in this condition, when hiding Little Bear, the experimenter exclaimed, "I'll help you find Big Bear. I'll show you where Big Bear is hiding. Look!". By making this claim, the experimenter expressed their desire to use Little Bear and the model as a means to convey information. For both age groups, children's performance on the intentional version of the task was significantly better than that on the standard version. Given this finding, we can conclude that young children can benefit from having the intention of the representation pointed out to them.

This research was used to guide to the development of my tasks, ensuring that the demands were appropriate for the age range of interest (4- to 6-year-olds). Based on this work, the legends in both of my studies are described as something *intended* to help a friend put the shapes into their correct boxes. With my Legend Tasks, I am able to address the specific issue of children's understanding of how symbol meanings are intentionally and effectively conveyed to an unknowing other.

Although the research on children's understanding of legends as a tool to convey symbol-referent relations is limited, there is a body of research that has addressed children's understanding of representations as a tool to record and share information. In this body of work, children are typically in situations where they have to convey information either to a future self or to an unknowing other. Eskritt and colleagues have conducted key studies in investigating this ability in children, and so I now turn to this work.

Children's Use of Representations as a Mnemonic Tool

For the most part, research on children's understanding of representations as a mnemonic tool has been done by presenting children with visual information, such as a set of cards, in which specific details (e.g., the unique identities, order of presentation, or location) need to be remembered (the representation is for one's future self) or communicated (representation for another). Children are then given the opportunity to create a representation that will later help them (or the unknowing other) complete the task based on what the representation conveys about the identities/order/location of the cards (e.g., Eskritt & Lee, 2002; Eskritt & McLeod, 2008; Eskritt & Olson, 2012; Lee, Karmiloff-Smith, Cameron, & Dodsworth, 1998).

The representations children create can be either in the form of iconic drawings (such as realistic drawings of the cards in the order they need to be remembered) or conventional notation (such as written descriptions of the order of the cards). In either case, children convey the information as a direct representation of how it exists. As such, there is no symbol system (i.e., no symbol-referent pairs) for which relations need to be conveyed and therefore this research does not address children's understanding of how to effectively convey those relations. The research in this domain has, however, helped to inform the task design for my thesis research, so it will be reviewed here.

Eskritt, Lee, and colleagues' research on children's developing understanding of effective representations (i.e., representations that clearly convey what is intended) has highlighted aspects of representation tasks that can cause children difficulty. For example, when creating a representation, having to convey details such as the order in which items appear (Lee et al., 1998) or the spatial location of items (Eskritt & Lee, 2002; Eskritt & McLeod, 2008) can be difficult for children even as old as 8 and 9 years of age. Therefore, tasks designed for use with younger children should involve neither sequential order nor spatial location.

Eskritt and Olson (2012) developed such a scenario for their investigation with Kindergarten and Grade One children. In this study, they investigated children's understanding of what makes a representation useful/informative for both their future self and for an unknowing other. This was achieved by having the children produce (in Phase One of their study) and evaluate (Phase Two) representations[2]. The representations were intended to convey the identities of three different target cards (drawn from a larger set). In both the Production and Evaluation Phases, children were told to pretend they owned a store, with a puppet named Sam, that sold cards varying in shape (circles, triangles, and rectangles) and colour (red, blue, and green).

In the Production Phase, children were told that customers came to the store to buy cards, which would later need to be delivered to the customer's house, but would sometimes fall out of the bag during delivery and get mixed up. Therefore, children were asked to "mark something down" to help them remember (notation for their future self) which cards the customer wanted. In another condition, they were told that it was Sam's turn to make the deliveries, so they were asked to make something that would help him know the correct cards to deliver to the customer (notation for another).

In the Evaluation Phase, children were told that Sam had made notes for them, but that he was uncertain if the notes were good or confusing. With the cards the customer

[2] Although verbal messages were also used in this study, only the visual representations are presented here given their direct relevance to the current project. See Eskritt and Olson (2012) for a full description of the verbal message production and evaluation, and for the results from these specific tasks.

wanted set out on the table, children judged six different sets of notes one at a time. Two of the notations contained irrelevant information (Sam's name or an irrelevant drawing), two contained only partial information (only the colour or shape of the cards when both kinds of information were needed), and two contained all the information needed to correctly identify the cards (colour and shape). After each note was presented, they were asked, "Is this a good note or a confusing note? When you look at this note, do you know which cards the customer wanted or you don't know which cards the customer wanted?"(p. 194).

Both the notations children produced themselves and the notations they evaluated (made by the experimenter, and described to the child as having been made by Sam) were categorized as one of three types: full (i.e., containing all of the information needed), partial (i.e., containing only some information), or irrelevant/no notation (i.e., containing information unrelated to the identities of the cards, if containing any information at all).

In terms of production, Grade One children made full notations (68%) more frequently than partial (16%) or irrelevant (16%) notations, whereas Kindergarten children made full notations (17%) less frequently than partial (45%) or irrelevant (38%) notations. This finding indicates that children become increasing able to effectively convey information through external representations during these years. Regardless of the quality of the notations children produced, their evaluations of the types of notations followed the same pattern, with children being more accurate at judging full notations (*M* = 1.4 out of 2, *SD* = 0.6) than they were at judging partial (*M* = 1.0, *SD* = 0.5) or irrelevant (*M* = 1.1, *SD* = 0.8) notations. This is surprising given that one would expect children with an understanding of what effective notations entail to be able to both produce and evaluate them, and children without this understanding to be unable to do either. The pattern that emerged could be due to children tending to respond "yes" across the trials, as this would result in accurate responses for the full notations, and inaccurate responses for the other two types.

Eskritt and Olson did consider this possibility, and report that only two children responded "yes" to every single question, and that excluding these children did not impact the pattern of results. They argue that children's better performance on full/effective notations, relative to ineffective notations, should be interpreted to mean that children are in fact better at identifying effective notations than rejecting ineffective ones. While their data supports this conclusion, I suggest that instead of comparing children's performance on the two different types, conclusions about children's understanding of notations should be based on their ability judge *both* good and bad ones. In other words, in order to be given credit for an understanding of notations, children should be able to recognize not only when notations are good, but also when they are not.

Comparisons *within* informative and uninformative types, on the other hand, can provide insight into what makes some notations more easily identifiable than others. Interestingly, Eskritt and Olson found that children were able to differentiate between the two types of irrelevant notations used in the task: they were more likely to identify an unrelated drawing as confusing than they were to identify Sam's name as confusing. They also differentiated between the two types of partial notations, being more likely to identify notations with just colour as confusing than they were to identify notations that included only shape, even though both were equally uninformative. Finally, on the informative notations, children were more likely to identify the shapes drawn in the appropriate colour as a good notation than they were to identify the shapes with the colour information presented separately.

These results speak to children's ability to produce and evaluate notations, and draw attention to specific aspects of notations that children struggle with. From this research, we know that from Kindergarten to Grade One children become increasingly able to create a representation that conveys the identities of cards that vary on more than one dimension. I have taken what we have learned from this research and applied it to investigate children's ability to evaluate and create legends that convey symbol-referent relations. To be considered successful on my Legend Evaluation Task, children must be able to consistently and accurately evaluate both effective and ineffective legends. Although I do not compare children's performance on effective and ineffective legends (as I have argued against such comparisons above), I have followed Eskritt and Olson's (2012) lead and made comparisons within effective and ineffective types.

Summary

As described above, we know that by around age 3 children are sensitive to the intention motivating the creation of a symbol (Bloom & Markson, 1998; Hartley & Allen, 2014; Myers & Liben, 2008), and that their performance can be improved by highlighting the intentional nature of the representation (Sharon, 2005). Therefore, in my Legend Tasks, the intention to convey information is made explicit. Specifically, the experimenter explains to the participant that the legend (whether created by the child or the experimenter) is for the intended purpose of helping another child put the cards back into the right boxes. The cards used are arbitrarily related to the identifiers on the boxes because the meaning of arbitrary symbols cannot be deduced through resemblance or established conventional meaning (i.e., they must be conveyed in some way; Myers & Liben, 2012).

We also know from previous research that between the ages of 5 and 7, children become increasingly able to create a representation that conveys information needed to complete a simple task (e.g., to convey the identities of the cards that vary in colour shape). However, even by age 9, children still have difficulty with representations that include details such as sequential order (Lee et al., 1998) or spatial location of items (Eskritt & Lee, 2002; Eskritt & McLeod, 2008). Therefore, my tasks avoid interference from such demands by using three simple symbol-referent pairs, to which location and order are irrelevant. From Eskritt and Olson (2012), we have evidence that when using a pared-down task, children's understanding of representations as a mnemonic tool improves between Kindergarten and Grade One. The findings of this research informed my design, which investigates the related, but distinct question of the factors that play a role in children's understanding of how to convey symbol-referent pairs.

Myers and Liben (2008) was the first study to investigate children's understanding of legends as a tool for conveying symbol-referent pairs. Although 63% of their 5- and 6-year-old participants were successful at conveying symbol-referent relations, it is possible that this success was influenced by children's exposure to effective legends in a previous task. Furthermore, what was classified as an effective legend may have been more accurately classified as an iconic representation of the objects hidden within the mapped room. Although this would appear to suggest that legend creation may be too difficult for children this age, it is important to consider that some of the difficulty experienced may have arose from the complexities of the task (such as the need to first create the symbol system, and then convey it).

Based on Myers and Liben (2012), we have some indication that 6- to 9-year-olds understand legends. This was evidenced by participants' ability to recognize the 'better' map as the one accompanied by a legend in the *map evaluation* task. Interestingly, most of the children could not verbally articulate what it was about the inclusion of the legend that made the map better. Therefore, my tasks avoid requiring children to provide sophisticated verbal explanations, and instead have them evaluate individual effective and ineffective legends (Study One) or create a legend to convey information (Study Two).

Further evidence for children's understanding of legends was demonstrated by participants' ability to verbalise the need for a legend in Myers and Liben's (2012) *map production* task. However, despite many children commenting on the need for a legend, they frequently did not produce one (and of those that did, only a subset were effective). Their performance, however, was constrained by their ability to create a well-crafted symbol system. To avoid this potential limitation in my research, the legends that children evaluate and create in my studies were based on clear, simple, pre-designed symbol systems that were presented to the child.

To explain differences in children's ability to evaluate and create legends, I turn to other cognitive skills. As mentioned in Chapter One, the cognitive skills investigated were Detection of Ambiguity and Executive Function (including Inhibitory Control, Working Memory, and Planning ability). I will now describe why these skills were predicted to be relevant to my research and how children typically perform on commonly used measures, followed by a review of research which has found that performance on these and similar measures relate to children's symbolic understanding.

Chapter Three: Cognitive Skills Predicted to Relate to Legend Task Performance

Recall that Detection of Ambiguity and Executive Function were expected to play a role in children's ability to evaluate and create legends, as was described in Chapter One (see pages 5-7). In this chapter, I provide a more detailed explanation of why these skills were predicted to relate to performance on my Legend Tasks. I also discuss how these skills are measured in children within my target age range, and how other research using these or similar measures has linked Detection of Ambiguity and Executive Function to representational understanding.

Detection of Ambiguity

The ability to detect ambiguity involves recognizing when something could be interpreted in multiple ways (Nilsen & Graham, 2012; Nilsen, Graham, Smith, & Chambers, 2008). This skill is often examined as a specific aspect of the broader concept of *Theory of Mind* (i.e., the ability to attribute mental states to oneself and others, and to consider those mental states when interpreting and predicting behaviour; e.g., Premack & Woodruff, 1978; Wellman & Liu, 2004). The ability to detect when something is ambiguous was expected to be related to children's ability to evaluate and create legends because the legends are made for the intended purpose of conveying information to an unknowing other. Therefore, being sensitive to when such information is conveyed clearly (i.e., unambiguously) should relate to children's performance on the Legend Tasks.

The ability to detect ambiguity has been measured in preschool children using both verbal and visual tasks. Two widely used tasks are the Ambiguous Messages task (e.g., Bearison & Levey, 1977; Nilsen & Graham, 2012) and the Droodle task (e.g., Chandler

& Helm, 1984; Perner & Davies, 1991). The Ambiguous Messages task measures children's ability to detect verbal ambiguity. In variations of this task (e.g., Bearison & Levey, 1977; Nilsen & Graham, 2012; Nilsen et al., 2008) children hear a series of unambiguous utterances (utterances that refer to only one possible referent) and ambiguous utterances (those that refer to more than one possible referent). Children are then required to make judgments about each utterance and evaluate whether it is 'good'/'clear' or 'not good'/'confusing'. Typically, 4-year-olds are unable to accurately judge the clarity of the statements, while 5-year-olds tend to achieve success (e.g., Nilsen & Graham, 2012).

Although there are different adaptions of this task, the task used in this thesis was modeled closely after Nilsen and Graham's (2012) version. In their longitudinal study, 4-year-olds were tested every 6 months (three time points in total, until the age of 5). In their task, participants watched as a sticker was hidden under one of two cups by Experimenter 1 (E1). The cups that served as the hiding places were matched in either size or colour, but not both (e.g., a small red cup and a small blue cup). Experimenter 2 (E2) could not see where the object was hidden because she sat behind a closed curtain. E1, speaking through a puppet named 'Spot', gave E2 a verbal clue as to where the sticker was hidden. For unambiguous clues, the distinguishing dimension was indicated, making it clear which cup the sticker was hidden under (e.g., 'under the *blue* cup'). For ambiguous clues, the description mentioned the shared dimension, thereby picking out both locations (e.g., 'under the *small* cup'). Children were asked to point to where they thought E2 would look for the sticker, and judge whether they thought the clue was 'good' (unambiguous) or 'tricky' (ambiguous). Children completed three trials with ambiguous clues and three with unambiguous clues for each of two conditions: one in which they watched as the sticker was hidden and were therefore knowledgeable of the hiding place (as was done in the task used for the present study), and one in which the participant was ignorant to the correct location. Children's ability to recognize when a clue was 'tricky' was taken as an indicator of their ability to detect ambiguity.

Regardless of whether or not the participant was aware of the sticker's location, the same pattern of findings emerged. In both conditions, 4-year-olds showed no difference in their evaluations of ambiguous and unambiguous clues. However, when they were 4.5 to 5 years of age, the children were significantly more likely to judge ambiguous clues as tricky relative to unambiguous ones. This finding evidences improvement on this task during the preschool years.

A notable limitation of this task, however, was that a number of the children could not consistently demonstrate an understanding of the term 'tricky'. When asked whether 'tricky' meant 'good' or 'not-so-good', 29% of the participants were unable to respond correctly at least two consecutive time points and were therefore excluded from analyses. Based on this, in order to avoid exclusion based on confusion with the terms, the term 'tricky' should have been removed and the choices presented to the participants should have been be 'not-so-good' and 'good' – which is how the question was asked in my adaptation of the task (see Method section for a full description of my task administration, and for evidence that children understood the terms used in the revised version, with 95% of participants responding that 'not-so-good' clues are unhelpful on their first attempt, and 99% responding correctly by their second attempt).

Other research has measured children's ability to detect ambiguity using visual tasks. In the Droodle task (Chandler & Helm, 1984; Perner & Davies, 1991), 3- to 5-year-olds are presented with an image that is open to multiple interpretations because the information provided underspecifies the item. In this task, children are introduced to an image that is then mostly covered so that it is unidentifiable from the portion shown (the visible portion could be a part of many possible items). For example, in Chandler and Helm's (1984) version of the task, the full image is of two elephants smelling a grapefruit. When partially covered, the subsection visible depicts only a circle and two rectangles (unrecognizable as the fruit and the ends of the elephants' trunks). Children are then asked if a child who had never seen the picture before would know its identity. Although children around 3 years of age do poorly on this task, they tend to be successful by around age 5 (e.g., Perner & Davies, 1991). Similar in structure to the Ambiguous Messages task described above, this task requires children to reflect on whether the information presented unambiguously conveys information to an unknowing other.

To assess children's sensitivity to ambiguity, I included both a verbal and a visual ambiguity measure in my investigation. The Ambiguous Messages and Droodle tasks were chosen because research has shown that children improve in performance during the age range of interest and, given the conceptual similarity of these tasks (Robinson & Robinson, 1982), they can be grouped together as an indicator of children's ability to detect ambiguity more generally (which was supported by the scores on these tasks being significantly correlated in both studies of this thesis). Collectively, performance on the tasks will be referred to as measuring *Detection of Ambiguity*, which was predicted to relate to children's evaluation and creation of effective legends.

Executive Function

Given the demands of my Legend Tasks (described on pages 6-7), Executive Function was also predicted to play a significant role in children's performance. Based on research with the age group of interest, there is evidence for a unitary construct of Executive Function (e.g., Hughes et al., 2010; Wiebe, Sheffield, Nelson, Clark, Chevalier, & Espy, 2011). Therefore, instead of looking for relations between the Legend Tasks and each of the constituent components of Executive Function, performance on the Legend Tasks was examined in relation to a composite indicator of Executive Function. This was accomplished by extracting an Executive Function component (using a Principal Components Analysis) that summarizes the patterns of correlations among performance on measures of Inhibitory Control, Working Memory, and Planning. Measures of these skills were selected because they were expected to relate to Legend Task performance, as will be described in detail below. Although the tasks selected were chosen because they map onto specific Executive Function skills, it is important to note that the overarching goal was to assess Executive Function and the role that it plays as a whole. As discussed by Garon, Bryson, and Smith (2008), Executive Function is argued to be a unitary construct with constituent subprocesses, regulated by a central attention system (Baddeley, 1986; Norman & Shallice, 1986; Shallice, 1988). As such, this approach provides a comprehensive measure of this ability.

The first Executive Function skill mentioned above is Inhibitory Control, which is the ability to inhibit or suppress an automatic (prepotent) response (e.g., Blair et al., 2005; Miyake et al., 2000). This skill is expected to contribute to children's evaluation and creation of legends because in both Legend Tasks children must inhibit or suppress their own knowledge of the symbol-referent relations in order to consider how the set of symbol-referent pairs can be effectively conveyed to another. A task that measures this ability in preschool children is the Black/White Stroop (Simpson & Riggs, 2005; Vendetti, Kamawar, Podjarny, & Astle, 2015). In this task, children are presented with solid black and solid white cards and are asked to respond with "white" when they are shown a black card and "black" when shown a white card. As such, they are required to inhibit their prepotent response (e.g., say 'white' to a white card) and instead respond with something else (e.g., say 'black' to a white card). Children's accuracy on this task improves dramatically between the ages of 3 and 5 years (e.g., Simpson & Riggs, 2005; Vendetti et al., 2015), and is related to other Executive Function skills (Vendetti et al., 2015); therefore, it is appropriate for capturing variability of performance in the present study.

The second Executive Function skill, Working Memory, is also important for dealing with the demands of the Legend Tasks. In both the evaluation and creation versions of the task, children must keep the symbol-referent relations in mind. Given this requirement for success, there is a clear Working Memory demand.

Baddeley's (1990) model of Working Memory consists of a domain-general component and two domain-specific components. The domain-general component is the *central executive*, which is involved in controlling attention, coordinating the domain-specific components, and processing information from long-term memory (Müller, Kerns, & Konkin, 2012). The domain-specific components are the *phonological loop* and *visuo-spatial sketchpad*. Phonological Working Memory is the ability to hold speech-based information in mind and use inner speech to manipulate it. In contrast, visuo-spatial Working Memory is the ability to remember what is being seen, as well as where it is in space (Baddeley, 1990).

A phonological Working Memory task used with young children is the Backward Word Span (e.g., Carlson, Moses, & Breton, 2002). In this task, children are asked to repeat, in backwards order, words spoken by an experimenter. Children younger than 4 years of age tend to display very poor performance (typically near floor), repeating the words back in the same manner they were said by the experimenter (Carlson et al., 2002). Four-and 5-year-olds, however, are more successful and can typically repeat two to three words in reverse order (Carlson et al., 2002), making this task was well suited for use with my sample.

To measure visuo-spatial Working Memory, a child-friendly Corsi Span task is often used with children in this age range (e.g., Rasmussen & Bisanz, 2005). In this task, children are presented with an array of dispersed 'lily pads' and are instructed to follow the experimenter's lead as they pretend their fingers are frogs jumping from lily pad to lily pad. Typically, 5-year-olds are able to successfully copy the experimenter's movements up to four lily pads in a row (Rasmussen & Bisanz, 2005) and therefore this measure is appropriate for children in the age range of interest. This task, taken together with the Backward Word Span, captures the skill implicated for keeping the symbol-referent relations in mind while evaluating and/or creating legends – as described, that skill is Working Memory.

The third aspect of Executive Function implicated in the Legend Tasks is Planning. Planning is the ability to formulate steps in order to achieve a goal (e.g., Hayes-Roth & Hayes-Roth, 1979), and was expected to contribute to performance on the

Legend Tasks given the need to plan for what an unknowing other would need to know in order to put the cards in the correct boxes. This ability is often measured in 3- to 5-year-olds by using the Truck Loading task (e.g., Carlson, Moses, & Claxton, 2004; Fagot & Gauvain, 1997). In this task, children are required to follow a series of rules when delivering party invitations on a pretend street. More specifically, they are told that invitations must match the colour of the house delivered to, invitations can only be taken from the top of the pile, and the delivery must be made in one direction (see Method section for more details). To be successful, children must consider all of the rules when packing up their delivery truck. Research evidences improvement in performance between the ages of 3 and 5 (Atance & Jackson, 2009; Carlson et al., 2004), so this task was used for measuring this ability in the sample of children for the present studies.

Cognitive Skills Related to Performance on Representational Tasks

Although no research to date has specifically investigated the relations between the skills mentioned above and children's evaluation and creation of effective legends, research has shown that these skills are related to representational understanding more generally. Therefore, I will briefly review this work.

Myers and Liben (2012) investigated children's performance on Droodle and classic Ambiguous Figures tasks (e.g., children are presented with an ambiguous duck/rabbit figure and are prompted for whether they see both interpretations; Rock, Gopnik, & Hall, 1994) in relation to children's symbol-communication understanding. Their symbol-communication score was a composite of children's performance on the map tasks described in Chapter Two: the *map evaluation* task (in which children chose between a map with a legend and one without) and the *map production* task (in which children verbally identified what information a naïve-symbol user would need and then conveyed that information in a legend). They found that performance on their ambiguity measures predicted children's symbol-communication scores above and beyond age and general cognitive ability (as measured by the Wechsler Intelligence Scale for Children; Wechsler, 2003) but *only* for the iconic symbols. Recall from the earlier description of this task that the iconic condition used stickers that resembled the hidden objects but that also resembled distractors, while in the arbitrary condition, the stickers varied in colour and pattern but did not resemble the hidden objects or the distractor objects that remained visible in the box.

The authors argue that only the iconic symbol-communication score related to children's sensitivity to ambiguity because it is only for the iconic symbols that children need to anticipate that someone else could interpret the symbol in a different way (i.e., that it might represent one of the distractors). For the arbitrary symbols, they claim that children's success is instead influenced by their ability to inform the symbol-user about the assigned meaning of the symbol rather than their ability to anticipate that someone else may interpret the symbol differently. Contrary to their claim, I posit that although the iconic version may make other possible referents (the distractor items) for a given symbol more salient (thereby requiring Inhibitory Control, which was not assessed in their study), arbitrary representations lend themselves to multiple interpretations to an even broader extent. As described in Chapter Two, children's ability to make a legend in their task is confounded by their ability to make a symbol system. Therefore, in a task that more specifically assesses children's ability to evaluate/create effective legends, I predicted that sensitivity to ambiguity would relate even in scenarios with arbitrary symbols.

Other research has identified Executive Function as a skill that plays an important role in children's ability to use representations. Walker and Murachver (2012) investigated Executive Function in relation to representational understanding using DeLoache's (2000) scale model task. Recall that in this task (described above in the review of Sharon, 2005), children use information provided by a scale model to locate objects in the represented room. Walker and Murachver followed a group of children from the age of 2.5 to 3.5 years, testing their performance on the scale model task in relation to measures of Executive Function. Although the measures they used to assess Executive Function are not the same as those described above (they used measures appropriate for these younger children), they do cover skills indicative of children's executive control. They included measures of Working Memory, Behavioural Inhibition (a task which required children to inhibit a prepotent response, similar to that required for the Black/White Stroop), and Set-Shifting (i.e., the ability to shift focus from one aspect of an object to another). They found that all of their Executive Function measures were significantly correlated with performance on the scale model task from 3 years of age and onward.

They also considered scale model performance in relation to children's false belief understanding. False belief understanding is the ability to attribute beliefs to another based on that individual's knowledge, despite their belief being inconsistent with reality, and predict that individual's behaviour based on their beliefs (Wellman, Cross, & Watson, 2001). Walker and Murachver (2012) found that this skill also contributed to children's performance on the scale model task. This finding suggests that children with a better understanding of the mental states of others tended to achieve more success using the scale model as a representation. Although their measure of mental state understanding does not capture the ability to detect ambiguity as described above, it does highlight the relationship between children's understanding of physical representations (the scale model) and mental representations (understanding that the character in the story will act based on their beliefs, even if they are incorrect).

The link between Executive Function and symbolic understanding has been further demonstrated by research utilizing reverse-contingency tasks. An example of such research, by Carlson, Davis, and Leach (2005), did so using the *Less is More* task. This task began by presenting 3- and 4-year-olds with two prizes: a small prize (two candies) and a big prize (five candies). Children were introduced to a naughty puppet and were told that every time they point to a prize, it would go to the puppet and the other prize would go to them. Children completed 16 test trials, with the candies awarded and replenished each time. In their first study, the authors established internal validity for the Less is More task as a measure of Executive Function by demonstrating strong relations with other measures of Inhibitory Control and Working Memory. In their second study, with 3-year-olds, they added three conditions wherein they replaced the candy prizes with symbolic representations. One symbolic condition used rocks in place of the candies (two vs. five), another used circles containing small and large amounts of dots (40 vs. 100), and the other used a small and a large animal (mouse vs. elephant). When tasked with pointing to the smaller prize (or the symbolic representation of it), children's performance was significantly better when the target items were animals as compared to the actual candies. Furthermore, when the target items were animals or dots, children performed significantly better than chance. Performance was no different from chance for the rocks or actual candies. The authors interpret this finding as evidence that adding symbolic distance had a positive effect of children's ability to point to the smaller reward. Given that performance on the Less is More task is taken as indicative of children's Executive Function ability, this work highlights the relation between Executive Function and children's emerging ability to use symbols to reach a goal.

Using a similar reverse contingency task, Apperly and Carroll (2009) presented children with an empty box and a box containing a prize (stickers). They investigated 3- and 4-year-olds' ability to point to the empty box they wanted to their opponent to receive, in order to keep the box with the prize for themselves. Consistent with Carlson and colleagues (2005), they found that children were better able to point to the empty box when the prize was *symbolically* represented. In their second experiment, Apperly and Carroll found that children who began the task in a symbolic condition not only demonstrated better performance than those who used the actual stickers, but continued to show improved performance when the representations were removed and the stickers were used instead. Therefore, although by the end of the task both groups of children were using the same stimuli, many children who had experience in the symbolic condition demonstrated transfer and continued to be successful on the task. The authors interpret this finding as evidence that the use of symbols does not merely help children to *execute* a strategy when selecting the appropriate box, but rather it helps them children *formulate* a strategy which can then be used on non-symbolic trials. Based on this research, the authors argue that the use of symbols influences the cognitive processes involved in performing reverse contingency tasks. Given the Executive Function demands on such tasks (Carlson et al., 2005), this is further evidence for the relation between Executive Function and symbolic use.

Summary of Predicted Relations with Cognitive Skills

I investigated Detection of Ambiguity and Executive Function as cognitive skills that relate to children's developing understanding of how symbol-referent relations are effectively conveyed via a legend. In support of the rationale presented, previous research has found links between children's representational understanding and sensitivity to ambiguity (Myers & Liben, 2012), as well as to Executive Function (e.g., Apperly & Carroll, 2009; Carlson et al., 2005; Walker & Murachver, 2012). This project will be the first, however, to specifically test the prediction that these cognitive skills relate to children's understanding of informative of legends. In Study One I investigated the relations between these skills and children's ability to evaluate legends, and in Study Two I investigated the relation with their ability to create legends. I now turn to Study One.

Chapter Four: Study One (Legend Evaluation)

My first of two studies investigates children's ability to evaluate effective and ineffective legends. While we know that children consider a map with a legend as being better than a map without one (Myers & Liben, 2012), we do not know if they can distinguish between legends that are useful and those that are not (i.e., effective vs. ineffective). Thus, the goal of this study was to examine 4- to 6-year-olds' developing sensitivity to effective and ineffective legends, and how such sensitivity is related to the targeted cognitive skills (Detection of Ambiguity and Executive Function). Although previous research has considered these skills as factors influencing representational understanding more generally (e.g., Myers & Liben, 2012; Walker & Murachver, 2012), it is not known whether they also relate to an understanding of what makes a legend an effective means for communicating symbol-referent relations. The present study addresses this issue.

As described in Chapter One, I conducted my investigation by presenting children with three uniquely marked boxes that each held a set of three identical cards (e.g., the cards with stars belonged in the box with a circle on top). Children were then presented with five legends that either effectively or ineffectively conveyed the relation between the symbol on top of the box and its referent (i.e., the contents; see Appendix A for photographs of the stimuli). There were two effective legends, each of which clearly indicated the correspondence between symbols and their referents: one presented the pairs as they were displayed (left to right on the table) from top to bottom in the legend, and the other from bottom to top. The three ineffective legends differed in the way in which they were ineffective. One depicted a violation of one-to-one mapping by pairing multiple symbols with the same referent (e.g., the square, circle, and triangle symbols all with stars). Another depicted a different one-to-one mapping violation by having multiple referents with the same symbol (e.g., the square symbol with moons, stars, and clouds). The third depicted incorrect symbol-referent pairs by mismatching the symbols and referents (e.g., pairing the moon with the triangle symbol when the moon belonged in the box with the square). With the presentation of each legend, children were asked whether or not it would help an unknowing other put the shapes/cards back in the right boxes. Performance was coded based on accuracy, and children were classified as Successful if they were correct in both of their evaluations of at least 4 of the 5 legends types (performing better than chance; full detail presented in Method section).

Hypotheses

My first hypothesis was that there would be an age effect for performance on the Legend Evaluation Task, with children who are able to accurately judge the effectiveness of legends being older (considering age in months) than children who are inaccurate. Research has demonstrated that significant changes in representational understanding occur during the preschool years (e.g., DeLoache, 1995, 2000). Therefore, it was expected that changes in awareness of how to convey symbol-referent relations would be taking place during the ages of 4 to 6.

Second, I hypothesized that children’s Detection of Ambiguity (as measured by verbal and visual ambiguity tasks) would relate to their performance on my Legend Task, with children who were successful in legend evaluation having higher Detection of Ambiguity scores that their unsuccessful peers. Sensitivity to ambiguity is expected to play a role in children's awareness of when a legend is effective because children must recognize when a symbol-referent relation is clearly interpretable. Third, I hypothesized Executive Function would relate to Legend Task performance, with children who were successful in their legend evaluations demonstrating better Executive Function than their unsuccessful peers. As described in Chapter One, the components of Executive Function that I argue to be relevant for this task are Inhibitory Control, Working Memory, and Planning. Based on the reasons presented in Chapter Three (see page 33), an underlying Executive Function component was used.

Method

Participants

Participants for this study were 4- to 6.5-year-olds (a range of 48 to 78 months; *M* [age in months] = 62.11, *SD* = 8.47). The final sample included 74 participants (33 boys), spread across the age range: 30 4-year-olds (11 boys); 31 5-year-olds (15 boys); and 13 young 6-year-olds (7 boys). Although the age groups are presented here for descriptive purposes, age in months was considered in all analyses because I was interested in the developmental trend over time as opposed to differences between ages in years. One additional child participated but was excluded because of interference from a classmate.

Participants were recruited by contacting daycares in the Ottawa area and obtaining informed consent from the daycare coordinator (see Appendix B) and the parents of the children who participated (see Appendix C), as well as verbal assent from the children themselves. Children participated in the study while at daycare by meeting with an experimenter in a separate room or quiet area. All children who participated in the study were asked if they wanted to play some games with the experimenter, and were able to discontinue testing at any time if they said that they want to stop, or if they appeared to be uncomfortable (none of which did). All children completed all tasks, with the exception of one child who refused to complete the Backward Word Span. All children were thanked and given stickers as a token of appreciation (with the teacher's approval). Stickers for all children (even non-participating) and an age-appropriate book were given to each participating class, and a letter of thanks (debriefing) was sent home to the participants' parents (see Appendix D).

Procedure

Participants completed the tasks individually in two sessions, each approximately 25 minutes in length. The sessions were scheduled roughly one week apart, in a quiet space made available by the daycare. In the first session, all children completed the Legend Evaluation Task. Across both sessions, measures of Detection of Ambiguity (Droodle and Ambiguous Messages), Inhibitory Control (Black/White Stroop), phonological Working Memory (Backward Word Span), visuo-spatial Working Memory (Corsi Span), and Planning (Truck Loading) were also included. Finally, the Peabody Picture Vocabulary Test-III (PPVT-III) was included as a measure of receptive vocabulary to control for potential differences resulting from general language ability, given that all tasks involve verbal instructions. The order of tasks was fixed to keep sessions consistent and investigate individual differences (see Table 1 for the order of task presentation).

Table 1

Order of Tasks for Each Testing Session

Session	Task 1	Task 2	Task 3	Task 4	Task 5
1	Set 1 of Legend Evaluation task	Black/White Stroop	Set 2 of Legend Evaluation task	Corsi Span	Set 3 of Legend Evaluation task
2	Ambiguous Messages Task	Backward Word Span	Truck Loading	Droodle	PPVT-III

Tasks

The protocols which were used to administer the following tasks can be found in Appendices E through K.

Legend Evaluation Task. The Legend Evaluation Task was the primary task of interest in this study (see Appendix E for the complete task protocol). In this task, children judged the effectiveness of legends that either did, or did not, effectively convey the presented symbol-referent relations. To begin, I asked the participants to identify the shapes that would be used on the cards[3] in the task and found that no child had any difficulty with this. They were then introduced to three boxes, each of which had a unique symbol on top (see Appendix A). Inside each of the boxes were three cards, all with the same shape (either crescent moons, stars, or clouds) that was arbitrarily paired with the symbol on the box. The symbols on the boxes varied across three sets of stimuli, which were presented in counterbalanced order (resulting in six orders). To introduce these stimuli, the experimenter said:

[3] Children were only required to identify the shapes on the cards, and not the boxes, as only the shapes on the cards were verbally labeled in the task. The symbols on the boxes were sometimes abstract in nature, so each box was simply referred to as 'this box' throughout the task. See Appendix A for the full set of stimuli.

> See these boxes? They each have something on top [points to tops of boxes], and they each have shapes inside. I have three different boxes. Each box goes with a different kind of shape. See this box? It has moons inside. Let's put them here so that we remember moons belong inside this box [set out in front]. Here is another box; it has stars inside. Let's put them here so that we remember stars belong inside this box [set out in front]. Here is another box; it has clouds inside. Let's put them here so that we remember clouds belong inside this box [set out in front]. We are going to take the shapes out and look at them. Later on, someone else has to put the shapes away. She has never seen these boxes before. She doesn't know what shape goes inside each box. But, she will need to put the shapes back in the right boxes. Your job is look at some things I brought, and tell me if they will help her put the shapes away.

Once the contents of the boxes were revealed, children were shown a series of legends, one at a time, and asked: "Do you think this will help my friend put the shapes back in the right boxes?". The boxes and cards remained on the table during this phase so that children did not need to rely on their memory regarding which shape went with which box. Five legends were presented for each set of boxes/contents (see Appendix A), one at a time, in a fixed-random order. Two were effective, and three were ineffective. As mentioned above, both of the effective legends depicted each symbol-referent pair, one from top to bottom and one from bottom to top. One ineffective legend contained all incorrect pairs, and the other two violated one-to-one mapping. Once the five legends were evaluated, the materials were removed from the table and another task was introduced.

This process of stimuli introduction and legend evaluation was repeated across three sets of stimuli (with the order of the stimuli sets counterbalanced between participants; each set separated by a task, see Table 1 above). As a result, children had the opportunity to evaluate each type of legend three separate times. The first set was used as practice trials (without feedback), and allowed children to see all types of legends that would be used in the task. The remaining evaluations (on the second and third sets) were scored based on accuracy, with chance accuracy for a given legend at 50% (two possible answers).

In order to categorize children into groups based on patterns of performance, responses to the Legend Evaluation Task were first coded for whether or not children responded with consistent accuracy to a given *type* of legend. Each type was coded as pass/fail, with a pass meaning they correctly evaluated both of that type for Sets Two and Three. For example, a child had to correctly reject the inaccurate legend that mismatched the symbols and referents for both Set Two and Set Three to pass the mismatched legend type. Given that children had to correctly evaluate two legends to count as succeeding on a given type, the chance of passing a given type is 25%.

The number of legend types that a child passed was summed to provide a score out of 5. Based on the binomial distribution, to perform significantly better than chance across the different types of legends, children were required to pass at least four of the five types ($p = .01$). Therefore, children who accurately evaluated at least four of the five legend types were coded as Successful, while the children who were unable to do so were coded as Unsuccessful.

By coding the children's performance in this way, I was able to ensure that children were not given credit for being Successful on the Legend Evaluation Task unless they could: (a) consistently evaluate both legends of a given type; and (b) identify more types than would have been possible by chance. Although differences in the Legend Evaluation Task performance across the different types of legends were explored, the primary interest was cognitive differences between children who were Successful versus Unsuccessful on the Legend Task. I now turn to the tasks used to measure these cognitive skills.

Droodle. The Droodle task requires participants to consider another's interpretation of an ambiguous image (e.g., Chandler & Helm, 1984; Perner & Davies, 1991; see Appendix F). In this task, children were presented with full, uncovered images of a bicycle, giraffe, and clock, and were asked what was being shown in each. Children had no trouble labeling the images that were used, responding with 99%, 88% and 97% accuracy, respectively, on their first attempt and 100% on their second attempt (although on their first attempt children were less accurate in their identification of the giraffe, as compared to the other items, performance across the three test trials had excellent reliability, as will be reported in the results section). After children had seen a given image, it was covered so that only a portion was shown. Using the giraffe as an example, all they could see was the giraffe's legs, which looked like two yellow lines; therefore, it was nearly impossible to tell what was being depicted from what was visible. Children were then introduced to a doll, Wendy, who had never seen the image before and were asked "Does Wendy know that this is a giraffe?". This procedure was followed for a total of three trials, each with a different image, with each trial scored as either one (for correctly indicating that Wendy would not know what the object was) or zero (for indicating that Wendy would know what the image was based on the very limited information provided). A total score was summed out of three. Children's Droodle score was then combined with their Ambiguous Messages score, resulting in a composite score for Detection of Ambiguity.

Ambiguous Messages. The Ambiguous Messages task requires participants to consider the perspective of another when dealing with messages that can be interpreted in more than one way (Nilsen & Graham, 2012). In my adaptation of this task (see Appendix G), children were introduced to two puppets (Chester the monkey, and Spot the dog) who were a playing game with cups of different colours and sizes. Before the task began, the experimenter ensured that children could identify the colours and sizes of the cups. The experimenter explained that in the game, she would hide a ball underneath one of the two cups sitting on the table. It was explained that during hiding, Chester would be sitting behind a barrier so that he could not see the cups, and children then watched as Chester was placed behind the barrier. Children momentarily experienced sitting behind the barrier themselves (so they could see that, from Chester's viewpoint, one could not see the cups), and were then asked a check question to ensure they understood Chester could not see the cups (89% of the children responded correctly on their first attempt, with the rest responding correctly on their second attempt, except for one child who was excluded from relevant analyses for being unable to respond correctly).

Children were reminded that Chester could *not* see the cups, but told that Spot *could* see the cups – so he would give Chester a clue about where the ball was hidden. They were asked to listen to the clue, and then point to where Chester would look for the ball. The experimenter explained that sometimes Spot would give a *good* clue, which makes it easy to find the ball, and that sometimes Spot would give a *not-so-good* clue, which does not make it easy to find the ball[4]. Children were asked to evaluate the clue by deciding whether Spot gave a good clue or a not-so-good clue. The order of the options was counterbalanced between participants so that half of the children were asked if it was a "good clue or not-so-good clue" while the other half were asked if it was a "not-so-good clue or a good clue".

All but two children responded correctly by their third attempt to the check question that *good* clues would help Chester find the ball. Those two were excluded from relevant analyses; one of which was the child who was already excluded for failing the viewpoint question above. In total, the children were fairly accurate with 76% responding correctly on their first attempt, 94% by their second, and 98% by their third. All but one child (also excluded from relevant analyses; note that this child was also missing the Backward Word Span) responded that *not-so-good* clues would not help Chester (95% were correct on their first attempt, and 99% by their second).

Children completed two practice trials, one with an unambiguous clue and one with an ambiguous clue. For the unambiguous clue, children watched as the experimenter hid the ball under a little blue cup (with the alternate being a little orange cup) and heard Spot say "The ball is under the blue cup". Children were asked to point to where Chester would look for the ball, and were asked whether Spot gave a good clue or a not-so-good clue. For the other practice trial, children watched as the cups were

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[4] The use of *not-so-good* was modeled after Nilsen and Graham (2012) who used *tricky*, but found children had difficulty with the term, so they explained the term *tricky* meant *not-so-good*, which children seemed to understand better.

replaced with a big and a little purple cup and Spot's clue was "The ball is under the purple cup". Once again, children were asked where Chester would look for the ball and whether Spot gave a good or not-so-good clue. Feedback on the practice trials consisted of saying either "You're right! That was a good (not-so-good) clue; that will (won't) make it easy to find the ball" or "Good try, but that was a good (not-so-good) clue; that will (won't) make it easy to find the ball".

Children then completed six test trials (each with a different pair of cups), with three unambiguous clues and three ambiguous clues, without any feedback. The type of clue, the dimension provided in the clue (size or colour), and whether the ball was under the cup on the left or the right, were all presented in a fixed-random order. Children received a score of one for each accurate evaluation of the clue, and a score of zero for each inaccurate evaluation. These scores were summed for a total out of six. This score was then divided by two (for a total out of three) so that its weighting would be equal to that of Droodle Task in the composite Detection of Ambiguity score.

Black/White Stroop. The Black/White Stroop task (Simpson & Riggs, 2005; Vendetti et al., 2015) is a simplified version of the of the Day/Night Stroop task (Gerstadt, Hong, & Diamond, 1994), which is used to measure children's Inhibitory Control. In the Black/White task, children were shown a series of black and white cards. If shown a black card, children were asked to say "white". If shown a white card, they were asked to say "black" (see Appendix H). Children completed up to three practice trials (with feedback) and 21 test trials (without feedback). Each trial involved inhibiting the instinctive response and instead responding with something in conflict. Children's responses were scored as zero for inaccurate responses and one for accurate responses. Total scores were tallied out of 21.

Backward Word Span. In this measure of phonological Working Memory, children are shown pictures of semantically unrelated items with single-syllable names, and are asked to name the items. Then, without seeing the items, children are asked to repeat the names in backwards order (Carlson et al., 2002). Specifically, for each trial, children were shown cards one at a time and were asked to say what each one was. For example, the experimenter showed a picture of a carrot (to which the child responds "carrot") and a tree (to which the child responds "tree"). The cards were then placed faced down on the table beside each other, and the child was asked to say the words in backwards order (to which the child should respond "tree, carrot"; see Appendix I). Participants completed two practice trials (of two pictures each) with feedback before proceeding to the test trials (without feedback). The first two test trials consisted of two items each, with the number of items increasing by one every two trials, up to a maximum of five items/words in a trial. The task continued until a child was unable to successfully respond to both trials of a given length. The participants' responses were recorded and their score was calculated based on a value of 0.5 for each correct trial, to which a maximum score of three was achieved.

Corsi Span. The Corsi Span is a child-friendly version of the Corsi Blocks task (Rasmussen & Bisanz, 2005). In this task, children were presented with a picture of nine identical 'lily pads' randomly distributed across a page. They were told to pretend that their fingers were frogs, and the frogs would be jumping from lily pad to lily pad. They were asked to watch carefully which lily pads the experimenter's frog jumped on and then jump on the same lily pads in the same order (see Appendix J). The first two trials involved jumping on only two lily pads, and feedback was provided. From that point on, feedback was not provided and the number of lily pads, starting at three, increased by one, for each set of two test trials. Trials were administered until the child completed all 10 trials in the task, or was unable to successfully respond to two trials of equal length. Participants' responses were recorded and their score was calculated based on a value of 0.5 for each correct trial. Thus, scores could range from zero to five, however the maximum score in my study for this task was 4.5.

Truck Loading. The Truck Loading task is a measure of Planning ability used with children in the age group of interest (Carlson et al., 2004; Fagot & Gauvain, 1997). In this task, children were told to pretend that they were mail carriers delivering coloured party invitations to houses of the matching colour (see Appendix K). Their job was to load the delivery truck with the invitations, and then deliver them. The invitations were sized such that they needed to lie flat on the back of the truck, and children were told that they had to be stacked on top of one another.

The children were taught three rules that need to be followed when making deliveries: (1) that the colour of the invitation must match the colour of the house to which it was delivered; (2) that the invitations can only be taken from the top of the pile; and (3) that the street is one-way so they cannot go back to a missed house (i.e., they could only pass by each house once). To successfully deliver the invitations, children needed to plan the order in which they should be piled into the back of the truck (i.e., putting the invitation to be delivered last into the truck first).

Children completed a series of trials that increased in terms of the number of invitations/houses. The first trial consisted of only two houses on the street, and children had two attempts to deliver the invitations (being reminded of the rules if they made an error on their first attempt). With each successful delivery, children moved onto the next level, with the number of houses increasing by one until there were five houses on the street (with two opportunities to deliver each time a new house was added). Consistent with the literature using this task, performance was scored out of four, with children earning a point for each level successfully completed.

Peabody Picture Vocabulary Test – Third Edition (PPVT-III). The PPVT-III (Dunn & Dunn, 1997) was used to measure receptive vocabulary. This standardized measure involves children viewing an array of four pictures and indicating which picture matches the word spoken by the experimenter. Following the procedure outlined in the testing manual, children were asked to identify increasingly difficult words. A raw score was calculated by subtracting the number of errors made from the ceiling item reached on the task.

Results

Preliminary Analyses

Prior to testing my hypotheses, preliminary analyses were conducted. Performance on each of the individual tasks was examined for order effects and task comprehension, and indices of reliability were calculated. Additionally, composite/component scores were created for use in the analyses. These results will be briefly discussed before presenting the main analyses.

Legend Evaluation Task. Recall that children's performance on the Legend Evaluation Task was coded as Successful if they were correct on at least four of the five legend types (significantly better than chance), and coded as Unsuccessful otherwise. Of the 74 children, 31 children were classified as Successful and 43 as Unsuccessful. There were too few instances of Successful and Unsuccessful children across the six orders to run a reliable analysis of order effects, however children were randomly assigned to a presentation order (with each order having 11 to 14 children assigned) and therefore any variations in the orders was not expected to have impacted the overall results.

Detection of Ambiguity. Children performed quite well on the three trials of the Droodle task, with a mean score of 2.45 out of 3 (*SD* = 1.15) and scores ranging from 0 to 3. Reliability of performance across all three trials was excellent (α = .98). On the Ambiguous Messages task, children performed similarly on the ambiguous (*M* = 2.20 out of 3; *SD* = 1.14) and unambiguous trials (*M* = 2.25, *SD* = 1.00), which were combined for a total score out of 6 (*M* = 4.45, *SD* = 1.61), with scores ranging from 1 to 6. Performance across the six trials had acceptable internal consistency (α = .67). In this task, there were two orders for the choices on the key question: children were asked if each statement was "a good clue or a not-so-good clue ", or if it was a "not-so-good clue or a good clue". The order in which this question was asked did not impact children's performance on the task out of 6, $t(69) = 0.77$, $p = .445$, and therefore order was not considered in subsequent analyses.

A composite Detection of Ambiguity score was planned for use in the analyses, which was comprised of the sum of the scores from these two ambiguity measures. However, it was first necessary to determine whether scores on the two measures were related, and they were significantly, and positively, correlated, $r = .46$, $p < .001$, even after controlling for age (in months) and receptive vocabulary, $pr = .24$, $p = .045$. To create the composite score, children's score on the Ambiguous Messages task was divided by 2 (resulting in a score out 3) and added to their score out of 3 on the Droodle. This composite score out of 6 ($M = 4.69$, $SD = 1.66$) was used in all analyses.

Executive Function. The Black/White Stroop, the Backward Word Span, the Corsi Span, and the Truck Loading task were used as measures of Executive Function (measuring Inhibitory Control, phonological and visuo-spatial Working Memory, and Planning, respectively). Children's performance on each of these measures, including reliability indices, can be found in Table 2. The Black/White Stroop consists of 21 trials of equal difficulty, and therefore Cronbach's alpha was used to assess internal consistency, which was found to be excellent. Cronbach's alpha was not appropriate for the Backward Word and Corsi Spans given that they increase in difficulty throughout the tasks. These tasks do however consist of pairs of trials of equal length, therefore two sub-scores were computed to calculate of Spearman-Brown split-half reliability. One sub-score was based on the sum of scores from one trial of each length, and the other was based on the sum of scores from the other trial of each length (for other research using a similar procedure, see Bayliss, Jarrold, Baddeley, & Leigh, 2005; Unsworth, Heitz, Schrock, & Engle, 2005). Results demonstrated acceptable reliability for the Backward Word Span, and good for the Corsi Span. Scores on the Truck Loading task were based on the highest level achieved, with each level increasing in difficulty, and therefore a measure of internal consistency is not applicable.

Table 2

Descriptive Statistics for Executive Function Tasks

Task	Mean (SD)	Range	Reliability
Black/White Stroop	15.99 (5.62)	0 – 21	Cronbach's α = .92
Backward Word Span	1.35 (0.56)	0 – 3	Split-half = .61
Corsi Span	2.31 (1.01)	0 – 4.5	Split-half = .80
Truck Loading	3.15 (1.32)	0 – 4	n/a

Note. All statistics are based on the entire sample of $N = 74$, with the exception of the Backward Word for which there was a single missing participant.

The relation between Executive Function and children's performance on the Legend Evaluation Task was considered by treating Executive Function as an overarching skill. To ensure that a Principal Component Analysis was justified, the Kaiser-Meyer Olkin measure of sampling adequacy (.66) and Bartlett's Test of Sphericity ($p < .001$) were considered, which indicated factorability of the data. Therefore, a Principal Component Analysis was conducted and a single component based on all four Executive Function measures was extracted. The extraction values indicate the proportion of each variable's variance (in this case, the individual measures) explained by the principal component (i.e., Executive Function), and therefore represent the relative contribution each variable makes to the Executive Function component score. Ideally, according to Kaiser's criterion, these extraction values should sum to an eigenvalue greater than 1 (Fabrigar, Wegener, MacCallum, & Strahan, 1999). My Executive Function factor meets this criterion as found in Table 3 ($\lambda = 2.12$, with 53.05% of the variance accounted for). Therefore, the Executive Function component score was used in subsequent analyses.

Table 3

Extraction Values for Executive Function Measures

Measure	Extraction Value
Black/White Stroop	.31
Backward Word Span	.36
Corsi Span	.70
Truck Loading	.75

Main Analyses

My three hypotheses all involved predictions regarding relations with children's performance on the Legend Evaluation Task. I expected age (first hypothesis), the ability to detect ambiguity (second hypothesis), and Executive Function (third hypothesis) to be differentiated between children who were Successful and Unsuccessful on the Legend Evaluation task. The group sizes for Successful and Unsuccessful participants were n = 31 and n = 43 respectively. However, recall that three children were excluded based on failure to respond correctly to comprehension questions on the Ambiguous Messages task. These three participants were all in the Unsuccessful Legend Evaluation group, and therefore this group size was reduced to n = 40 for the main analysis. Means for these variables, grouped by Legend Evaluation task performance, can be found in Figure 1. Note that raw scores were used for age (measured in months), Detection of Ambiguity (composite score), and PPVT. The component score from the Principal Component Analysis serves as the Executive Function score.

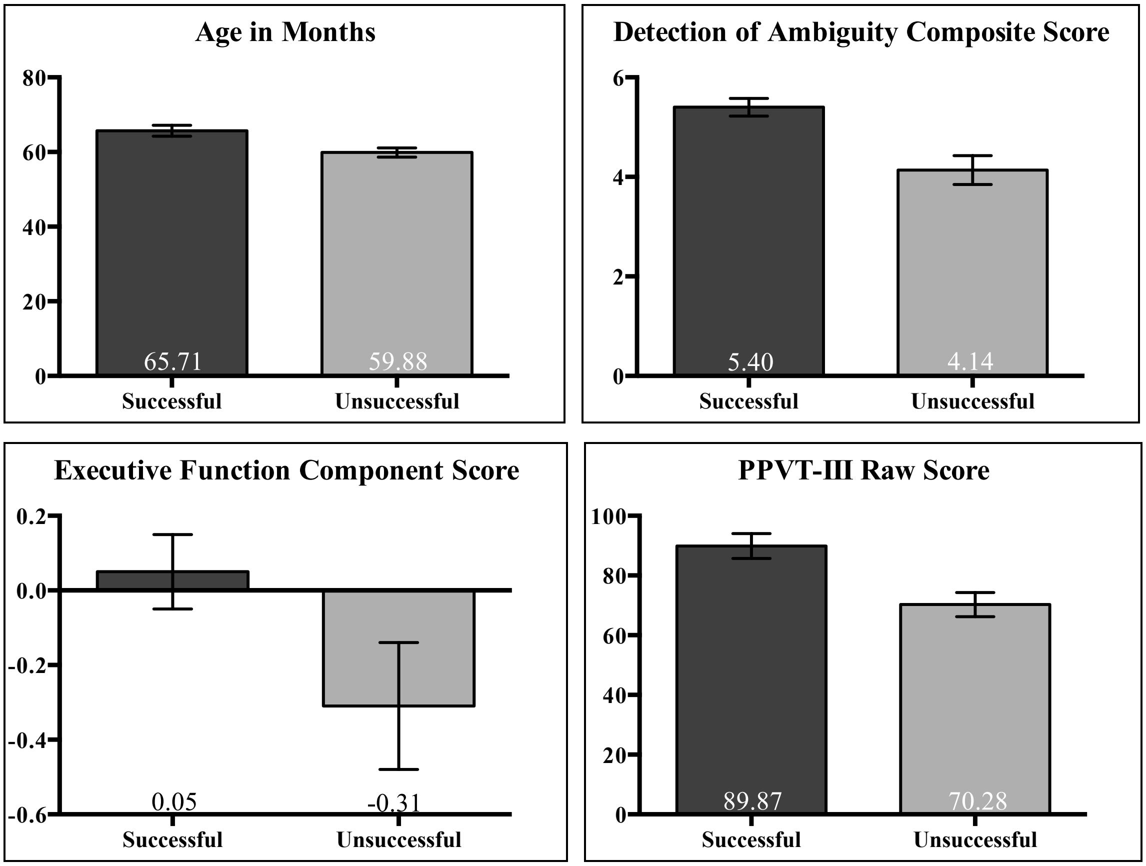

Figure 1. Mean scores by Legend Evaluation Task performance. Error bars represent standard error of the mean.

To test my hypotheses, I used a Discriminant Function Analysis[5] to describe the differences between the two groups (Successful vs. Unsuccessful). A Discriminant Function Analysis tests whether the groups differ with respect a set of variables and, according to Klecka (1980), is conducted with at least one of two goals in mind: (1) *interpretation* of group differences (i.e., addresses whether we can discriminate between groups on a set of variables, how well those variables discriminate, and which of those are the best predictors); and/or (2) *classification* (i.e., assign a case based on the group that it most closely resembles on a set of characteristics). Given that the current project

[5] Although Binary Logistic Regression was a potential alternative for analyzing the data, Discriminant Function Analysis was the preferred method because it has stronger power when assumptions regarding the distribution of the predictor variables are met (Tabachnick & Fidell, 2007).

aims to consider the differences between Successful and Unsuccessful children on the Legend Task with regards to age and performance on measures of Detection of Ambiguity and Executive Function, there is a clear rationale for using a Discriminant Function Analysis for interpretation (the first goal outlined above). Age in months, Detection of Ambiguity, Executive Function, and PPVT-III were expected to contribute to the underlying discriminant function that explains differences between Successful and Unsuccessful participants on the Legend Evaluation Task, and were therefore included when checking the appropriate assumptions. There are a number of assumptions that pertain to this analysis, which were carefully checked and will be addressed before proceeding to the final results.

Assumptions. Prior to conducting the analysis, relevant assumptions were checked. All individual scores were within the range of ±3.29 standard deviations and therefore there were no outliers to consider. Although Box's M was significant ($p < .001$) suggesting that the homogeneity of covariance assumption was violated, Tabachnick and Fidell (2007) argue that you can disregard this violation when sample sizes are equal (defined as falling within the 1:1.5 rule). The group sizes fell within these parameters (Successful $n = 31$ and Unsuccessful $n = 40$), and therefore continuing with the analysis is justified. Levene's test for Equality of Variances was not significant for age ($p = .810$) or PPVT-III ($p = .749$), but was for Detection of Ambiguity and Executive Function (*ps* < .001), suggesting violations of homogeneity of variance. However, this violation can be ignored if sample sizes are roughly equal and if the variance ratio between the two groups is less than 10. For Executive Function, the ratio of variance for Unsuccessful participants ($s^2 = 1.17$) to Successful participants ($s^2 = 0.30$) is 3.90 to 1 and well under the limit of 10 to 1. For Detection of Ambiguity, the ratio of variance for Unsuccessful participants ($s^2 = 3.47$) to Successful participants ($s^2 = 0.99$) is 3.51 to 1 and once again well under the limit of 10 to 1. Therefore, the analysis is robust to this violation.

Normality statistics were also examined within each group. All variables, with the exception of Detection of Ambiguity for Successful legend evaluators, had skewness and kurtosis values were within the recommended ±2 range (Tabachnick & Fidell, 2007). Detection of Ambiguity scores for children who were Successful on the Legend Evaluation task was negatively skewed (-5.63) and leptokurtic (8.46). Discriminant Function Analysis, however, is robust to violations of normality when they result from skewness and kurtosis, as opposed to outliers (Tabachnick & Fidell, 2007). This robustness is ensured with roughly equal sample sizes, provided that two-tailed tests are used (and they were). Tabachnick and Fidell (2007) also state that robustness is expected when there are at least 20 cases in the smallest group and only a few predictors (five or fewer), which is the case with the present data.

Data was checked for multicollinearity, revealing that all predictor variables are significantly correlated with each other, $ps < .009$. This suggests that some predictors may be redundant. When conducting the analyses, SPSS excludes variables with insufficient tolerance, therefore Discriminant Function Analysis is protected against such violations. The assumption of independence is met because there is no reason to suspect any one participant's scores are correlated with any other participant's scores. Based on these discussed assumptions, use of a discriminant function analysis is warranted.

Discriminant Function Analysis. A Discriminant Function Analysis was performed to find the best linear combination, based on the predictor variables (Detection of Ambiguity, Executive Function, Age in months, and PPVT-III), that maximally discriminates between children who were Successful versus Unsuccessful on the Legend Evaluation Task. The enter method was chosen because it simultaneously forces all predictors into the model, and this was desired given the theoretical rationale for the predictors presented above. This method was preferable to stepwise given that stepwise techniques are influenced by random variation in the data and therefore results are seldom replicated (Field, 2009). Given that my sample is made up of two groups, only one function was derived with an eigenvalue of .26. The canonical correlation, CC = .46, represents the correlation between the discriminant function and Legend Evaluation Task performance. The function is significant, $\lambda = 0.79$, χ^2 (4, $N = 71$) = 15.53, $p = .004$, indicating that the four predictor variables were differentiated between the two groups.

The Structure Matrix provides the correlations between each variable and the latent variable that the discriminant function represents. The results of the analysis suggests that all four variables contribute to the function based on the following coefficients: Executive Function = .89, Detection of Ambiguity = .81, PPVT-III = .79, and Age = .71. These coefficients, however, represent the relations between the variables and the discriminant function without any controls in place. Therefore, the Standardized Canonical Discriminant Function Coefficients should be used to provide better insight into the importance of each predictor to the function. These standardized values are partial coefficients that represent the unique relationship between a given variable and the latent discriminant function while the effects of the other variables have been controlled for. Based on these values, both Executive Function (.49) and Detection of Ambiguity (.43) have loadings over .33 and therefore are the variables of most importance for explaining group differences (Tabachnick & Fidell, 2007). Neither Age (.28) nor PPVT-III (.02) met this criterion.

Additional Analyses

In addition to testing the outlined hypotheses, an exploratory analysis was also conducted to consider potential differences in children's ability to evaluate the different types of legends. Children's performance on each of the individual legend types (their score out of 2, as presented in Figure 2) was compared within the types of effective and ineffective legends. To examine differences in performance on the two effective legend types, a paired-samples t-test was conducted which revealed that children were significantly better at evaluating the effective legend type which presented the items from top to bottom than they were at the effective legend type which presented the items from bottom to top, $t(73) = 2.41$, $p = .019$. To compare performance among the ineffective legends types, a Repeated-Measures Analysis of Variance was conducted to examine the within-participant effect of legend type. This analysis revealed no significant differences in terms of children's performance on the three types of ineffective legends, $F(1.78, 129.89) = 0.24$, $p = .762$, $\eta_p^2 < .01$ (using Greenhouse-Geisser because sphericity cannot be assumed; Mauchly's Test of Sphericity, $p = .009$). Thus, the three ineffective types demonstrate similar levels of difficulty.

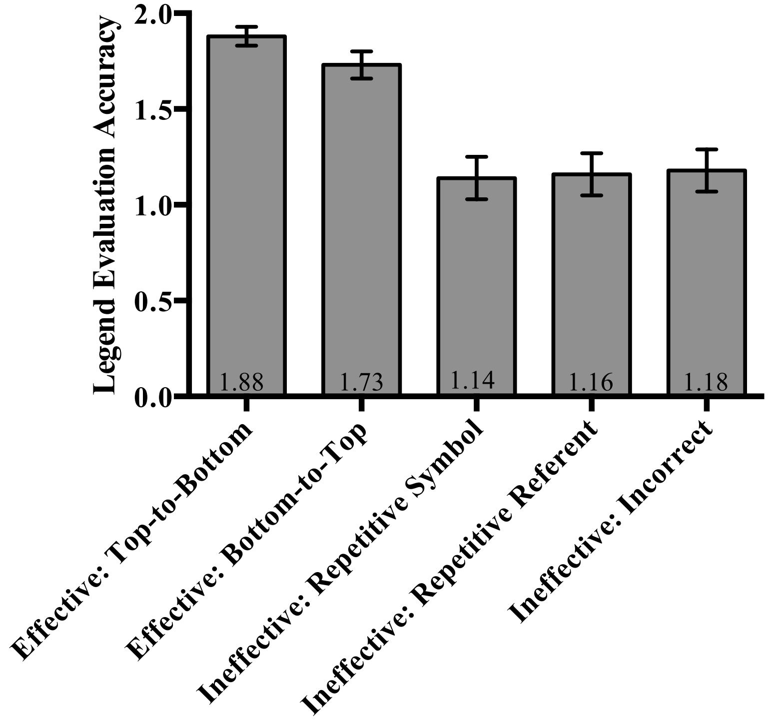

Figure 2. Children's performance on the various types of legends (all children). Performance is scored out of 2. Error bars represent standard error of the mean.

Discussion

In Study One I investigated children's developing ability to evaluate effective and ineffective legends and the cognitive skills hypothesized to relate to this ability. In support of my hypotheses, I found that age, Detection of Ambiguity, and Executive Function differed between children who were Successful and Unsuccessful on the Legend Evaluation Task, with children who were Successful being older and having more advanced cognitive skills. However, the findings of particular interest are the *unique* relations with children's performance on the Legend Task, above and beyond the other variables (including a measure a receptive vocabulary). Interestingly, the standardized coefficients from the Discriminant Function Analysis revealed that the contribution of age was not significant above and beyond the other variables included.

Both Detection of Ambiguity and Executive Function, however, uniquely accounted for differences in Legend Evaluation Task performance. Therefore, although older children tended to outperform younger children, it was the underlying cognitive skills that uniquely related to success on the Legend Task. Thus, we now have some support for the claim that children who are able to demonstrate an understanding of how to (and not to) convey symbol-referent relations are more sensitive to how information is perceived and interpreted by another, and have more advanced Executive Function skills (some combination of holding information in mind, inhibiting a prepotent response, and planning).

The differences in Detection of Ambiguity and Executive Function based on children's ability to evaluate effective and ineffective legends are consistent with other research on children's understanding of representations. Such work has identified these skills as important, but has done so by either using symbol systems that the children themselves created (causing additional task demands; Myers & Liben, 2012), examining children's understanding of representations (not how the meanings of the representations are conveyed; Walker & Murachver, 2012), or examining how adding symbolic distance affects performance on an Executive Function task (Apperly & Carroll, 2009; Carlson et al., 2005). The present study extends the existing research, and goes beyond children's understanding of symbols, to highlight the targeted skills as being important for understanding how the relation between symbols and their referents is effectively conveyed. This finding has important implications as it indicates that changes in children's understanding of how to convey symbol-referent relations are related to at least two specific cognitive skills.

This work has important implications for educators. In a school setting, children are often faced with many situations that require symbol-referent communication (e.g., the meaning of lines on a map, the meaning of written words, the meaning of stars on a behaviour chart, etc.). The results from this research emphasize the underlying skills that are needed for appropriately meeting the demands of such tasks, and therefore the development of these skills should be an area of focus for educators.

Despite the clear pattern of results, there are several points for consideration. One such point for the above analysis was that three children were excluded based on their failure to answer check questions on the Ambiguous Messages task. All three children were Unsuccessful on the Legend Evaluation Task, and therefore it was worth considering whether excluding these children from the analysis may have skewed the results. However, re-running the analyses with the inclusion of all participants had minimal impact on the standardized coefficients (Detection of Ambiguity = .38, Executive Function = .52, Age = .26, PPVT = .07) and therefore did not change the overall pattern of results.

In addition to my planned analyses, I compared children's performance within the effective and ineffective legend types and found a difference for the two types of effective legends, and no difference for the ineffective ones. This pattern warrants some further consideration; however, since the study was not designed to investigate such differences, the interpretation is merely speculative. Although the two effective legends each contained the identical information, and clearly paired each symbol with its corresponding referent, they differed in the order in which the pairs were presented. One type depicted the pairs (as they were presented from left to right on the table), going from top to bottom in the legend, while the other presented the pairs going from bottom to top. Children performed quite well on both types of legends, but were significantly better when evaluating the legend that presented the pairs from top to bottom. This is understandable given that this legend followed the familiar structure of conventional print. So, it is possible that children simply followed a matching procedure and therefore having the items in order made this particular legend easier to understand. Alternatively, perhaps, children expect the order of the items in a legend to be relevant to its effectiveness. If this is the case, then children need to develop the understanding that the order of presentation of symbol-referent pairs in legends is *irrelevant*. This would align with the principles for governing 'good' counting (e.g., Gelman & Gallistel, 1978), and research which suggests that children do not come to realize that order is irrelevant (i.e., that items in a set can be counted in an unsystematic order but still be correct) until age 10 or older (e.g., Kamawar, LeFevre, Bisanz, Fast, Skwarchuk, & Smith-Chant, 2010).

Although the current data does not allow for a thorough investigation of what accounts for differences in performance on the two types of effective legends, it was still possible to consider age differences and working memory performance in relation to success on each type. Within the present sample, there was neither an age difference, nor a Working Memory difference, between passers and failers in identification of these types of legends, $ps > .16$. It is worth noting, however, that there were very unequal sample sizes ($n = 61$ and $n = 13$ for the bottom-to-top legend; $n = 68$ and $n = 6$ for the top-to-bottom legend), and although the assumption of homogeneity of variance was met ($ps > .10$), the lack of significant findings may still be unreliable. It is also possible that these differences do not emerge until children are slightly older, as is the case with counting. Thus, investigating children's understanding of the rules that govern legends is an area for exploration in future research.

I also compared children's performance within the three ineffective legend types, and found that children performed with similar accuracy across all three. This was an interesting finding given the different kinds of errors presented in each. One ineffective legend presented incorrect symbol-referent pairs throughout, but contained all of the symbols and referents used in the task. In contrast, the other two legends (the violations of one-to-one mapping) had a single symbol or referent repeated in each pair (and were therefore missing either two of the symbols or two of the referents used in the task). Although the legends that were clearly missing items may seem more obviously incorrect, children showed no difference in accuracy across the three types. Despite the similar accuracy, it is still possible that the three legends made different, but equally difficult, demands. Future research will need to further investigate the different types of ineffective legends to explore these potential differences, and could begin with an investigation of the individual components of Executive Function to examine how different types of ineffective legends may make different Working Memory, Planning and/or Inhibitory Control demands. Ideally, such a study would include multiple measures of each of the Executive Function skills, and extract a component score for each one (i.e., through Principal Component Analysis), so that the varying demands of the different types of legend could specifically examined.

Previous work has investigated young children's understanding of symbols, and I have added to this body of research by investigating children's ability to recognize when the meanings of symbols are effectively conveyed and by identifying two cognitive skills that relate to this important ability. My research has implicated Detection of Ambiguity and Executive Function as important for success on a novel Legend Task, using symbols that were arbitrarily related to their referents (inspired by Myers & Liben, 2008), created with the explicit intention to convey information (Sharon, 2005) and avoided spatial location (Eskritt & Lee, 2002) and sequential order (Lee et al., 1998) as details to be conveyed. This investigation into children's evaluation of legends, and the related cognitive abilities, provides us with insight into their understanding of how the meanings of arbitrary symbols should be conveyed to an unknowing other. This research does not, however, tell us whether children are able to convey such meanings themselves. More specifically, Study One does not inform us about children's ability to *create* an effective legend.

To more fully appreciate children's understanding of effective legends, their ability to convey a symbol system to others must also be investigated. Thus, as a direct extension to Study One, Study Two investigated children's creation of legends using two approaches. Children's legend creations were considered in terms of their ability to create a legend: (1) prior to having seen an example from the researcher; and (2) after having been exposed to effective legends that the researcher created. The latter approach allowed me to investigate whether exposure to effective legends helps unsuccessful children improve. In this second study, I also examined relations with the cognitive skills that were covered in Study One to see if these same skills played a role in children's production of legends.

Chapter Five: Study Two (Legend Creation)

The overarching goal of the current thesis was to investigate 4- to 6-year-olds' understanding of how symbol-referent relations are effectively conveyed through legends, and to identify factors that relate to children's success. In Study One, I found evidence that children who are able to accurately evaluate legends are more cognitively skilled in terms of Detection of Ambiguity and Executive Function than their peers who are unable to do so. Study Two sought to extend our knowledge of children's emerging understanding of how symbol-referent relations are conveyed by examining their ability to *create* legends, and to look for evidence that the same cognitive skills that related to evaluation in Study One, also relate to the ability to create effective legends.

Children's ability to create legends was examined in two situations. First, they were given the opportunity to create a legend *prior* to having seen examples from the researcher (using Eskritt & McLeod's, 2008, terminology I will refer to effective legend creation on this trial as 'spontaneous' production). Then, for those were unsuccessful at this first opportunity, their ability to create an effective legend was examined after exposure to effective examples. This research question was inspired by Eskritt and McLeod's (2008) finding that after seeing a demonstration on how to make effective notes, 9- to 11-year-olds' note-taking skills improved significantly (this study is described in detail below). I predicted that brief exposure to effective legends would have a similar effect and help improve children's understanding of how to convey symbol-referent pairs, thus making children more skilled at creating effective legends.

From previous research, there is evidence that children can appropriately use symbols (e.g., Myers & Liben, 2008) and that they have some understanding of what a symbol-user needs to know (e.g., Lee et al., 1998; Myers & Liben, 2012). Despite having this knowledge, they do not necessarily apply it when creating symbols of their own (e.g., Eskritt & McLeod, 2008; Myers & Liben, 2012). My research expands upon the research examining children's ability to create symbols, by investigating their ability to convey symbol meanings.

The goals of this second study were to: (1) invesitage children's spontaneous production of legends, prior to having seen an example from the experimenter (i.e., during the pre-test phase); (2) examine whether the cognitive skills of interest (Detection of Ambiguity and Executive Function) were related to children's ability to create effective legends during the pre-test phase; (3) determine whether exposure to effective legends (relative to a baseline condition) improved legend quality (in the post-test phase) for those children who initially made ineffective legends; and (4) examine whether the cognitive skills of interest (Detection of Ambiguity and Executive Function) were related to whether or not children improved as a function of exposure (in the post-test phase). By addressing these goals, I will have identified factors that play a role in children's ability to convey the meanings of symbols.

To address my research goals, I developed the Legend Creation Task. During a pre-test phase, children were asked to "make something" that would help a friend put cards back into the right boxes (using stimuli from the Legend Evaluation Task in Study One). Children who created effective legends received the remaining cognitive measures, but only children who created ineffective legends (i.e., those that did not clearly convey the symbol-referent pairs) continued to the next phase of the task.

To investigate the impact of exposure, the children who failed to create an effective legend during the pre-test were assigned to one of two conditions: exposure to effective legends (experimental condition) or participation in an unrelated task (baseline condition). Children assigned to the exposure condition were asked to evaluate effective legends, by judging whether or not they would help someone put the shapes away in the correct boxes. Regardless of their response, each legend was explained as to highlight why it was effective (extended task details are included in the method section, see page 75). Children assigned to the baseline condition played a game in which they were asked to spot the differences between two pictures, which took approximately the same amount of time as the legend exposure (1-2 minutes).

Regardless of the condition to which they were assigned, all children were then given two new opportunities to create legends in the post-test phase: first with the same set of stimuli that was used initially (and shown in the effective legends), and then with a new set of items (that the children had not seen before). Children's legends on both post-test trials were scored as effective (for conveying the symbol-referent relations) or ineffective (for conveying insufficient of incorrect information). These post-test trials allowed me to determine the impact of exposure, including whether any improvement in legend creation transferred to a new set of stimuli.

I predicted that children's ability to create legends would improve after exposure to effective legends. During exposure, children are asked to evaluate examples of effective legends (using the current task's stimuli), followed by an explanation of why they are good examples (e.g., "It helps because this has the square and the moon, so it shows that the square box has moons inside", etc.). Therefore, children's attention is directed toward the characteristics of an effective legend. The expected effect of this exposure is in line with other research that has found improvements in children's ability to create mnemonic notations following minimal training (Eskritt & McLeod, 2008), and improvements in their representational drawings following experience with informative representations created by another (Callaghan, 1999). Although this related research does not address children's creation of legends to convey symbol-referent pairs, it does suggest that children's success on representation tasks can demonstrate improvement after relatively simple interventions.

While the research reviewed in Chapter Two is relevant for both Study One and Study Two, there is additional research that is particularly pertinent here, so this work will be discussed before turning to the current study.

Research Demonstrating the Benefits of Exposure on Children's Symbolic Creations

Eskritt and McLeod's (2008) research demonstrating improvements in children's note-taking abilities, as a result of a brief training exercise, is central to my second study so it will be reviewed in detail. Across three studies, they investigated age-related change, task demands, and direct instruction (training) as factors that play a role in children's notational productions for their future selves. Through this research, they identified factors that contribute to children's ability to make effective notations. Although their studies involved older children (5- to 7-year-olds and 9- to 11-year olds), and their tasks were more complex, their work highlights the positive impact that training/exposure can have on children's creation of notations.

In their first experiment, 5- to 7-year-olds completed two different memory tasks, each under different conditions. One memory task was *Concentration* (much like the popular memory card game), in which children were shown a 6 x 4 array of cards (12 pairs) face-down on a table, and were tasked with finding all of the pairs in as few turns as possible, while turning the cards over two at time (and then turning them back if they were not a pair). The images on the cards included both objects (e.g., a snowman, a moon) and abstract designs (equal numbers of both). To find the pairs in the minimal number of turns, children needed to track the identities of the cards they had turned over, as well as their spatial locations in the array. The researchers recorded the number of turns required to find all 12 pairs.

The other memory task was the *Store task,* in which children needed to track the identities of cards that a customer ordered so they could be delivered later on. The images on the cards varied in terms of shape (rectangles, triangles, and circles) and colour (blue, red, and green). This task required children to track the customer's three orders of three cards each (for a total of nine cards out of a deck of 38). After all of the cards had been mixed back in with the original deck, children were asked to put the cards for each of the customer's orders into gift bags for delivery. In order to succeed, they had to be able to accurately identify the cards that belonged to a particular order by relying on shape and colour information, but it did not require that they track the order or location of the cards (unlike in the Concentration game). The researchers recorded the number of cards (out of nine) that children were able to identify correctly within each set.

For both the Concentration and the Store task, children were given two trials, each in one of two conditions: one with the opportunity to make notes (i.e., the 'write' condition, wherein children were invited to "mark down anything you want to help you remember the cards better", p. 57) and one without (i.e., the 'no-write' condition). The use of two different memory 'games', with different demands (e.g., whether or not spatial information needed to be tracked), allowed for an examination of whether the type of task would affect the notes that children produced when given the opportunity.

Children were categorized based on the type of notation they produced in the write condition of each task: *full notations* were those that contained both types of relevant information (e.g., identity and location information in the Concentration task, or colour and shape in the Store task); *partial notations* were those that contained only one type of relevant information (e.g., only identity in the Concentration task, or only shape in the Store task); and *non-mnemonic notations* were those that contained no useful information (e.g., a drawing of a rainbow). Although full notations were those that contained both types of information relevant to the task, they were not required to be good quality notations to be classified as full. For example, children may have included both identity and location information in their notes for the Concentration task, but were inaccurate in their representation of the cards' locations. To take such errors into consideration, Eskritt and McLeod evaluated the quality of full notations on the basis of specific criteria: the degree to which the identities of the cards could be distinguished from one another; the degree to which the locations of the cards were represented; and completeness with which all cards were represented in the notations.

In the Concentration task, children's performance was also evaluated based on the number of turns required to find all of the pairs. Interestingly, neither the type of notation produced (full, partial, or non-mnemonic), nor the condition (write vs. no-write), impacted the number of turns required to find all of the pairs. Eskritt and McLeod point out that this likely because even when children produced full notations, they were frequently of poor quality. In particular, children had difficulty capturing location information in their notes by either miscounting or mixing up columns and rows. Given that even full notations were not necessarily informative, the similar performance in the different conditions, or using the different types of notes, is not surprising.

A difference in performance between the write and no-write conditions was found for the Store task, however. They found an interaction between condition and notation type, indicating that the write condition provided an advantage, but only when children made full notations. The researchers interpret this to mean that making full notations, when given the opportunity, leads to better performance on the task.

Another possible explanation for the superior performance of the children who created full notations was that they spent more time on the task (attending to the cards) than the other types of note-takers. The researchers considered this possibility and found that although the children who were categorized as ‘full note-takers’ did spend more time than other participants on the write condition, they also spent more time on the no-write condition, with no apparent benefit. This finding was interpreted to support the researchers’ claim that it was the use of full notations, and not time spent, that led to this group’s superior performance.

Eskritt and McLeod went on to compare children’s performance on their two types of notation tasks (Concentration and Store tasks) to consider how task demands impact children’s note-taking ability. Recall that the Concentration task required children to notate spatial location, while the Store task did not. Considering evidence from other research that finds that children more easily notate objects/identities (e.g., Bialystok & Codd, 1996; Callaghan, 1999; Hughes, 1986) than location or sequential information (e.g., Cohen, 1985; Eskritt & Lee, 2002; Karmiloff-Smith, 1979; as reviewed in Triona & Klahr, 2007), Eskritt and McLeod directly compared children's performance on the two kinds of tasks. They found that while very few children produced full notations on the Concentration task (9%), nearly half did so on the Store task (42%). Furthermore, almost all children produced either the same type of, or more sophisticated, notation for the Store task as compared to the Concentration task. The authors interpret this difference as indicating the demands of the tasks, as opposed to characteristics of the children, are what drive the differences in the types of notations produced across these tasks.

To test their claim that child characteristics did not drive differences in performance, Eskritt and McLeod considered differences in children's memory. To do so, they considered the number of turns needed to complete the Concentration task as an index of memory. They found that recall ability, as measured this way, did not differ among children who produced different types of notations (full, partial, or non-mnemonic) on the Store task (controlling for age). Therefore, while children who produced full notations outperformed their partial and non-mnemonic notation-producing peers, it was not due to a difference in general memory ability (as measured by turns required on the Concentration game).

Although performance on the Concentration task provides some indication of children's memory ability, additional measures would have helped to address the question of 'what cognitive skills contribute to children's note-taking ability?'. Given the requirement to hold information in mind while producing the notation (simultaneous storage and processing of information), I would expect Working Memory to contribute to children's performance on these note-taking tasks. Specifically, I would expect phonological Working Memory to contribute to performance on the Store task, given the need to hold the descriptions of the cards in mind, and expect both phonological and visuo-spatial Working Memory to contribute to performance on the Concentration task, given the additional demand of tracking, and recording, spatial information. Further, to create full notations, children must plan out the steps required to capture all of the relevant information in their notes, as well as inhibit their current knowledge of the cards to consider what their future self might need to know. These latter demands implicate both Planning and Inhibitory Control, both aspects of Executive Function, as skills that contribute to note-taking performance. Finally, children's ability to recognize when notations are ambiguous (such as partial notations) would likely contribute to their ability to create full, unambiguous notations. Therefore, the ability to detect ambiguity is another cognitive skill that may have been more advanced in children who made full notations on Eskritt and McLeod's task. In the current study, I will assess these cognitive skills as they were also chosen based on the demands of my Legend Creation Task.

In their second experiment, with an older sample of participants (9- to 11-year-olds), Eskritt and McLeod (2008) continued their investigation of children's ability to make notations. They argued that even partial/non-mnemonic note-takers might know how to use notes made by others, but simply lack the knowledge of what to include when making notes, and/or lack the knowledge of how to represent such information. If this were the case, then showing children how to make effective notes may be sufficient support for them to create effective notes themselves. To investigate whether this was the case, they examined whether children's performance benefitted from training in which the researcher demonstrated how to represent identity and spatial location information in the Concentration game. Children first took part in a pre-test, without training, to see if they could spontaneously make notes containing relevant information, which they termed ‘functional’ notations (referring to both the full and partial types of notations described in their first study). Children who did not produce functional notations (i.e., they produced non-mnemonic ones) were then assigned to their training condition. The training began with the experimenter placing a practice deck of cards (pairs of cards picturing safari animals) facedown in 4 x 2 grid formation, and then drawing a 4 x 2 grid on a piece of paper. The researcher then turned over the cards two at time, showing participants that the identity and location of the cards could be represented using the grid (this took approximately one minute). Afterward, the experimenter’s grid was removed, and children were instructed to use the strategy that had just been demonstrated to them.

Of the 60 children who participated in the pre-test, 27 spontaneously produced functional notes, while 33 did not and therefore went on to receive the training described above (there was no control condition). Then, in the post-test phase, all 60 participants played two games of Concentration (one write and one no-write game) with a new deck of cards (the same used in the first study), but this time in a 6 x 4 array.

Performance on the write condition trial of the post-test was used to assess the impact of the training on children’s note-taking. They found that 89% of the children of who spontaneously made functional notes on the pre-test continued to do so on the post-test. Of the participants who received training (none of whom made functional notes on the pre-test), 73% went on to make functional notes on the post-test (these participants were classified as the ‘trained note-takers’).

The researchers then compared the notes created by the spontaneous and trained note-takers in terms of quality (i.e., distinguishable identifies of the cards, accuracy of location information, and completeness of cards represented; the same evaluation criteria as described in the first study). They found that both were of high quality, with no significant difference between them. Furthermore, performance on post-test of the Concentration task (as measured by turns required to find all pairs) did not differ based on whether children were spontaneous or trained note-takers, but did differ for the write and no-write conditions with children performing better in the write condition. This demonstrates that children were able to find the pairs in fewer turns when they had the opportunity to make notes, but they were equally good whether they made those notes spontaneously or as a result of having improved from training.

The authors interpret these findings to support their claim that children were aware of how to use notes as a memory strategy, but were simply unaware of what information to include, or how to include it when making notes of their own. They found that most children in their sample could easily gain the necessary awareness, however, through brief training. The researchers did note that in order to rule out the possibility that children may have improved simply by having multiple opportunities to create notations, and not because of the training *per se*, a control group (i.e., children who received no training) was needed for comparison purposes. This was done in their third experiment.

Eskritt and McLeod (2008) repeated their second study, this time including a control group, and a modified post-training protocol. In this experiment, the deck of cards used consisted of only 10 matching pairs (20 cards in total), but was otherwise similar to the experimental deck used in the previous studies. The training that was administered to the experimental group was also similar to the training that was used in their second study. The researchers then examined whether children who improved following training would transfer their skills to a similar task. To examine transfer, children received two versions of the Concentration task: one with the cards arranged in a 5 x 4 grid, and the other with the cards arranged in a circle, with the order of versions presented as a between-subjects condition. Children who did not spontaneously produce functional notes on the version they received first were then trained on that specific version (i.e., either the grid or the circle). They were then given the opportunity to make notes on that version, and then finally received the other layout of the Concentration game (for which they received no training).

Of the 102 children who participated, 45 spontaneously made notes without training on the pre-test. Those who did not (n = 57) were assigned to either the training group (n = 33; numbers trained on circle vs. grid were not reported) or the control group (n = 24). Significantly more children in the training group improved on their first post-test trial (the version for which they received training; 61%, n = 20), as compared to the control group (4%, n = 1). Of those who spontaneously made notes on the pre-test, 78% (n = 35) continued to make functional notes on the first post-test.

Following their first post-test trial, children then completed the version of the task they had not seen before. Of the spontaneous note-takers, 69% (n = 31) made functional notes on this new task, while only 12.5% (n = 3) of the children in the control group did so. Of particular interest was the performance of the trained note-takers: 17 out of the 20 children who had demonstrated improvement on the first post-test trial (i.e., directly following the training) went on to produce functional notations for the other version of the task (an additional two trained children who did not improve on the first task also made functional notes on the second task).

The high level of success, and transfer, of these children on an untrained spatial layout supports Eskritt and McLeod's conclusion from the their second study: children simply lacked the knowledge of what information to include and how to represent it in their notations, and once shown, they could apply it. The lack of improvement in the control group lends support to their claim that improvement was not a function of practice alone, but rather from explicit training on how to make functional notes. From this research, it is clear that some of the difficulty children experience when producing notations is due to a lack of awareness of what information should be included and how, and not just due to an inability to create informative representations.

Eskritt and McLeod provide clear evidence that children's notations can significantly improve following a brief training exercise. This finding motivates my second study, with the goal of investigating whether children's creation of legends can be improved through similar kinds of exposure. Furthermore, my research also investigates the role of cognitive skills (Detection of Ambiguity and Executive Function) as a way to explain differences in performance between children who do/do not spontaneously make effective legends, as well as children who do/do not improve following participation in the exposure condition.

As Eskritt and McLeod point out, task demands can strongly influence children's performance, especially in circumstances where spatial location is involved. Therefore, Eskritt and McLeod's (2008) use of older participants was well suited for their investigation given their tasks' demands. My research question, however, was focused on younger children (4- to 6-year-olds); thus, my Legend Tasks are much simpler. For example, children were not required to keep track of spatial or sequential information in order to produce an effective legend. In the absence of these demands, evidence from Callaghan (1999) suggests that children as young as 2 to 4 years old can benefit from training when required to produce representations.

Callaghan (1999) investigated young children's ability to create pictorial representations for the purpose of conveying information to another (as opposed to one's future self, as was done in Eskritt & McLeod, 2008). In this study, 2- to 4-year-olds were asked to make drawings of toys that would be used in a game. During the game, children would hold up one of the drawings they made to tell the experimenter which toy to pass to them through a tube. The toys were a large ball, a small ball, a group of three small balls, a 'spider' ball with many sprouting legs, and a black stick, all of which could be drawn with circles and/or lines and easily distinguished from one another (note that all balls were the same colour: orange with green and purple spots). After each child had made their drawings, they were scored based on whether or not they captured the distinguishable features of the toys (e.g., whether they drew little lines sticking out from a circle to distinguish the spider ball from the plain ball). Then, the next phase began. This phase of the task consisted of eight trials in which the children would hold up the drawing they created to inform the experimenter about which item should be put down the tube. The experimenter always chose the toy the child intended, regardless of the effectiveness of the representation (the intended object for each drawing had been noted while children made their drawings).

In the next phase, the experimenter made effective, clearly distinguishable drawings and it was the child's turn to put the depicted toy down the tube. Once again, this was repeated for a total of eight trials. An additional five trials were also included wherein each child was presented with a drawing of the toy, and asked to choose between the toy itself and a duplicate of the drawing to put down the tube. This was done to ensure that children understood that the drawings served as representations of actual objects, and that they were not inclined to put drawings themselves down the tube. After a five-minute break, children were given a second opportunity to make drawings of the same toys so that the researchers could examine their drawings for potential improvement resulting from exposure to the experimenter's effective drawings.

Comparisons of children's drawings before and after exposure revealed that although 2-year-olds did not demonstrate improvement, both the 3- and 4-year-olds' drawings significantly improved in quality (in terms of distinguishable features). This serves as evidence that the experience children had viewing the experimenter's drawings helped them to then create better drawings themselves (though it seems plausible that children improved simply through practice making the drawings or continued experience with the objects, this explanation was ruled out in Callaghan's second study, as described below).

This study also provided insight into young children's understanding of representations, as evidenced by their ability to select the correct toy when presented with the experimenter's drawing. Results indicated that while 2-year-olds performed at chance, 3- and 4-year-olds were significantly better than chance at selecting the appropriate object. Recall that an additional five trials were also included to investigate whether children would treat the drawings themselves as objects. As a group, the two-year-olds put almost half of the drawings down the tube, suggesting that it may be their lack of representational understanding that resulted in their poor performance on the other phases of the task. In contrast, the 3-year-olds put a quarter of drawings down, while the 4-year-olds did not put any. The lack of representational insight of two-year-olds has been previously demonstrated in other research as well (e.g., DeLoache, 2000; DeLoache, Miller, & Rosengren, 1997). Based on their inability to understand the representational nature of the drawings, it was not surprising that the younger children did not produce effective drawings even after exposure to an experimenter's effective drawings.

Relevant to the current project, many 3- and 4-year olds were able to create drawings that effectively captured the distinguishing features of the toys, and those who were unable to do so often improved after experience with the experimenter's drawings. This study serves as evidence that even younger children are capable of producing representations that convey information to an unknowing other (though, it is noted that they were not asked to indicate the representing relation in their drawings). As such, I was confident that although my participants were younger than those in Eskritt and McLeod's (2008) study, their performance on my task would yield appropriate variability given the level of success of the 3- and 4-year-olds in Callaghan's study.

The design of Callaghan's (1999) first study, with children producing representations in one phase and using representations produced by the experimenter in another, allowed for a comparison of children's production to their understanding. Children were categorized as pass/fail on the *understanding* task based on their ability to match the pictures created by the experimenter to their appropriate objects (matching at least six out of the eight picture/object pairs), and categorized as pass/fail on the *production* task based on their ability to distinguish between the objects (producing three or four distinctions). Children performed similarly on the production and understanding tasks, with over 80% performing consistently (i.e., passing or failing both tasks). The authors interpreted children's similar performance on both tasks as support for the claim that children's ability to produce effective symbols is related to their ability to understand drawings as symbolic. A possible, but unexamined, explanation for the similarities in understanding and production is that both abilities rest on other, related cognitive skills. It is possible that being able to detect ambiguity, and/or having better Executive Function, facilitates success on both types of tasks. Although not a direct investigation of the symbolic skill investigated via Callaghan's task, my work examines these skills and their relations to each understanding (Study One) and production (Study Two) of legends.

In her second experiment, Callaghan ruled out other factors that may have led to children's improvement, such as practice making the drawings or experience with the objects. In this experiment, after creating drawings and using them to communicate with experimenter, children were not exposed to drawings made by the experimenter; instead, the experimenter pointed to the objects that were to be put down the tube. Then, the participants were asked to create drawings of the objects again, and this second set of drawings was compared to the first set. Without the exposure to the experimenter's drawings, Callaghan found that the children actually made *fewer* distinctions on their second set of drawings – indicating that experience pointing to the objects did not have the same effect as using the experimenter's drawings. As such, the improvement found in the first experiment is unlikely due to practice making the drawings or experience with the objects, and was in fact a consequence of having been exposed to effective representations of the objects. Unknown from Callaghan's research, however, is whether the improvement that was seen in her first study would have transferred to another task.

Taking another approach to investigate of the impact of experience, Callaghan added a new and final phase in her second study in which the experimenter attempted to match the child's drawings with the intended objects, and expressed the inability to do so when the drawings were unclear. More specifically, the experimenter picked up one of the ambiguously pictured items and said, "When I look at these pictures I can't tell which one goes with this. Can you draw me another one so that I can be sure it goes with this one and not one of the others?"(p. 1321). Children then made a third set of drawings, allowing them the opportunity to improve based on the experimenter's feedback. On this new set of drawings, the 3- and 4-year-olds made more distinctions between the objects than they had on previous trials, therefore demonstrating improvement as a result of the feedback. This is consistent with Eskritt and McLeod's (2008) finding that children have the ability to create notes/drawings that convey information, but they sometimes require support to do so effectively. Callaghan's findings suggest that one form of this support may be to point out when drawings are unclear.

Based on both Eskritt and McLeod (2008) and Callaghan (1999), it is clear that exposure and feedback can help children improve their representations to convey information. Such findings motivated my second study, which investigated whether children's creation of legends could be improved through experience gained from effective legend exposure. In addition to the effect of exposure, I also investigated whether the cognitive skills included in Study One (i.e., Detection of Ambiguity and

Executive Function) were related to children's performance on the pre-test, as well as their ability to improve as a function of exposure (in the post-test phase).

Hypotheses

My first hypothesis was that there would be an age effect for performance on the pre-test of the Legend Creation Task, with children who create effective legends being older (considering age in months) than children who make ineffective legends. As outlined in Study One, research has demonstrated significant changes in representational understanding during the preschool years (e.g., DeLoache, 1995, 2000). Specific research investigating children's *production* of representations has shown that children become more skilled at creating external representations to convey informative between the ages of 2 and 4 (Callaghan, 1999), and between the ages of 5 and 7 (Eskritt & Olson, 2012; Marti, Garcia-Mila, & Teberosky, 2005). Therefore, despite not finding a significant effect of age for evaluation in Study One, I predicted that changes in children's creation of legends would be taking place during this time.

As in Study One, and for the same reasons outlined there and in Chapters One and Three, my second and third hypotheses (respectively) were that children's Detection of Ambiguity and Executive Function would relate to performance on the pre-test of the Legend Creation Task, above and beyond differences in age and vocabulary, with those who created effective legends being more advanced in these cognitive skills than those who did not.

My fourth hypothesis was that children assigned to the exposure condition, but not the baseline condition, would demonstrate improvement on the two post-test trials (one for the same set of stimuli and one for a new set to demonstrate transfer). This hypothesis was based on Eskritt and McLeod's (2008) finding that children's note-taking performance improved after watching effective note-taking be modeled by an experimenter. Although their task was more complex and participants were older than the sample for the present study, they demonstrate that minimal training can have an impact. Further, work with younger children (Callaghan, 1999) has suggested that even children as young as 3 and 4 years of age can improve their representational drawings once they have had experience using informative drawings created by another. Therefore, I predicted that 4- and 5-year-olds who initially failed to create an effective legend would do so after exposure to effective legends.

Lastly, I predicted that the cognitive abilities hypothesized to relate to performance on the pre-test (the first legend creation), would also relate to whether or not children improve as a result of exposure. More specifically, my fifth and sixth hypotheses (respectively) were that Detection of Ambiguity and Executive Function scores would be greater for those children who demonstrated improvement on the post-test trials, than those who did not (following exposure). These predictions were motivated by the expectation that these skills contribute to children's awareness of what makes an effective legend (see Chapter 3 for further details) and, therefore, children with more advanced Detection of Ambiguity and Executive Function skills would have enough understanding of legends to benefit from training and be able to apply the knowledge once it is gained.

Method

Participants

A total of 115 children participated in this study (62 boys), with 51 four-year-olds and 64 five-year-olds (a range of 48 to 70 months; *M* [age in months] = 60.30, *SD* = 6.12.

An additional two children were also tested but were missing multiple measures and were therefore not included in analyses. No participant for this study took part in Study One. Participants were recruited and tested in a similar manner as outlined above for Study One; the only difference being that Study One was limited to daycares, whereas recruitment and testing for this study also included children in local schools, with the approval of the school board's research advisory committee. Consent forms specific to school principals and parents can be found Appendices L and M respectively.

Procedure

Tasks for this study were administered in a similar manner as the tasks for Study One: two testing sessions of approximately 25 minutes in length, scheduled roughly one week apart. During the pre-test of the Legend Creation Task, children's legends were categorized as either effective or ineffective (based on criteria which will be outlined on page 93). Children who made ineffective legends on the pre-test proceeded with the remainder of the task (in either the exposure or baseline condition). Children who made effective legends on the pre-test did not continue with the Legend Creation Task, as no change would be expected in their performance. All participants received the Detection of Ambiguity and Executive Function measures, as well as the PPVT-III. The order of task presentation was fixed and is presented in Table 4.

Table 4

Order of Tasks for Each Testing Session

Session	Task 1	Task 2	Task 3	Task 4
1	Black/White Stroop	Legend Creation Task	Corsi Span	Ambiguous Messages
2	Truck Loading	Counting & Labeling	Droodle	PPVT

Note. Participants who did not receive the full Legend Creation Task (those who were effective on the pre-test) completed the Truck Loading task at the end of Session 1 to more evenly distribute the length of the sessions.

Tasks

In addition to the Legend Task, the following measures (described in detail for Study One in Chapter Four) were included: Droodle (Detection of Ambiguity – visual), Ambiguous Messages (Detection of Ambiguity – verbal), Black/White Stroop (Inhibitory Control), Backward Word Span (phonological Working Memory), Corsi Span (visuo-spatial Working Memory), Truck Loading (Planning), and PPVT-III (receptive vocabulary). A description of the new task (the Legend Creation Task) will follow, and protocol can be found in Appendix N.

Legend Creation Task. The Legend Creation Task is similar to the Legend Evaluation Task in terms of both stimuli and introduction. The primary difference is that in the creation version, children were asked to “make something” that would help the friend put the shapes away (see Appendix N). As in the Legend Evaluation Task, the task begins by introducing the boxes and corresponding cards with shapes on them (for this trial, all children saw the first set of stimuli presented in Appendix A). Participants watch as cards are removed from the boxes and are told:

> We are taking these shapes out so we can look at them. Later on, someone else has to put the shapes away. She has never seen these boxes before. She doesn't know what shape goes inside each box. But, she will need to put the shapes back in the right boxes. You can use these [referring to a piece of paper and a pencil] to make something that will help her put the shapes back into the right boxes.

Once the legend (or whatever the child created during the pre-test phase) was complete, it was removed from the child's sight. Children's legends were coded as either Successful or Unsuccessful, based on whether or not they contained sufficient information to convey the relation between the symbols and their corresponding referents, (inter-rater reliability was 100% agreement by two independent coders). In keeping with Myers and Liben (2008), legends could be Successful by making either: (1) categorical legends, which display each symbol with its corresponding type of referent; or (2) redundant legends, which display each symbol with three instances of the referent (one for each appearance of the card). For example, a child who drew the square, circle, and triangle, with the corresponding moon, star, and cloud, was coded as Successful (categorical), while a child who drew the square with three moons, the circle with three stars, and the triangle with three clouds, was coded as Successful (redundant). However, a child who missed details about the referents or symbols (by drawing only the square, circle, and triangle), for example, was counted as Unsuccessful. Further examples of Unsuccessful, Successful categorical, and Successful redundant legends can be found in Appendix O.

While most redundant legends made note of the entire set of stimuli, one child produced a partially redundant legend that included all three moons with the square box, two stars with the circle box, and one cloud with the triangle box. Given that this legend captured more items than necessary to convey the symbol-referent pairs, it was coded as redundant. It is also important to note that children's legends were categorized based on the *intended* creation, and not their drawing ability. For example, if a child verbalized they were drawing a moon, the experimenter recorded that it was a moon and judged it as such regardless of whether the identity would have been known based on the child's drawing alone. This coding decision was based on the fact that the skill of interest was children's knowledge of what to include when conveying symbol-referent relations, not their level of artistic ability.

Children who were Unsuccessful on the pre-test were assigned to either the exposure or baseline condition of this task. Children in the exposure condition were then exposed to two effective legends created by an experimenter. To ensure that children were reflecting on the presented legends, they were told to evaluate the legends and were asked to justify their response by elaborating on why each legend was or was not helpful (in child friendly language; see Appendix N). The majority of children responded 'yes' when asked if each legend was helpful, with 94% doing so in response to top-to-bottom legend and 86% in response to the bottom-to-top legend. Regardless of their response, children were given feedback with the experimenter explaining why the legend was helpful (i.e., "It helps because this has the square and the moon, so it shows that the square box has moons inside", etc.). The two legends, presented one at a time in counterbalanced order, were based on the same stimuli for which children had attempted to create a legend in the pre-test. After the presentation of each legend, it was removed from sight before proceeding with the task.

Children in the baseline condition did not see the examples of the effective legends, but instead completed an unrelated task that took approximately the same amount of time (1-2 minutes). In this task, children were presented with two pictures that looked similar but contained a number of differences (see Appendix P). Children were asked to identify three ways in which the pictures were different, and were provided with assistance when appropriate.

After receiving either the exposure or baseline condition, children were given a new piece of paper. Using the same set of boxes and cards that were used in the pre-test, they were asked to once again make something that would help the friend put the shapes away in the correct boxes (post-test A). It is important to note these were the same instructions given in the pre-test phase (and that they were different from Eskritt and McLeod's post-test instructions which specifically asked children to use the strategy demonstrated to them during training).

After the child was finished, the legend and the set of boxes/cards were removed and a new set of boxes and cards (with different images on them; the second set shown in Appendix A) was introduced. At this point, children were asked to create a third legend (post-test B) to examine transfer and potentially rule out producing an effective legend by simply re-creating one that they had just seen (in the exposure portion of the task). Performance on each post-test was coded as Successful or Unsuccessful (scored as described above). Children's performance on the two post-tests (each coded as Successful or Unsuccessful) was scored by two independent coders, who found 100% agreement on post-test A and only a single disagreement on post-test B, which was resolved through discussion and coded as Unsuccessful.

Results

Preliminary Analyses

As in Study One, preliminary analyses were conducted prior to testing the outlined hypotheses. The measures used were examined for order effects and children's comprehension of instructions. Additionally, composite/component scores were created for use in the analyses. These results will be outlined below, before presenting the main analyses.

Legend Creation Task. Recall that children's performance on the Legend Creation Task was coded as Successful if their legend conveyed the symbol-referent pairs or Unsuccessful if their legend contained insufficient or incorrect information. Children who were Unsuccessful on the first production trial (n = 70) were then randomly assigned to either the exposure (n = 35) or baseline condition (n = 35). Children in the two conditions were compared in terms of gender (Chi-square), as well as age (in months), receptive vocabulary, and all cognitive measures (e.g., all Executive Function and Detection of Ambiguity tasks; ANOVA), and no significant differences were found (ps > .05). Children's improvement did not differ based on the order in which they viewed the experimenter's effective legends for post-test A, χ^2 (1, N = 35) = 0.88, p = .573, nor for transfer after improvement in post-test B, χ^2 (1, N = 35) = 0.92, p = .596.

Detection of Ambiguity. As in Study One, two Detection of Ambiguity measures were used: the Droodle (visual) and the Ambiguous Messages task (verbal). On the Droodle task, all children were able to identify two of the three items used in the task on their first attempt (the bicycle and the clock), with eight children (7%) requiring a second attempt to identify the giraffe. Despite the additional difficulty identifying the giraffe, performance was highly reliable across all three test trials (α = .91). Overall, children performed well, and similar to the participants in Study One, with a mean score of 2.62 out of 3 (*SD* = 0.92).

On the Ambiguous Messages Task, two children failed to answer check questions correctly (one child failed to understand the terms “good” and “not-so good”, while the other failed only “not-so-good”) and therefore were excluded from relevant analyses. All remaining children understood these terms, and understood that Chester, the character behind the barrier, could not see the cups (as indicated by correct responses to check questions within three attempts). As in Study One, children were randomly assigned one of two orders for the key questions in the task: they were asked if each statement was “a good clue or a not-so-good clue ”, or if it was a “not-so-good clue or a good clue”. The order in which this question was asked did not impact children’s performance on the task out of 6, $t(111) = 0.38$, $p = .708$, and therefore order was not considered in subsequent analyses. As was done in Study One, children’s performance on the ambiguous (*M* = 1.87 out of 3; *SD* = 1.19) and unambiguous trials (*M* = 2.22, *SD* = 0.99), were combined for a total score out of 6 (*M* = 4.09, *SD* = 1.43). Performance across the six trials had very poor internal consistency (α = .45) and therefore was carefully examined before included in main analysis. Performance on the Droodle task significantly correlated with performance on the Ambiguous Messages task, $r = .30$, $p = .001$, even after controlling for age (in months), $pr = .25$, $p = .008$, and marginally after age and PPVT-III, $pr = .19$, $p = .052$. Therefore, as planned, a composite score was created by dividing children’s score on the Ambiguous Messages task by 2 (resulting in a score out 3), and adding it to their score out of 3 on the Droodle. This composite score out of 6 ($M = 4.71$, $SD = 1.27$) was similar to performance in Study One and was used in all analyses.

Executive Function. The Black/White Stroop, the Backward Word Span, the Corsi Span, and the Truck Loading task were used as measures of Executive Function (measuring Inhibitory Control, phonological and visuo-spatial Working Memory, and Planning, respectively). Children's performance on each of these measures, including indices reliability, can be found in Table 5. The procedure for assessing reliability used in Study One was repeated for Study Two, using Cronbach's alpha for the Black/White Stroop (which was found to be good in terms of internal consistency) and Spearman-Brown split-half for on subscores for the Backward Word and Corsi Spans (which were both acceptable).

Table 5

Descriptive Statistics for Executive Function Tasks

Task	Mean (SD)	Range	Reliability
Black/White Stroop	16.95 (4.43)	0 – 21	Cronbach's $\alpha = .88$
Backward Word Span	1.13 (0.65)	0 – 3.5	Split-half = .62
Corsi Span	2.27 (0.75)	0 – 3.5	Split-half = .66
Truck Loading	3.19 (1.28)	0 – 4	n/a

Note. All statistics are based on the entire sample of $N = 115$.

As in Study One, a Principal Component Analysis was used to produce a common component score based on the four Executive Function measures. To ensure that a Principal Component Analysis was justified, the Kaiser-Meyer Olkin measure of sampling adequacy (.65) and Bartlett's Test of Sphericity ($p < .001$) were considered, which indicated factorability of the data. The Black/White Stroop, Backward Word Span, Corsi Span, and Truck Loading task were entered into the Principal Component Analysis and a single component was extracted. Extraction values, presented in Table 6, sum to an eigenvalue greater than 1 ($\lambda = 1.70$, with 42.39% of the variance accounted for). Therefore, this Executive Function score was used in subsequent analyses.

Table 6

Extraction Values for Executive Function Measures

Measure	Extraction Value
Black/White Stroop	.28
Backward Word Span	.47
Corsi Span	.45
Truck Loading	.49

Hypotheses One through Three

My first three hypotheses all involved predictions regarding factors related to success on the pre-test of the Legend Creation Task. I predicted that age (first hypothesis), the ability to detect ambiguity (second hypothesis) and Executive Function (third hypothesis) would relate to children's performance on their first attempt at a legend in the Legend Creation Task.

The group sizes for Successful and Unsuccessful participants were $n = 45$ and $n = 70$, respectively. However, recall that two children were excluded based on failure to respond correctly to comprehension questions on the Ambiguous Messages task. These participants were each in different groups, reducing Successful and Unsuccessful participants to $n = 44$ and $n = 69$ respectively. Age in months, Detection of Ambiguity, Executive Function, and PPVT-III were all considered as variables that may differ according children's performance on the Legend Task. Means for these variables, grouped by Legend Creation Task performance, can be found in Figure 3.

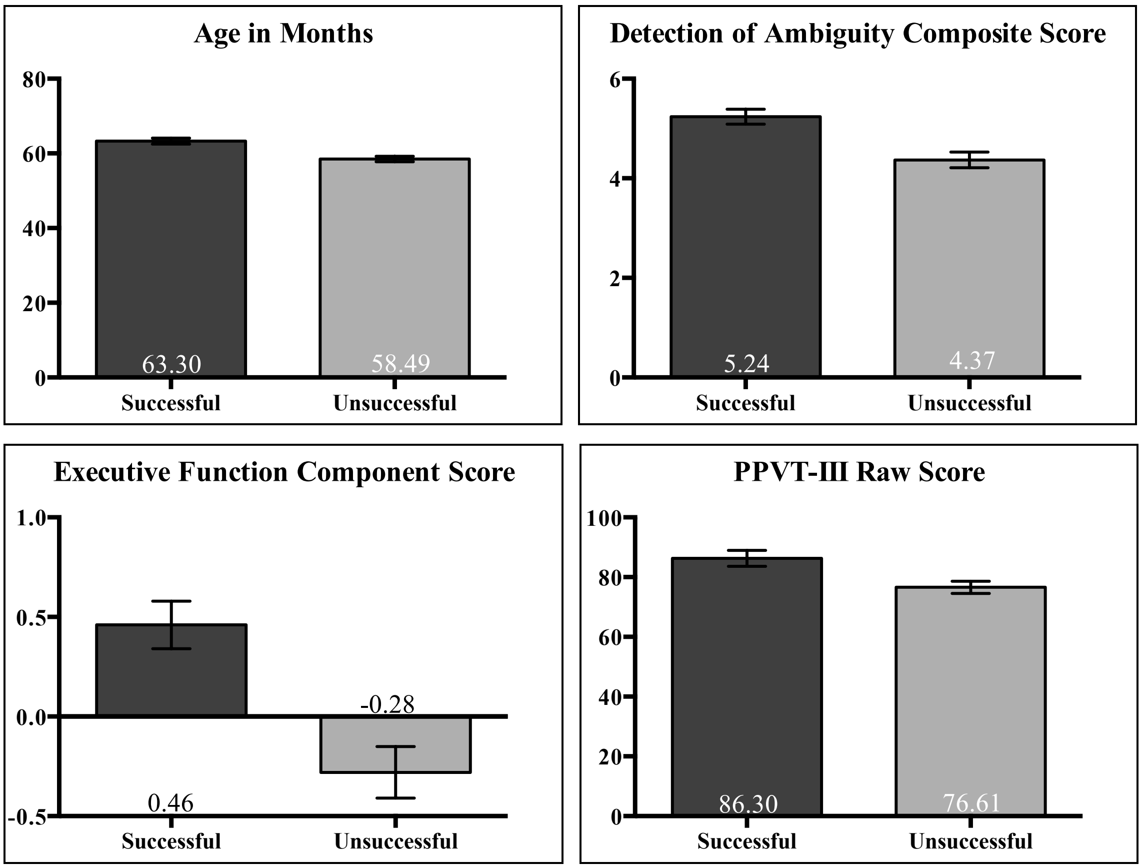

Figure 3. Mean scores by Legend Creation Task performance. Error bars represent standard error of the mean.

As in Study One, a Discriminant Function Analysis was used to describe the differences between the two groups (Successful vs. Unsuccessful). The variables graphed above were examined for their contributions to the underlying discriminant function that explains differences between Successful and Unsuccessful participants. Prior to conducting the analysis, all relevant assumptions were checked.

Assumptions. All variables were within the range of ±3.29 standard deviations and therefore there were no outliers to consider. Normality statistics were also examined within each group and all variables had skewness and kurtosis values within the recommended ±2 range (Tabachnick & Fidell, 2007), with the exception of Detection of Ambiguity. Detection of Ambiguity scores for children Successful on the Legend Creation Task were negatively skewed (-5.79) and leptokurtic (9.47); scores for children who were Unsuccessful were also negatively skewed (-3.58). Discriminant Function Analysis is robust to violations from skewness and kurtosis when groups are equal, which was not the case (with 44 and 69 children in the Successful and Unsuccessful groups respectively). Therefore scores on Detection of Ambiguity were transformed using reflection and logarithm, which brought skewness and kurtosis statistics for both groups within the recommended range (Successful: skewness = 1.82, kurtosis = 0.54; Unsuccessful: skewness = -0.04, kurtosis = -0.82). Transformed scores were used for the remainder is this analysis.

Box's M was not significant (p = .036) suggesting that the homogeneity of covariance assumption was met. Levene's test for Equality of Variances was significant for Executive Function (p = .006), suggesting a violation of homogeneity of variance for this variable, which can problematic when groups are not equal. The larger group (Unsuccessful, n = 69, s^2 = 1.07) had greater variance than the smaller group (Successful, n = 44, s^2 = 0.58), but the ratio between them is less than 3, and therefore this violation was not a concern. Data was also checked for multicollinearity, revealing a number of significant correlations among the variables (the predictor variables were significantly correlated with each other, *ps* < .009). This suggests that some predictors may be redundant and decrease power, possibility resulting in an increased Type-II error rate, which will be important to keep in mind when interpreting the results. To address this violation, SPSS excludes variables with insufficient tolerance when running Discriminant Function Analysis. The assumption of independence is met because there is no reason to suspect one participant's scores are correlated with any others.

Discriminant Function Analysis. A Discriminant Function Analysis was performed to find the best linear combination, based on the predictors, that discriminates between the two groups. Given that there are only two groups, Successful and Unsuccessful on the pre-test, only one function was derived and the eigenvalue was .30. The canonical correlation, CC = .48, represents the correlation between the discriminant function and Legend Creation Task performance. The discriminant function is significant, $\lambda = 0.77$, χ^2 (4, N = 113) = 28.41, $p < .001$, indicating that the four predictor variables were differentiated between the two groups.

The correlations between each variable and the latent variable that the discriminant function represents, suggest that all four variables contribute to the function: Detection of Ambiguity = -.74 (recall that this is based on the transformed data, and therefore the negative coefficient indicates a positive effect), Executive Function = .71, Age = .76, and PPVT-III = .51. The standardized coefficients, representing the correlations when all other variables are controlled for, indicate that, consistent with Hypotheses One and Two, the variables making an important contribution are Age (.53) and Detection of Ambiguity (-.48). However, support was not found for my third hypothesis, which predicted that Executive Function would play a role, as neither Executive Function (.27) nor PPVT-III (.09) met the cut-off of .33 (Tabachnick & Fidell, 2007).

Hypothesis Four

My fourth hypothesis was specific to children's performance on the post-test phase; more specifically, it was that children's legends would improve if they were exposed to effective exemplars. To examine children's improvement as a function of condition (exposure vs. baseline), children's performance on post-test A was examined first. Children's legends were categorized as Successful if they created an effective legend (this test involved the same stimuli from the pre-test), and Unsuccessful otherwise. Of the 35 children assigned to the exposure condition, 17 children (49%) improved and were successful on post-test A. In comparison, only three of the 35 children (9%) assigned to the baseline condition improved, significantly fewer than those who received exposure, χ^2 (1, N = 70) = 13.72, $p < .001$.

To examine whether children were able to transfer what they had learned, they were further categorized based on whether they created an effective legend on post-test A *and* transferred this newly acquired skill to create an effective legend on post-test B (creating a new legend, based on novel stimuli). Of the 17 children in the exposure condition who improved, 15 went on to be successful on the transfer task (post-test B). An additional three children who received exposure created an effective legend on post-test B, though they had not done so for post-test A. The three children in the baseline condition who improved also transferred their skills, and an additional three children without exposure were successful on post-test B, though they were not on post-test A. As expected, based on the high proportion of improvers that transferred to the new task, the difference between the exposure and baseline conditions remains significant even when comparing those who improved *and* transferred to those who did not improve directly following exposure, χ^2 (1, N = 68) = 11.87, p = .001.

Hypotheses Five and Six

My fifth and sixth hypotheses were that, within the exposure condition, those who improved would have higher scores on measures of Detection of Ambiguity (Hypothesis Five) and Executive Function (Hypothesis Six) than those who did not, as it would be these skills that would facilitate benefitting from exposure. Recall that of the 35 children who received exposure, 17 improved on post-test A. To compare the 17 improvers to the 18 non-improvers, Discriminant Function Analysis was used. Recall from above that two children were excluded from analyses involving Detection of Ambiguity scores for failure to correctly answer comprehension questions, one of which received exposure. The excluded child who received exposure was a non-improver, making the groups for analysis equal at 17 participants each. Means for the predictor variables, grouped by whether or not they improved, can be found in Figure 4.

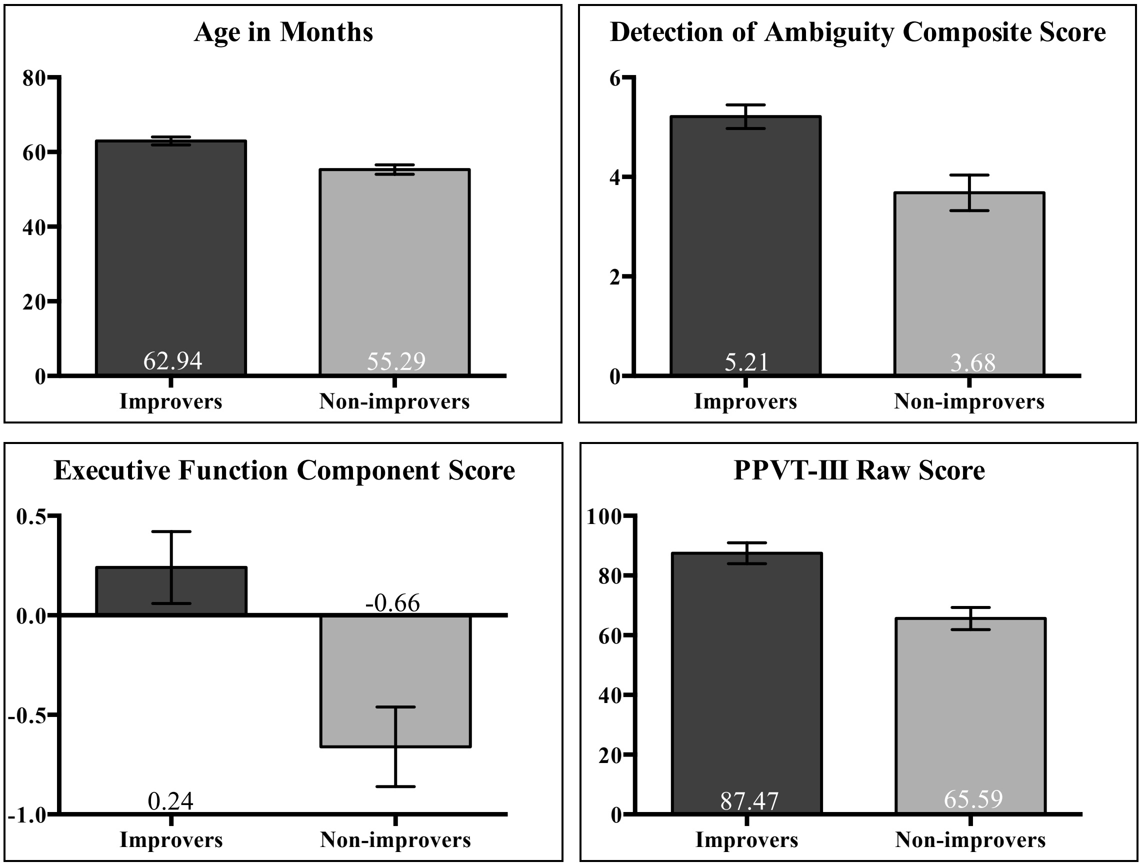

Figure 4. Mean scores by improvement on Legend Creation Task. Error bars represent standard error of the mean.

Assumptions. As done for previous hypotheses, all assumptions were carefully checked prior to analysis. The only violations found were of normality and homogeneity of variance, both for Detection of Ambiguity, which was not a concern given the equal size of the groups (Tabachnick & Fidell, 2007). There was some multicollinearity, with Detection of Ambiguity significantly correlating with Executive Function (r = .59, p = .014) and PPVT-III (r = -.49, p = .044), which may result in a decrease of power.

Discriminant Function Analysis. A Discriminant Function Analysis was used to compare children who improved following Exposure to those who did not in terms of Detections of Ambiguity, Executive Function, Age, and PVVT-III. The function derived has an eigenvalue of 1.60, and a canonical correlation (correlation with improvement performance) of .78. The discriminant function is significant, $\lambda = 0.39$, χ^2 (4, $N = 34$) = 28.63, $p < .001$, indicating that the four predictor variables were differentiated between the two groups. The correlations between each variable and the latent variable that the discriminant function represents, suggest that all four variables contribute to the function: Detection of Ambiguity = .50, Executive Function = .47, Age = .64, and PPVT-III = .60. However, the standardized coefficients represent the correlations when all other variables are held constant, and suggest that the variables of importance are Age (.64), Detection of Ambiguity (.52), and PPVT-III (.52). Executive Function does not appear to be a contributing factor (.04) once these others variables are accounted for.

When conducting the analysis on the basis of children who improved and transferred, compared to those who did not improve, somewhat similar results were obtained (once again assumptions were checked and deemed satisfactory). The derived function had an eigenvalue of .87, and a canonical correlation of .68. The function is significant, $\lambda = 0.54$, χ^2 (4, $N = 34$) = 18.74, $p = .001$, with unstandardized loadings as follows: Detection of Ambiguity = .80, Executive Function = .59, Age = .57, and PPVT-III = .45. Once all other variables are held constant, it is clear that the variables of most importance for explaining group differences are Detection of Ambiguity (.72) and Age (.50), while Executive Function (.12) and PPVT-III (.14) have do not appear to have an effect.

Additional Analyses

Throughout the process of data collection, additional questions arose. One such question was whether there were differences among children who produced different kinds of effective legends on the pre-test trial of the Legend Creation Task (n = 44[6]). Recall that children who made effective legends did so in one of two ways: (a) making a categorical legend that paired each symbol with its correct referent (n = 29); or (b) making a redundant legend that depicted each symbol with all cards that belonged inside, despite the cards all being identical (n = 15). Given that these were two different ways of expressing the symbol-referent relation that varied in terms of efficiency (with the former being more efficient and adult-like), differences between these two groups of children were of interest. The two groups of children (categorical and redundant legend-makers) were compared in terms of Detection of Ambiguity, Executive Function, Age, and PPVT-III scores using Discriminant Function Analysis (see Table 7 for mean scores). The only assumption requiring attention was normality for Detection of Ambiguity. Given the unequal groups, it was necessary to transform the data (reflect and logarithm transformation was used), which brought the skewness and kurtosis statistics within the recommended range, and therefore the transformed data was used in the analysis. The discriminant function is not significant, $\lambda = 0.94$, χ^2 (4, N = 44) = 2.35, p = .671, indicating that the groups do not significantly differ on the variables of interest.

Table 7

Means for Predictor Variables by Effective Legend Creation Type

Predictor	Categorical Legend Makers Mean (SD)	Redundant Legend Makers Mean (SD)
Age (in months)	63.07 (5.42)	63.73 (4.77)
Detection of Ambiguity	.22 (.22)	.15 (.16)

[6] Recall that one child who was Successful on the pre-test was excluded based on failure to response to a check question for Ambiguous Messages, and therefore the group being compared was n = 44.

Executive Function	.37 (.78)	.63 (.72)
PPVT-III	86.59 (16.44)	85.73 (20.43)

Note. Detection of Ambiguity statistics are reported post-transformation, therefore lower scores indicate better performance.

An additional question was whether those children who produced effective legends on the pre-test (n = 44; 66% of which made categorical legends) differed from children who improved and transferred following exposure (n = 15; 67% of which made categorical legends) on the other cognitive measures. Once again, it was necessary to use transformed scores for Detection of Ambiguity. The discriminant function is not significant, $\lambda = 0.97$, χ^2 (4, N = 59) = 1.51, p = .825, indicating that the groups were not significantly different in terms of Detection of Ambiguity, Executive Function, Age, or PPVT-III (see Table 8 for mean scores).

Table 8

Means for Predictor Variables, Comparing Children who were Successful on the Pre-test to those who Improved and Transferred

Predictor	Successful on Pre-test Mean (SD)	Improved and Transferred Mean (SD)
Age (in months)	63.30 (5.16)	62.33 (4.29)
Detection of Ambiguity	.19 (.21)	.17 (.17)
Executive Function	.46 (.76)	.27 (.68)
PPVT-III	86.30 (17.66)	84.47 (12.17)

Note. Detection of Ambiguity statistics are reported post-transformation, therefore lower scores indicate better performance.

Discussion

In Study Two I investigated children's ability to create legends, whether this ability improved after exposure to effective legends, and the role of two underlying cognitive skills in performance (and changes in performance). My first three hypotheses predicted that children's performance on the pre-test of the Legend Creation Task would relate to other factors. In support of Hypotheses One and Two, I found that children who were Successful on the pre-test were older and better able to detect ambiguity than those who were Unsuccessful. However, I failed to find support for my third hypothesis, which was that children who were Successful on the pre-test would have better Executive Function than those who were Unsuccessful.

The effect of age for children's creation of legends is consistent with other research (Callaghan, 1999; Eskritt & Olson, 2012), and speaks to the development of the ability, with children's becoming more skilled at making effective legends between 4 and 5 years of age. Although most children were recruited from junior and senior Kindergarten classrooms, some participants were recruited from daycares and may have been in Grade One. The differences in participants' grades could contribute to the effect of age, with children in higher grades having more experience/exposure to symbols through literacy and numeracy activities. As a result of this experience, these children could have greater symbolic understanding and therefore better performance on the Legend Creation Task. However, this data was not collected at the time of testing and is not able to be retrieved; therefore, it is not possible to test for this possibility.

Another possible explanation is that specific skills (presumably correlated with age) are driving this effect. A more novel, and interesting, finding is that Detection of Ambiguity *uniquely* relates to children's ability to produce legends, above and beyond the effect of age. This indicates that sensitivity to whether information is clearly conveyed plays a role in children's ability create a legend that conveys the symbol-referent relations in such a way that the intended interpretation is made clear. This finding is consistent with previous, related, work.

Myers and Liben (2012) also report that children's ability to detect ambiguity relates to their ability to communicate symbol meanings; however, they found that this was only the case when the symbols were iconicly, and not arbitrarily, related to their referents. They interpret this as evidence that detection of ambiguity is required only for iconic symbols, arguing that it is only iconic symbols (with other possible referents that match, but are in fact not the intended ones) that require sensitivity to the possibility that someone else may interpret the symbol in a different way. As outlined in Study One (see p. 37), I argue that arbitrary symbols also lend themselves to multiple interpretations. Without the salient alternative, there is not an obvious incorrect interpretation to be considered, and there is in fact an even broader range of alternative interpretations to be taken into account. My finding that Detection of Ambiguity relates to children's ability to convey the relations between arbitrarily-related symbol-referent pairs serves as evidence that this type of symbol communication also relies on the ability to recognize when something is open to other, incorrect interpretations.

The finding that Executive Function did not relate to children's performance on the pre-test of the Legend Creation Task, contrary to Hypothesis Three, was a surprising one. Given the demands of the task (as outlined in Chapter Three), it would appear that Inhibitory Control, Working Memory, and Planning ability would facilitate success on the task. However, my results demonstrate that Executive Function, as measured in this study, does not relate to performance once the other variables are taken into account. Therefore, although Executive Function may be an important underlying skill for understanding representations like DeLoache's scale model (Walker & Murachver, 2012), or for evaluation of legends (Study One), it does not uniquely relate to children's creation of legends. This pattern suggests that children's creation of legends does not make the same Executive Function demands as the other discussed measures of symbolic understanding. Therefore, it is possible that there is something specific about legend creation, in contrast to legend evaluation, that does not require Executive Function above and beyond other cognitive skills.

Another possible explanation for this finding (or lack thereof) could be the rapid development of Executive Function during the age range investigated, as demonstrated by a significant correlation with age in months, $r = .47$, $p < .001$. As suggested when addressing the assumptions for the main analysis, this significant correlation results in multicollinearity, which decreases power and increases the risk of Type-II error. To further investigate the overlap between age and Executive Function, a Principal Components Analysis was conducted examining the two variables. A single underlying component was extracted, which accounts for 73.6% of the variance. As such, the variables are highly redundant and therefore it is not a surprise that the contribution made by Executive Function ability is not significant above and beyond the effect of age.

Future research should continue to consider the possible role of Executive Function and investigate the role of Executive Function in a more targeted way. The unitary approach to the Executive Function construct, taken in this study, involved a single measure of each Executive Function component and therefore limited a thorough investigation of the individual contributions. So, although the common component extracted from my measures of Inhibitory Control, Working Memory, and Planning was not significant, a targeted investigation of each of these aspects of Executive Function might yield different results, and perhaps pinpoint an Executive Function skill that is relevant.

To investigate whether the present data would suggest if this could be the case, the individual Executive Function measures were included in a Discriminant Function Analysis alongside age, Detection of Ambiguity, and PPVT-III. The function was significant ($p < .001$) and standardized coefficient for phonological Working Memory (.50) was above the .33 cut-off, suggesting that it made a unique contribution to the discriminant function, with Detection of Ambiguity (-.37) still making a unique contribution, and would therefore would merit further investigation in future research. None of the other Executive Function measures met the criteria for making an important contribution once all other variables were taken into account.

Based on the use of only a single measure of phonological Working Memory, the poor reliability of the measure used, and the post-hoc exploration of the data, the relation between phonological Working Memory and children's creation of legends should be interpreted with caution; at best, it is suggestive. However, this does provide a basis for future research to specifically target phonological Working Memory and investigate the relation with children's ability to create effective legends.

My fourth hypothesis was that exposure to effective legends would help children who initially made ineffective legends improve on subsequent productions. In support of this hypothesis, I found that almost half (49%) of the children who were exposed to effective legends went from being ineffective to effective legend creators on the first post-test, while only 9% of the children not exposed did so. This improvement is impressive given that children were not explicitly trained, nor directed to use the strategy presented, but rather were only *briefly* exposed to two effective legends, with the symbol-referent pairings pointed out (the entire exposure experience only lasted about 1-2 minutes). The fact that only three children (9%) improved on the first post-test without such exposure (i.e., in the baseline condition), it is evident that the improvement demonstrated in the exposure condition is not due to practice gained by having a second attempt at creating a legend. There was the possibility, however, that the improvement was the result of children re-creating the legends presented to them in the exposure condition (and not necessarily of an increased awareness of how to effectively convey symbol-referent pairs). However, this possibility was tested using a second post-test, in which children's legends were based on a novel set of stimuli, ones for which no legend had been shown. Given that most of the children who improved following exposure went on to create effective legends with the new materials (88% transferred to the new stimuli), we can be confident that children's legends improved not because they were simply recreating (replicating) the specific legends that they had been shown, but because they better understood what to include in their legends and/or how to include it.

Eskritt and McLeod (2008) found even greater levels of post-training success with their older participants: 73% in their second study and 61% in their third. Their greater rates of success, compared to the 49% of the children who improved in my study, could be for multiple reasons. While it is important to note that they used a different task, with an older age group, one explanation for this difference could be their use of explicit instruction to the children. In their task, an experimenter explicitly demonstrated a strategy and specifically instructed the participants to use that strategy when making notes. My exposure condition, however, did not introduce the effective legends as examples for the children to follow. Rather, they were presented by asking children whether or not they would be helpful so that children would have the opportunity to reflect on whether to not each one was effective, followed by an explicit description of what made them effective. As such, this may have resulted in fewer children deciding to alter the way in which they conveyed symbol-referent pairs based on what they had just seen. Future research could test this possibility by employing additional support (as done in Eskritt and McLeod), as a third condition, with the age group examined in this thesis. By adding such a condition to my Legend Creation task, it could be determined if this age group could do better still, with the use of more explicit training. Such an investigation could also include measures of Detection of Ambiguity and Executive Function (with multiple measures of the constituent skills) to further explore how these skills may relate to children's ability to learn from this kind of experience.

In support of my fifth hypothesis, I was able to demonstrate that Detection of Ambiguity related to children's improvement following exposure, for both performance using the same set of stimuli and performance using a new set (i.e., both post-tests). The unique importance of Detection of Ambiguity adds to Myers and Liben's research, and extends beyond their evidence for the role of ambiguity detection for children's communication of symbol meanings (Myers & Liben, 2012). Specifically, my findings indicate that Detection of Ambiguity not only relates to children's ability to create effective legends spontaneously, but also relates to their ability to improve following exposure to effective legends. This supports my expectation that the ability to detect ambiguity plays an important role in children's ability to use what they learn from exposure when creating legends of their own. Based on this finding, I would argue that Detection of Ambiguity ability would relate to children's ability to improve from minimal experience or training on other symbolic tasks as well. I would expect that those children who improved from Eskritt and McLeod's (2008) training, as well as those who improved from experience with another's drawings in Callaghan's (1999) task, are better able to detect ambiguity than those who continued to be unsuccessful.

This research has important implications for educators, as it helps identify which children will more easily learn from this kind of experience when conveying the meanings of symbols. In doing so, assistance to ineffective legend creators can be tailored based on their ability to detect ambiguity. Children who are better able to detect ambiguity may be able to convey symbol meanings following exposure an effective example, however those with poor ambiguity detection and may require additional support in developing that skill, which will then facilitate their ability to learn from exposure.

Interestingly, the children who made effective legends on the pre-test and those who did so after exposure, were not different in terms of Detection of Ambiguity or any other predictors included in the investigation. Furthermore, similar proportions of children made categorical legends (66% of the spontaneous legend creators and 67% of those who improved), further indicating the similarity between the groups. This finding aligns with Eskritt and McLeod (2008), who found that the quality of notations produced by children who improved following training was not different from the quality of notations made by children who produce them spontaneously (without training). The authors interpret this finding as evidence that the children who do not initially produce functional notes simply lack the knowledge, but not the skill, of what to include or how to do so, and once that is demonstrated to them, they are able to produce high quality notes. Those children who made non-mnemonic notations, but then improved following training, may have had the skill for producing functional notations but did not know how to use it until they underwent the training. If this was the case, it is not surprising that these children were not significantly different from those who produced functional notes on the pre-test. Similarly, participants in my research who improved following exposure may have had the necessary ability to create effective legends, but needed a small level of support to apply that ability. Given this interpretation, the similarities between these children and the children who were able to create effective legends on the pre-test are not surprising.

Based on the present data, it remains unknown what differentiates those who are spontaneously successful from those who require exposure to effective examples. The present research was unable address this question, and therefore future research should aim to explore other variables that were not included in the present investigation (such as experience with legends) to determine what accounts for the difference in Legend Task performance between these two groups.

My sixth and final hypothesis was that Executive Function would relate to children's ability to improve on the Legend Creation Task following exposure. As was the case with performance on the pre-test, I did not find support for a role of Executive Function. Once again, however, age was correlated with performance and may have masked any relation with Executive Function. Another possible explanation for the lack of a relation with Executive Function, as mentioned above, could be the encompassing approach to the construct and not a targeted investigation of specific Executive Function skills, which may have individually played an important role. Once again, it is also possible that legend creation simply does not make Executive Function demands above and beyond other cognitive skills.

In addition to the planned analysis, I examined potential group differences between the categorical- and the redundant-legend creators on the pre-test. Given that children who created categorical legends were able to abstract the relevant information needed to convey the symbol-referent pairs, it was possible they were more advanced in terms of other cognitive skills, as compared to those children who made redundant legends (by depicting all of the information in front of them). There was no evidence of significant differences of age, Detection of Ambiguity, Executive Function, or PPVT-III; however, the groups were small. So, although the children who made redundant legends were *inefficient* by conveying more detail than was required, they were not otherwise different from their peers who made more efficient legends. Choice between the two strategies for creating effective legends may depend on personal preference, or perhaps other cognitive skills not examined here. However, based on the present data, there is no evidence that children who select one strategy are different from those who select the other. This is interesting because as adults we might argue that children who are able to abstract the symbol-referent relation and convey only the pairs are those who have created the 'better' legend, yet the alternative is undeniably correct (albeit unnecessarily laborious). Future research should investigate children's evaluations of these two types of legends to examine differences in their opinions of what counts as correct, and differences in which type of legend is deemed to be 'better'.

Although the present study sheds new insight on children's ability to create effective legends, as well the cognitive skills that relate this ability and the role of exposure for improving performance, it is not without its limitations. My research demonstrated a significant effect of exposure on children's legend creations, however 51% of children were still not successful even after seeing the effective legends created by the experimenter. Given the proportion of children who did not improve from the exposure to effective legends, future research aiming to improve children's legend creations should be more explicit in instructions and feedback on the children's performance. One method of doing so would be to employ Eskritt and McLeod's (2008) approach in which the production strategy is demonstrated and children are clearly told to use that strategy in their own notations.

Also of interest for future research would be whether the benefits of the exposure used in my study were long-lived. To test this, the children would need to be followed up after some time had elapsed (e.g., 4 weeks) to determine whether those who had improved following exposure would still produce effective legends on the task (with new stimuli). Yet another question would be about the transfer of the improvement, and how far reaching it really is. Children who improved in my study demonstrated considerable success transferring to a new task, however the task was identical in structure to the task for which they saw effective legends. Therefore, in a possible extension to this research, children could then be presented with a conceptually different task (such as Myers & Liben's, 2008, make-a-map task wherein children attempted to convey the locations of toys in a room using stickers on a map, as described on pages 10-11) to see if they continued to create effective legends. Once again, it would be important to consider the cognitive skills of interest to examine whether they differ between those who do, and do not, maintain improvement.

Another possibility for future research is to investigate whether exposure to *ineffective* legends has a similar impact on children's performance. Perhaps if a child is presented with an ambiguous legend to *use* when completing a task (e.g., a legend that underspecifies its referent), she or he may gain insight into the fact that the intended referent is unclear. I predict that some children will recognize the legend is unclear and then take that into account when making their own legends in the future, thereby demonstrating improvement from this alternate form of exposure. As was the case with exposure to effective legends, children likely require sensitivity to ambiguity to learn from exposure to ineffective legends as well. Robinson and Robinson (1977) found that 5- and 6-year-olds often fail to see underspecified information as ambiguous when the communication happens to be interpreted as it was intended. As such, it seems as though children who do not have the ability to detect ambiguity, would incorrectly assume their interpretation of an ambiguous legend is the correct one, and as a result not benefit from exposure to this kind of legend without explicit and detailed training. This, however, is an open question and perhaps one for future researchers to consider.

Another limitation of the current research was the possibility that some children may have not fully understood the task, which may have caused them to make ineffective legends. Of the children who made ineffective legends on the pre-test (n = 70), 29 drew only the cards that belonged inside. It was possible that some of these children may have believed the boxes would not be moved, and that the unknowing other would be able to put the cards back into the correct boxes just by following the drawn order. To consider whether this was the case, I examined the performance of children who drew only the cards (contents), and who were then assigned to the baseline condition (n = 15). If these children's legends improved after having seen the boxes get moved between trials, then that would indicate support for this possible misinterpretation. Of the 15 children, only three improved, while six continued to draw the cards, four switched to drawing only the boxes, and two drew partial and/or unorganized legends. Thus, this interpretation is unlikely.

Overall, Study Two has found evidence for children's ability to create informative legends and, when unable to do so, their ability to improve following exposure to effective examples. Furthermore, this work highlights how children's ability to detect when information is ambiguous plays an important role in both their ability to create legends and their ability to improve following exposure. In conjunction with Study One, these results speak to children's developing understanding of what makes an effective legend. The concluding chapter of this thesis (Chapter Six) considers the contribution of both studies, and will address what Studies One and Two, taken together, tell us about children's emerging understanding of informative legends.

Chapter Six: General Discussion

Symbols are created with the intention to represent something, however, in order for someone to accurately interpret a symbol, the intended meaning must be conveyed in some way (Myers & Liben, 2012). In both of my studies, I investigated children's understanding of how the meanings of symbols are effectively conveyed. This was achieved by examining children's ability to evaluate legends (Study One) and create legends (Study Two). Legends were the ideal tool for this investigation given their simple format and explicit pairing of symbols with their intended referents. Across the two studies, I address three major goals. These were to investigate (1) children's developing understanding of what makes an effective legend; (2) cognitive skills that are related to children's evaluation and creation of legends; and (3) the effect of exposure on children's ability to create an informative legend.

Study One investigated children's ability to accurately evaluate effective and ineffective legends, and the skills that relate to their success. While it was clear from other work that 6- to 9-year-olds recognize the need for a legend (Myers & Liben, 2012), this was the first study to examine children's ability to identify various types of legends as effective or ineffective, and it involved younger children than previously examined. Further, previous research suggests that children's symbolic understanding is related to other cognitive skills (Apperly & Carroll, 2009; Carlson et al., 2005; Myers & Liben, 2012; Walker & Murachver, 2012), but this was the first study to specifically investigate the relations between these skills and children's understanding of informative legends.

The findings presented in Study One provide clear evidence for the unique relations between cognitive skills and children's ability to evaluate effective and ineffective legends. One, the ability to detect ambiguity, demonstrates the importance of being able to detect when something is unclear (and therefore open to other, incorrect, interpretations), when considering whether or not a legend effectively conveys the symbol-referent pairs. The second skill, Executive Function also uniquely relates to children's success when evaluating legends. Based on this finding, we know that a cognitive component common to the ability to hold information in mind, inhibit a prepotent response, and plan ahead, relates to accuracy when identifying legends as helpful or unhelpful. However, this finding does not speak to the specific Executive Function skills and the contributions each of them make, independent of the others. Study Two also investigated Detection of Ambiguity and Executive Function to examine their importance to children's ability to create informative legends, as well as their relation to whether or not children's performance improved following exposure to effective examples. Findings from this second study implicated Detection of Ambiguity as being uniquely related to children's ability to effectively convey symbol-referent relations via a legend, as well as their ability to improve following exposure. In contrast with Study One, Executive Function (as an overarching construct) was not related to performance either before or after exposure, once other variables were taken into account. One possible explanation for the inconsistent findings with regards to Executive Function in the two studies has to do with the difference in the extraction values of the two independently calculated principal components. Recall that for each study, a Principal Components Analysis was used to derive a common Executive Function factor score. In Study One, the measures of Planning ability (Truck Loading task) and visuo-spatial Working Memory (Corsi Span) had the strongest loadings on the factor score. In Study

Two, the strongest loadings were more evenly distributed across Planning (Truck Loading) and both types of Working Memory (phonological and visuo-spatial, as measured using the Backward Word and Corsi Spans, respectively). This speaks to differences in variability in performance on the Executive Function tasks across the two studies, which resulted in the derived components being differentially representative of the Executive Function skill set. While some of this difference could be due to the slight differences in the age range of the participants (with Study 1 including young 6-year-olds and Study 2 limited to only 4- and 5-year-olds), other differences are likely due to error. The differences in the two derived Executive Function scores may have contributed to the difference in the findings and the lack of relation between Executive Function and legend creation.

Another possible explanation for the lack of relation between Executive Function and children's performance on the Legend Creation Task, as discussed in Chapter Five, is that age may have masked the relations with Executive Function ability. Prior to ruling out Executive Function as a contributing factor, a more thorough look at each of the constituent Executive Function components would be required. Based on an exploratory look at individual components in present the data, there is suggestive evidence meriting a closer examination of the role of phonological Working Memory. This investigation is a recommended next step for future research, as it would help better inform researchers and educators as to what demands children are faced with when attempting to convey the meanings of symbols.

Based on my findings from Study One and Study Two, it is clear that children's ability to detect ambiguity plays an important role in their understanding of what makes an effective legend. This common skill, which relates to children's performance on both evaluation and production tasks, may explain the similarities in children's performance on representational understanding and production tasks, as found by Callaghan (1999). A direction for future research is to investigate children's symbolic understanding and production, alongside measures of Detection of Ambiguity. Provided this research replicates the relation found by Callaghan, it would then allow for an investigation of whether the relation between understanding and production is significant above and beyond the contribution of Detection of Ambiguity. Such research would be informative, as it would address the question of whether success on both types of tasks may be driven by some other cognitive skill that facilitates both understanding and production.

An additional goal of Study Two was to investigate whether exposure to effective legends could help children improve the legends they create themselves. Findings from this study provide evidence that children who initially create ineffective legends can improve following exposure. Importantly, the results indicate that the improvement demonstrated was not simply the result of practice (as evidenced by the relative lack of improvement in the baseline condition), and that children were not simply re-creating the legends they had seen in the exposure condition, because most of the children who improved went on to transfer to novel set of stimuli. This research indicates that brief exposure to effective legends can help children realize what needs to be included in the legends they create themselves. This provides support for Eskritt and McLeod's (2008) claim that children may know how to use representations, but be unaware of what to include in the representations they create. This awareness can be achieved through direct feedback (Callaghan, 1999), explicit training (Eskritt & McLeod, 2008), or exposure to effective examples (Study Two).

Although my second study indicates that exposure to effective legends can improve children's ability to create one themselves, it does not suggest that exposure is sufficient. While children who received exposure to effective legends were significantly more successful than those who did not receive such exposure, only about half of them went on to create effective legends. Although this rate of success yielded variability, which allowed for an investigation of cognitive skills that relate to improvement following exposure, exposure is clearly not able, on its own, to improve all children's understanding of what an effective legend looks like. A more explicit method, such Eskritt and McLeod's (2008) training, may result in greater success. However, it is possible that there is no method that would, by itself, guarantee improvement in the age group of interest, because success is likely, at least in part, to depend on the cognitive skills children bring to the task.

Eskritt and McLeod reported greater rates of success following their training paradigm, which was more explicit and instructive than the one here. However, given the differences in tasks and the age of the participants, it not possible to directly extrapolate from their findings and make comparisons to my study. As such, future research should conduct a tiered investigation including my two conditions (baseline and exposure) alongside a more explicit training condition (like the one used by Eskritt & McLeod) to examine the relative contributions of each approach. Differences in Detection of Ambiguity and specific aspects of Executive Function would also be important for consideration when interpreting differences that results from the different conditions. An interesting finding would be that explicit training resulted in even greater rates of success than exposure, with evidence for Detection of Ambiguity and Executive Function differing as a function of whether or not children improve from the training. Given the nature of the different conditions, with variation in the degree of support/intervention, it would be particularly interesting if the cognitive skills differed between participants succeeding at each of the various levels.

The exposure used in the present study was found to be successful in improving the legends created by many of the previously-unsuccessful participants. A limitation, however, is that the duration of the improvement is unknown. Furthermore, it is unknown whether the improvement and transfer demonstrated on the Legend Creation Task would transfer to a more distant task. Investigations of both the lasting effects and the possibility of further transfer of the exposure would speak to the robustness of this important finding from Study Two, and therefore should be an area of focus for future research.

Although there are remaining questions to be addressed in future research, the two studies presented here provide important insight on children's developing understanding of how symbolic relations are effectively conveyed. In addition, the results of this research speak to children's symbolic understanding at a broader level, and can be used to guide future research questions. For example, literacy, pretend play, and verbal skill development are other areas of cognitive development involving symbolic understanding, which may implicate Detection of Ambiguity and Executive Function as contributing factors. Furthermore, based on the current findings, experience/exposure may play an important role in children's development in these and other related areas.

Based on the current findings, I predict that Detection of Ambiguity and Executive Function, as well as experience with symbols, would also relate to these other forms symbolic understanding. It is important to note, however, that these findings, both for my study and speculations regarding other kinds of symbolic awareness, would not be expected universally. Callaghan, Rochat, and Corbit (2012) found that a Canadian sample of 3- to 5-year-olds performed better than their Indian and Peruvian peers on tasks involving pictorial symbols. Children in the Indian and Peruvian settings had very little prior experience with pictures, as compared to their Canadian counterparts, which was interpreted by the authors as accounting for differences in performance. The authors interpret their findings to mean that children's explicit knowledge of pictorial symbols as functional representations develops more rapidly in cultures that encourage the use of pictures as symbols at young age. This research emphasizes the importance of exposure to symbols, but also suggests that the findings from my research are presumably limited to children in a Canadian context (with similar levels of experience using symbols).

Based on the current findings, we have evidence for Detection of Ambiguity and Execute Function as factors that uniquely relate to legend evaluation, and Detection of Ambiguity and Age as factors that uniquely relate to legend creation. These findings speak to the importance of some specific cognitive skills for children's understanding of what an informative legend should include. In addition, we have evidence that experience gained through exposure can help children better understand how to convey symbolic relations. Taken together, this research helps identify factors that relate to children's understanding of how to effectively convey symbol-referent relations.

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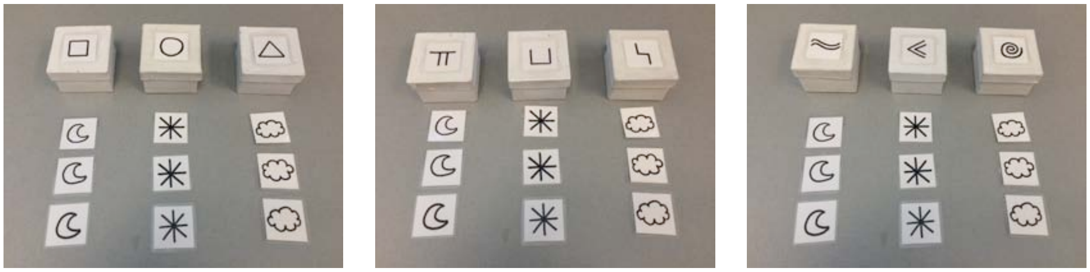
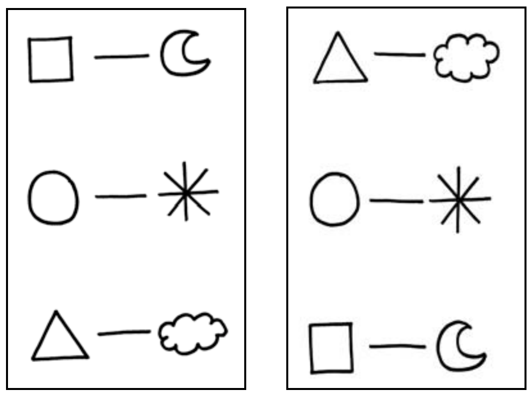
Appendix A: Legend Evaluation Task Stimuli

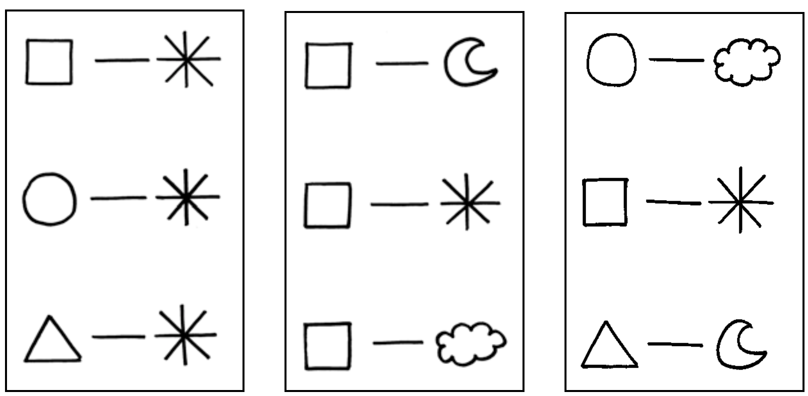
Photos of the three sets of boxes and cards used in the task:



Corresponding effective legends (examples based on the first set shown above):



Corresponding ineffective legends:



Appendix B: Daycare Program Coordinator Consent Form

Carleton UNIVERSITY
Canada's Capital University

Children's Representational Development Lab

Fall 2013
Dear Program Coordinator,

As part of a current project on children's cognitive development, we are talking to children to learn about their understanding of how symbols work. The study has been approved by the Carleton University Ethics Committee for Psychological Research and it involves no physical or psychological risks for the children who take part. In this letter, we will describe the project and request your permission for your centre's participation.

Should you wish to participate in the current project, we will provide you with individual informed consent letters to distribute to the parent(s) or guardian(s) of each child within this age range in your centre. Once consent letters have been returned to you from parents, we will arrange a convenient time for you to have one of our researchers at your center to conduct the study. The researchers are university students with current police record checks, and they will be sensitive to the children at all times.

Children will participate in a number of games. For example, in one game, children will be shown legends and asked if those legends would be helpful to put items back where they belong. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they decide to stop playing part-way through).

We will meet with each child twice, approximately 25 minutes each time. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. Children can stop playing at any time during the session.

The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses, and the information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. The consent form will be kept separate from the data in a secure environment and will be destroyed after 2 years.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi_kamawar@carleton.ca. The primary researcher involved in this project is Andrea Astle, M.A. and she can be reached at 613-520-2600, ext. 2885 or andrea_astle@carleton.ca. If you have any ethical concerns about this study, please contact Dr. Shelley Brown (Chair, Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1505). The ethics protocol number for this study is 13-018. Should you have any other concerns about this study, please contact Dr. Anne Bowker (Chair, Dept. of Psychology, 613-520-2600 ext. 8218).

Your consent is required for your centre's participation in this project. Kindly sign the attached consent form indicating whether we may provide you with individual consent forms for parents of children within this age range in your centre. If you would like a summary of the research results once the study is completed, please contact Andrea Astle. However, please note that individual feedback regarding the children cannot be provided.

Thank you for your consideration.
Sincerely,

Deepthi Kamawar, PhD

Appendix B Continued

Carleton University Symbol Study

Carleton UNIVERSITY
Canada's Capital University

I have read the attached description of the study on cognitive development and I understand the conditions of my centre's participation.

We understand that the study will require two 25 minute testing sessions, with children of appropriate ages, whose parents/guardians have given written consent for their children's participation in the research project. We will also allow the children to familiarize themselves with the researchers during preliminary activities.

Name of Centre: ____

Address: ____

____

Signature: __________________________________ Date: _________________________

Name & Title: ___________________________________

Appendix C: Parent/Guardian Consent Form

Carleton UNIVERSITY
Canada's Capital University

Children's Representational Development Lab

Fall 2013
Dear parent(s) or guardian(s),

As part of a current project on children's cognitive development, we are talking to children to learn about their understanding of how symbols work. The study has been approved by the Carleton University Ethics Committee for Psychological Research and it involves no physical or psychological risks for the children who take part in it. In this letter, we will describe the project and request your permission for your child to participate. The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your child's involvement.

Children will participate in a number of games. For example, in one game, children will be shown legends and asked if those legends would be helpful to put items back where they belong. Children usually enjoy these kinds of activities and will be given stickers as thanks (even if they decide to stop playing part-way through). All games will be played with university students with current police record checks, and they will be sensitive to the children at all times.

We will meet with each child twice, approximately 25 minutes each time. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. Children can stop playing at any time during the sessions. The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses, and the information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. The consent form will be kept separate from the data in a secure environment and will be destroyed after 2 years.

Should you wish to participate in future research, any contact information provided along with the names and birth dates of your child and other children in the family, will be kept in a password protected database and will only be available to researchers in our lab. Once your children are older than twelve years, their information will be removed from our database. Future participation is completely voluntary and you can ask to be removed from our database at any time.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi_kamawar@carleton.ca. The primary researcher involved in this project is Andrea Astle, M.A. and she can be reached at 613-520-2600, ext. 2885 or andrea_astle@carleton.ca. If you have any ethical concerns about this study, please contact Dr. Shelley Brown (Chair, Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1505). The ethics protocol number for this study is 13-018. Should you have any other concerns about this study, please contact Dr. Anne Bowker (Chair, Dept. of Psychology, 613-520-2600 ext. 8218).

Your consent is required for your child's participation in this project. Kindly sign the attached consent form indicating whether your child may participate in this research and return it to your child's daycare. If you would like a summary of the research results once the study is completed, please contact Andrea Astle. However, please note that individual feedback regarding the children cannot be provided.

Thank you for your consideration.
Sincerely,

Deepthi Kamawar, PhD

Appendix C Continued

Carleton University Symbol Study

Carleton UNIVERSITY
Canada's Capital University

I have read the attached description of the study on cognitive development (understanding symbols) and I understand the conditions of my child's participation. My signature indicates that I agree to let my child participate in the study.

Child's Name: ____

Child's Date of Birth: Year 200___ Month ________ Day ________

Parent's/Guardian's Name: ________________________________

Signature: ____________________________ Date: ____________

Please indicate the language(s) spoken at home and then please circle the ones that your child is

fluent in: ______________ _______________ ______________

In our lab we conduct many other studies that children find quite enjoyable (usually in the form of games and stories). We provide free parking and a small 'thank-you' gift to the children.

May we contact you again in the future to see if you are interested in having your child participate in other projects? All participation would be completely voluntary and you would be under no obligation to participate if we contact you.

____ Yes If yes, please provide phone number or email: __________________________

____ No

Other Children in the family:

Child's Name: ____________________________________

Date of Birth: year _______ month ________ day ________

Child's Name: ____________________________________

Date of Birth: year _______ month ________ day ________

Child's Name: ____________________________________

Date of Birth: year _______ month ________ day ________

Appendix D: Thank-You Letter (debriefing)

Carleton
UNIVERSITY
Canada's Capital University

Children's Representational Development Lab

Fall 2013
Dear Parent(s) or Guardian(s),

Earlier this year we contacted you to invite your child to participate in our study on how children understand symbols. Thank you for agreeing to allow your child to participate – we had a lot of fun!

The purpose of our current research program is to gain a better understanding of how children come to that one thing can serve as a representation for another. For example, how legends are used. This understanding is an important one because it helps children become effective symbol-users.

We played a game with your child, where they had the opportunity to look at some legends and decide if they were effective in conveying specific information. In addition to having a great time, the participation of your child in this project has provided us with data on how and when children begin to understand that legends can help us keep track of things we normally wouldn't be able to remember. We are very excited to start investigating the results of our study.

For more information about our findings, or for a summary of the project once it is complete, please contact Andrea Astle by email at andrea_astle@carleton.ca.

If you have any ethical concerns about this study, please contact Dr. Shelley Brown (Chair, Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1505). The ethics protocol number for this study is 13-018. Should you have any other concerns about this study, please contact Dr. Anne Bowker (Chair, Dept. of Psychology, 613-520-2600 ext. 8218).

The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses, and the information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. We cannot provide any information about an individual child, only about the study as a whole. If you have any concerns about any aspect of your child's development, we suggest that you consult with your family doctor or pediatricians.

If you would like to participate in future projects in our lab at Carleton University, please contact us at the Children's Representational Development Lab by email at crdl@carleton.ca or by phone at 613-520-2600 ext. 2885.

Thank you,

Deepthi Kamawar, PhD

Appendix E: Legend Evaluation Task Protocol

SET A

Legend Evaluation Task

Shape Check (only for Trial 1): **See these shapes? Can you show me the MOON?...CLOUD?... STAR?...**
(randomize; indicate accuracy below; repeat max 3x)

MOON________ CLOUD ________ STAR ________

SET A *[Take out boxes with line symbols]*
See these boxes? They each have something on top, and they each have shapes inside. I have three different boxes. Each box goes with a different kind of shape. See this box? It has moons inside. Let's put them here so that we remember moons belong in this box *(set out in front).* **Here is another box; it has stars inside. Let's put them here so that we remember stars belong in this box** *(set out in front).* **Here is another box; it has clouds inside. Let's put them here so that we remember clouds belong in this box** *(set out in front).*

We are taking these shapes out so we can look at them. Later on, someone else has to put the shapes away. She has never seen these boxes before. She doesn't know what shape goes inside each box. But, she will need to put the shapes back in the right boxes. Your job is look at some things I brought, and tell me if they will help her put the shapes away.

[Point to effective top-to-bottom legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to other/incorrect legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to repetitive symbol legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to effective bottom-to-top legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to repetitive referent legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

Appendix E Continued

SET B

Legend Evaluation Task

Shape Check (only for Trial 1): **See these shapes? Can you show me the MOON?...CLOUD?... STAR?...**
(randomize; indicate accuracy below; repeat max 3x)

MOON________ CLOUD ________ STAR ________

SET B *[Take out new boxes with double-lined symbols]*
See these boxes? They each have something on top, and they each have shapes inside. I have three different boxes. Each box goes with a different kind of shape. See this box? It has moons inside. Let's put them here so that we remember moons belong in this box *(set out in front).* **Here is another box; it has stars inside. Let's put them here so that we remember stars belong in this box** *(set out in front).* **Here is another box; it has clouds inside. Let's put them here so that we remember clouds belong in this box** *(set out in front).*

We are taking these shapes out so we can look at them. Later on, someone else has to put the shapes away. She has never seen these boxes before. She doesn't know what shape goes inside each box. But, she will need to put the shapes back in the right boxes. Your job is look at some things I brought, and tell me if they will help her put the shapes away.

[Point to repetitive referent legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to effective top-to-bottom legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to repetitive symbol legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to other/incorrect legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to effective bottom-to-top legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

Appendix E Continued

SET C

Legend Evaluation Task

Shape Check (only for Trial 1): **See these shapes? Can you show me the MOON?...CLOUD?... STAR?...**
(randomize; indicate accuracy below; repeat max 3x)

MOON________ CLOUD ________ STAR ________

SET C *[Take out new boxes with geometric shapes]*
See these boxes? They each have something on top, and they each have shapes inside. I have three different boxes. Each box goes with a different kind of shape. See this box? It has moons inside. Let's put them here so that we remember moons belong in this box *(set out in front).* **Here is another box; it has stars inside. Let's put them here so that we remember stars belong in this box** *(set out in front).* **Here is another box; it has clouds inside. Let's put them here so that we remember clouds belong in this box** *(set out in front).*

We are taking these shapes out so we can look at them. Later on, someone else has to put the shapes away. She has never seen these boxes before. She doesn't know what shape goes inside each box. But, she will need to put the shapes back in the right boxes. Your job is look at some things I brought, and tell me if they will help her put the shapes away.

[Point to repetitive symbol legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to effective top-to-bottom legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to repetitive referent legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to effective bottom-to-top legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

[Point to other/incorrect legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N

Appendix F: Droodle Protocol

DROODLE TASK

<u>Trial 1</u>

Show uncovered picture of bicycle.
I've got a picture here – I would like you to look at it. What is this a picture of?
Circle response below:

Correct: bicycle Incorrect: _______________

If correct:
You're right! It's a bicycle!
If incorrect:
Good try! But it's a bicycle! So what is this a picture of?

Correct: bicycle Incorrect: _______________
Repeat 2x and continue to test trials.

Cover picture so only small section visible.
Introduce Wendy.
Now this is Wendy, she has never seen this picture before. She can only see this *(point to visible section).* **Does Wendy know this** *(hold up entire page)* **is a bicycle?"**
Circle response below:

YES <u>NO</u>

Remove Wendy.

<u>Trial 2</u>

Show uncovered picture of giraffe.
Now I have another picture! I would like you to look at it. What is this a picture of?
Circle response below:

Correct: giraffe Incorrect: _______________

If correct:
You're right! It's a giraffe!
If incorrect:
Good try! But it's a giraffe! So what is this a picture of?

Correct: giraffe Incorrect: _______________
Repeat 2x and continue to test trials.

Appendix F Continued

DROODLE TASK CONTINUED

Cover picture so only small section visible.
Bring out Wendy.
Remember Wendy? She has never seen this picture before. She can only see this *(point to visible section).* **Does Wendy know this** *(hold up entire page)* **is a giraffe?"**
Circle response below:

YES NO

Remove Wendy.

Trial 3

Show uncovered picture of a clock.
Now I have another picture! I would like you to look at it. What is this a picture of?
Circle response below:

Correct: clock Incorrect: _______________

If correct:
You're right! It's a clock!
If incorrect:
Good try! But it's a clock! So what is this a picture of?

Correct: clock Incorrect: _______________
Repeat 2x and continue to test trials.

Cover picture so only small section visible.
Bring out Wendy.
Remember Wendy? She has never seen this picture before. She can only see this *(point to visible section).* **Does Wendy know this** *(hold up entire page)* **is a clock?"**

Circle response below:

YES NO

Remove Wendy.

Appendix G: Ambiguous Messages Protocol

Version A

AMBIGUOUS MESSAGES

Size/Colour check:
Let's look at these cups! I have big ones and little ones, in different colours.
Can you show me a big one?_____ And a little one?______
Now let's look at these ones! Can you show me one that is:

Purple_____ Red_____ Blue_____ Orange_____ Green_____ Yellow_____
If incorrect, provide feedback and repeat up to 2x. Continue to trials.

Set up:
Monkey at same side of table as child, with divider in between. Little blue and orange cups placed upside-down on child's side of the divider. E and dog puppet at other side of the table.

This is Spot *(make puppet wave).* **And this is Chester** *(move monkey up and down).* **In this game, I'm going to hide this ball** *(show pom pom ball)* **under one the cups. Chester can't see the cups, because this is in the way** *(point to divider).* **Come over here** *(tap table)* **so that you can see what Chester sees! When you look from here, you can't see the cups** *(once child has seen, have them go back to their seat).*

Check questions: *(Divider in place)*
So can Chester see the cups? *(motion over cups).*

[yes] [no]

If correct: **You're right! Chester can't see the cups** *(motion over cups)*.
If incorrect: **Good try, but Chester can't see the cups** *(motion over cups),* **because this is in the way** *(point to divider). Repeat question up to 2x.*

But, you know what? Spot can see the cups. So he's going to watch, and then he'll give Chester a clue about where the ball is hidden. Sometimes Spot will give a *good* clue. Good clues make it easy to find the ball. Sometimes Spot will give a *not-so-good* clue. Not-so-good clues *don't* make it easy to find the ball. Your job is to listen to the clue, and then point to where Chester will look for the ball. Do you understand? Ok!

Comprehension questions:
If a clue makes it easy to find the ball, is it a good clue or a not-so-good clue?

[good] [not-so-good]

If a clue does *not* make it easy to find the ball, is it a good clue or a not-so-good clue?

[good] [not-so-good]

Provide feedback and repeat up to 2x. Continue to trials.

Appendix G Continued

Version A

Ambiguous Messages Practice Trials

P1. *Set out little blue and orange cups. Hide ball under blue cup.*

Spot: **The ball is under the blue cup.**

E: **Point to where Chester will look for the ball!** [blue] [orange]

Remember what Spot said. Did Spot give a good clue, or a not so good clue?

[good] [not]

If correct: **You're right! That was a good clue; that will make it easy to find the ball.**
If incorrect: **Good try, but that was a good clue; that will make it easy to find the ball.**
Continue to P2.

P2. *Set out big and little purple cups. Hide ball under little cup.*

Spot: **The ball is under the purple cup.**

E: **Where will Chester look for the ball?** [big] [little]

Remember what Spot said. Did Spot give a good clue, or a not so good clue?

[good] [not]

If correct: **You're right! That was a not-so-good clue; that won't make easy to find the ball.**
If incorrect: **Good try, but that was a not-so-good clue; that won't make easy to find the ball.**
Continue to test trials.

Appendix G Continued

Version A

Ambiguous Messages Test Trials

T1. **Ok, let's try another one!**
Bring big red and blue cups. Hide ball under blue.
Spot: **The ball is under the blue cup.**

E: **Where will Chester look for the ball?** [red] [blue]

Did Spot give a good clue, or a not so good clue? [good] [not]

T2. *Bring big and little yellow cups. Hide ball under big.*
Spot: **The ball is under the yellow cup.**

E: **Where will Chester look for the ball?** [big] [little]

Did Spot give a good clue, or a not so good clue? [good] [not]

T3. *Bring little orange and green cups. Hide ball under green.*
Spot: **The ball is under the little cup.**

E: **Where will Chester look for the ball?** [orange] [green]

Did Spot give a good clue, or a not so good clue? [good] [not]

T4. *Bring little and big red cups. Hide ball under big.*
Spot: **The ball is under the big cup.**

E: **Where will Chester look for the ball?** [little] [big]

Did Spot give a good clue, or a not so good clue? [good] [not]

T5. *Bring big purple and yellow cups. Hide ball under purple.*
Spot: **The ball is under the big cup.**

E: **Where will Chester look for the ball?** [purple] [yellow]

Did Spot give a good clue, or a not so good clue? [good] [not]

T6. *Bring little and big blue cups. Hide ball under little.*
Spot: **The ball is under the little cup.**

E: **Where will Chester look for the ball?** [little] [big]

Did Spot give a good clue, or a not so good clue? [good] [not]

Appendix H: Black/White Stroop Protocol

Black/White Stroop

Now we're going to play a different game!

Show black.

This card is black, right? When you see this card, I don't want you to say 'black'. No, I want you to say 'white'.

Remove black; show white.

This card is white, right? When you see this card, I don't want you to say 'white'. No, I want you to say 'black'.

Training:

Show white. If hesitation - **What do you say for this one?**

[W] [B] (Good.)

Show black. If hesitation - **What do you say for this one?**

[W] (Good.) [B]

number of training trials

If wrong or no response on either trial, repeat rules and training. Max of three training trials – always continue with test trials.

Testing - No feedback:

Circle or write in child's response, if not black/white:

1	W	B	________	8	W	B	________	15	W	B	________
2	W	B	________	9	W	B	________	16	W	B	________
3	W	B	________	10	W	B	________	17	W	B	________
4	W	B	________	11	W	B	________	18	W	B	________
5	W	B	________	12	W	B	________	19	W	B	________
6	W	B	________	13	W	B	________	20	W	B	________
7	W	B	________	14	W	B	________	21	W	B	________

No self-correct : Record first complete response

e.g. : If child says 'Black – no white' code as 'black.' If child says 'Bl--White' code as 'white'.

Appendix I: Backward Word Span Protocol

BACKWARD WORD SPAN

I'm going to show you some cards with some pictures on them. I want you to name the picture on each card and say what it is, aloud. Once you've looked at all of the pictures, I want you to tell me the names of them, but in backwards order. Do you understand? Let's try one.

Practice Trials:

Show carrot. **What's this? [carrot] or ___________. Good job, now remember that!**

Show tree. **And what's this? [tree] or ___________. Good job.**

Now can you tell me the names of those pictures, in backwards order? [tree – carrot]

If correct: **Good job, that's right!**
If incorrect: **Remember to tell me the pictures in backwards order. You saw "carrot" then "tree" so you need to tell me "tree, carrot".**

Let's try another one!

Show frog. **What's this? [frog] or ___________. Good job, now remember that!**

Show ball. **And what's this? [ball] or ___________. Good job.**

Now can you tell me the names of those pictures, in backwards order? [ball – frog]

If correct: **Good job, that's right!**
If incorrect: **Remember to tell me the pictures in backwards order. You saw "frog" then "ball" so you need to tell me "ball, frog".**

Test Trials:

1. **Apple – Turtle** _____ (√ or x)
2. **Hand – Cake** _____ (√ or x)
3. **Chair – Elephant – Tiger** _____ (√ or x)
4. **Seashell – Mittens – Flower** _____ (√ or x)
5. **Mug – House – Balloon – Pencil** _____ (√ or x)
6. **Sunglasses – Bike – Rabbit – Book** _____ (√ or x)
7. **Leaf – Shoe – Horse – TV – Bird** _____ (√ or x)
8. **Bee – Spoon – Banana – Hat – Bus** _____ (√ or x)

Appendix J: Corsi Span Protocol

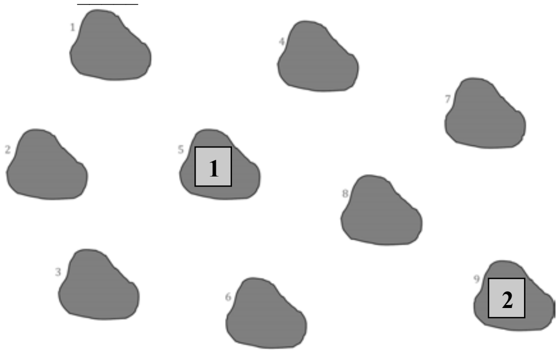
CORSI SPAN

Place page with "lily pads" on table in front of child.
Point to one lily pad per second. Stop when child makes an error on both strings of the same length (e.g., when both items 5 and 6 are incorrect). Provide no feedback after 2 training trials.

See these lily pads? We are going to pretend that our fingers are frogs jumping from lily pad to lily pad. After my frog jumps on the lily pads, you make your frog jump on the same ones in the same order. So watch which ones I jump on, and when I'm done it will be your turn to jump on the lily pads the same way.
Do you understand? Ok, let's try one! Watch carefully.

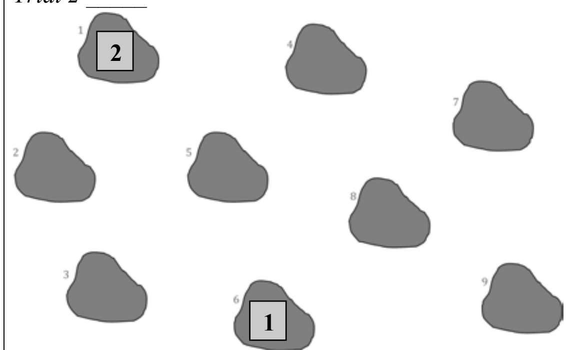
Score below (! or x).

Trial 1 _____



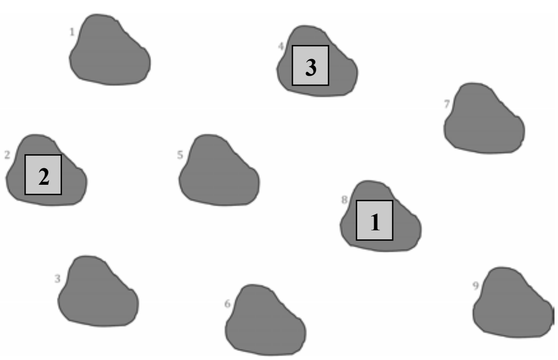
That's right! *or* **Good try! But I pointed to these ones.**

Trial 2 _____

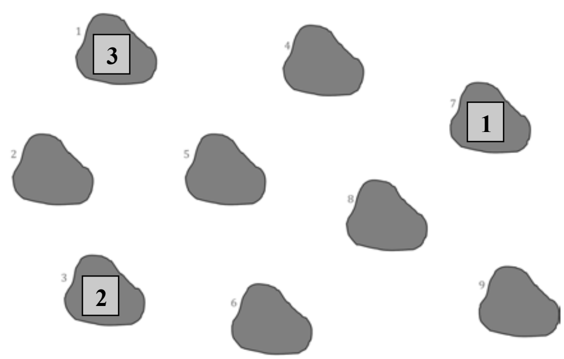


That's right! *or* **Good try! But I pointed to these ones.**

Trial 3 _____

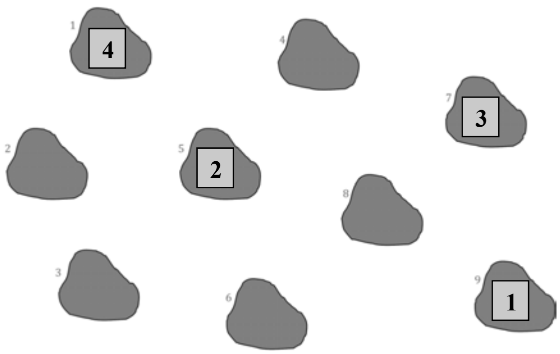


Trial 4 _____

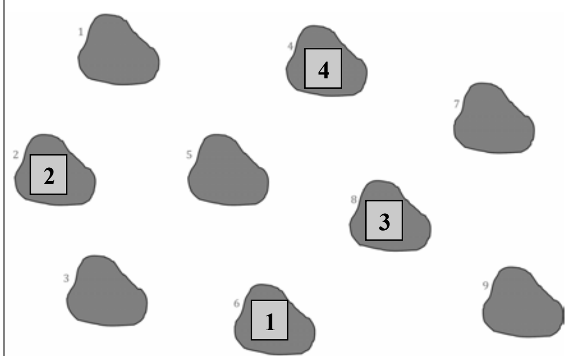


Appendix J Continued

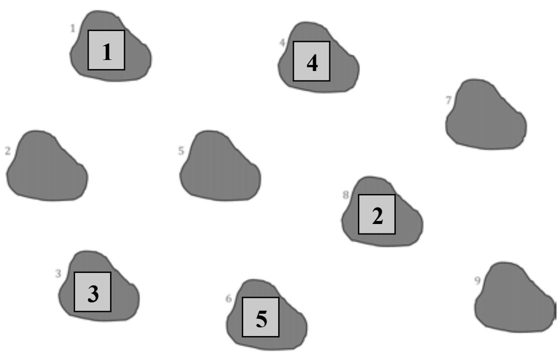
Trial 5 _____



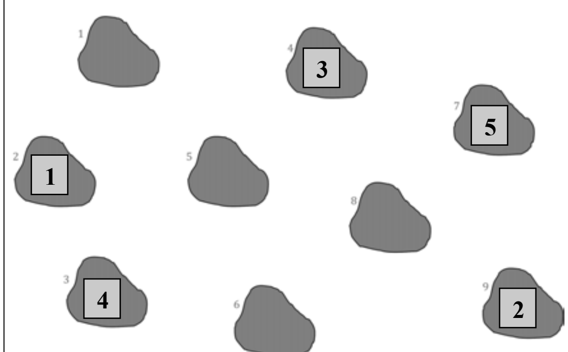
Trial 6 _____



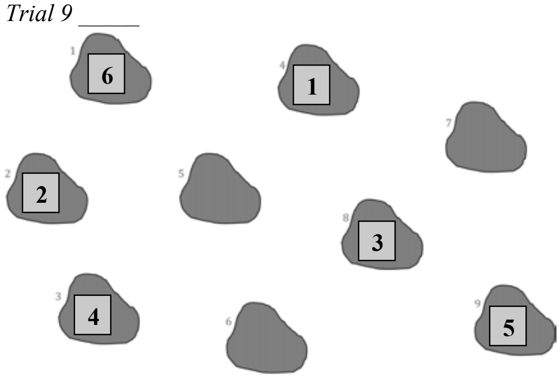
Trial 7 _____



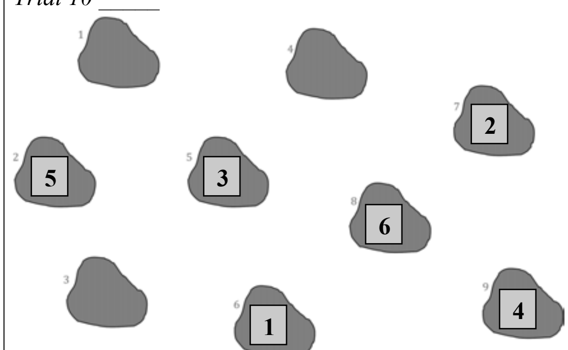
Trial 8 _____



Trial 9 _____



Trial 10 _____



Appendix K: Truck Loading Protocol

TRUCK LOADING TASK

Colour check: *(place sheet with colours on table)*
Can you show me Purple? White? Green? Blue? Red? *(randomize)*
Record accuracy:
Purple____ White____ Green____ Blue____ Red____

(*start with white house and envelope*)

O.K. Now we're going to play a new game. Let's pretend that you're a mail carrier. We're going to have a party and I need you to deliver this party invitation to this house *(point)*

See, the white invitation goes to the white house. First we need to load the truck *(let child place white invitation in back of truck*)

<u>Direction Rule</u>
Now this is a one-way street which means that you can only drive this way with the truck *(point with finger).* **You have to follow the arrows**. **Why don't you deliver the white invitation to the white house?** *(place truck at start, and have child drive the truck all the way around the road, back to the start).*

If incorrect: **O.K. remember this is a one-way street, so you need to drive around like this** (*demo*). **Why don't you try again?**
Total # of tries until correct (max 3, then continue):_____________

O.K.! (*take back white invitation*)

<u>Order Rule</u>
(add purple house) **Now there are two houses that we want to invite to the party. The white invitation goes to the white house and the purple invitation goes to the purple house** *(point)*

Now, we need to deliver these party invitations fast so that everyone will be able to come to the party. The fastest way is to drive around the block only one time.

We need to put the invitations in the back of the truck so that the top invitation goes to the house that you are driving by. You always have to take the invitation off the top of the truck so that the top invitation goes to the first house and the next invitation goes to the next house.

So now we need to load the truck. Let's see here, it looks like the first house you will drive by is the white house, so the white invitation has to go on the very top.

And the second house you will drive by is the purple house, so the purple invitation needs to go on the bottom.

So first let's put in the purple invitation and then put in the white invitation.

Appendix K Continued

(*Pile the 2 invitations in truck, one at a time*.)
Now, remember, we can only take an invitation from the top of the truck. We can never take an invitation from the bottom of the truck. So can I take one from the bottom like this? (*demo*)

No way!
If yes, repeat until says no (max 3 times, then continue)
Total # of tries until correct:______________

Now let's deliver the invitations. Why don't you drive? (*try and have C deliver the invitations, but help if needed)* **See, now as I drive by, I can first deliver the white invitation to the white house and then next I can deliver the purple invitation to the purple house. Yeah, now everyone can come to the party!**

<u>LEVEL 1: 2 houses</u>

(*Place red then green)*. **Here's a red invitation for the red house and a green invitation for the green house (***point*).

Now it's your turn to deliver the party invitations to all of the houses on the block so that everyone can come to the party. O.K., remember the rules, each color invitation goes to the same color house, and you need to follow the arrows around the block because this is a one-way street. And when delivering the invitations, you can only take the top invitation; you can never take one from the bottom.

Here are the invitations. *(Place down, red slightly to C's left and green slightly to right)*

O.K., now it's your turn to load the truck.

____ ____ CORRECT
Good job! Let's add another house.

INCORRECT *(remind of rule broken and circle)*
____ ____ [colour rule] **Whoops! Remember each color invitation goes to each color house**
____ ____ [direction rule] **Whoops! Remember this is a one-street, so you have to follow the arrows. You can only drive in one direction, no backing up.**
____ ____ [order rule] **Whoops! Remember you can only take an invitation from the top of the truck. You can never take an invitation from the bottom of the truck.**
____ ____ [tries to drive around block another time] **Whoops! We ran out of time. It's time for the party to start. Remember you can only drive around the block once.**

TRIAL 1: PASS (go to next level) FAIL (repeat; **This one is a hard one. Let's try again**).

TRIAL 2: PASS (go to next level) FAIL (stop)

Appendix K Continued

<u>LEVEL 2: 3 houses</u>

Now let's pretend that there are 3 houses on the block and you want to invite all 3 houses to the party (*place blue, white, green).* **Here's a blue invitation for the blue house. Here's a white invitation for the white house. And here's a green invitation for the green house** (*point*).

Here are the invitations (*place down, green slightly to C's left, blue in front, and white slightly to right*)
Go ahead and load up the truck.

____ ____ CORRECT
Good job! Let's add another house.

INCORRECT *(remind of rule broken and circle)*
____ ____ [colour rule] **Whoops! Remember each color invitation goes to each color house**
____ ____ [direction rule] **Whoops! Remember this is a one-street, so you have to follow the arrows. You can only drive in one direction, no backing up.**
____ ____ [order rule] **Whoops! Remember you can only take an invitation from the top of the truck. You can never take an invitation from the bottom of the truck.**
____ ____ [tries to drive around block another time] **Whoops! We ran out of time. It's time for the party to start. Remember you can only drive around the block once.**

TRIAL 1: PASS (go to next level) FAIL (repeat; **This one is a hard one. Let's try again**).

TRIAL 2: PASS (go to next level) FAIL (stop)

<u>Level 3: 4 houses</u>
Now let's pretend that there are 4 houses on the block and you want to invite all 4 houses to the party (*place purple, green, blue, white)* **Here's a purple invitation for the purple house,….etc** *(point).*

Here are the invitations. *(place down centered from left to right: green, blue, purple, white)*

Go ahead and load up the truck.

____ ____ CORRECT
Good job! Let's add another house.

INCORRECT *(remind of rule broken and circle)*
____ ____ [colour rule] **Whoops! Remember each color invitation goes to each color house**
____ ____ [direction rule] **Whoops! Remember this is a one-street, so you have to follow the arrows. You can only drive in one direction, no backing up.**
____ ____ [order rule] **Whoops! Remember you can only take an invitation from the top of the truck. You can never take an invitation from the bottom of the truck.**
____ ____ [tries to drive around block another time] **Whoops! We ran out of time. It's time for the party to start. Remember you can only drive around the block once.**

Appendix K Continued

TRIAL 1: PASS (go to next level) FAIL (repeat; **This one is a hard one. Let's try again**).

TRIAL 2: PASS (go to next level) FAIL (stop)

<u>Level 4: 5 houses</u>

Now let's pretend that there are 5 houses on the block and you want to invite all 5 houses to the party. *(place green, white, red, purple, blue)*

Here are the invitations. *(place down centered left to right: green, blue, purple, red, white)*

Go ahead and load up the truck.

____ ____ CORRECT
Good job!

INCORRECT *(remind of rule broken and circle)*
____ ____ [colour rule] **Whoops! Remember each color invitation goes to each color house**
____ ____ [direction rule] **Whoops! Remember this is a one-street, so you have to follow the arrows. You can only drive in one direction, no backing up.**
____ ____ [order rule] **Whoops! Remember you can only take an invitation from the top of the truck. You can never take an invitation from the bottom of the truck.**
____ ____ [tries to drive around block another time] **Whoops! We ran out of time. It's time for the party to start. Remember you can only drive around the block once.**

TRIAL 1: PASS (stop) FAIL (repeat; **This one is a hard one. Let's try again**).

TRIAL 2: PASS (stop) FAIL (stop)

Great job!

TOTAL NUMBER OF TRIALS: ________

HIGHEST LEVEL ACHIEVED: _______

Appendix L: School Principal Consent Form

Carleton UNIVERSITY
Canada's Capital University

Children's Representational Development Lab

Fall 2013

Dear Principal,

As part of a current project on children's cognitive development, we are talking to children to learn about their understanding of how symbols work. The study has been approved by the Ottawa-Carleton Research Advisory Committee and the Carleton University Ethics Committee for Psychological Research. It involves no physical or psychological risks for the children who take part. In this letter, we will describe the project and request your school's participation.

Should you wish to participate in the current project, we will provide you with individual informed consent letters to distribute to the parent(s) or guardian(s) of each child in your school between the ages of four and five years. Once consent letters have been returned to you from parents, we will arrange a convenient time for you and the teachers to have one of our researchers conduct the study at the school. The researchers are university students with current police record checks, who are experienced in working with children, and will be sensitive to the children at all times.

To investigate how children use and create symbols, we will ask children participate in a number of games. For example, in one game, children will be asked to create a legend that would help a friend put items back where they belong. Children will be given stickers as thanks (even if they decide to stop playing part-way through).

We will meet with each child twice, approximately 25 minutes each time, in the school during regular school hours. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. Children can stop playing at any time during the session.

The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses, and the information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. The consent form will be kept separate from the data in a secure environment and will be destroyed after 2 years.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi_kamawar@carleton.ca. The primary researcher involved in this project is Andrea Astle, M.A. and she can be reached at 613-520-2600, ext. 2885 or andrea_astle@carleton.ca. If you have any ethical concerns about this study, please contact Dr. Shelley Brown (Chair, Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1505). The ethics protocol number for this study is 13-018. Should you have any other concerns about this study, please contact Dr. Anne Bowker (Chair, Dept. of Psychology, 613-520-2600 ext. 8218).

Your consent is required for your school's participation in this project. Kindly sign the attached consent form indicating whether we may provide you with individual consent forms for parents of children within this age range. If you would like a summary of the research results once the study is completed, please contact Andrea Astle. However, please note that individual feedback regarding the children cannot be provided.

Thank you for your consideration.
Sincerely,

Deepthi Kamawar, PhD

Appendix L Continued

Carleton University Symbol Study

Carleton UNIVERSITY Canada's Capital University

I have read the attached description of the study on cognitive development and I understand the conditions of my school's participation.

We understand that the study will require two 25 minute testing sessions, with children of appropriate ages, whose parents/guardians have given written consent for their children's participation in the research project.

Name of School: ____

Address: ____

____

Signature: _________________________________ Date: _________________________

Name & Title: ___________________________________

Appendix M: School Parent Consent Form

Carleton UNIVERSITY
Canada's Capital University

Children's Representational Development Lab

Fall 2013

Dear parent(s) or guardian(s),

As part of a current project on children's cognitive development, we are talking to children to learn about their understanding of how symbols work. The study has been approved by the Ottawa-Carleton Research Advisory Committee and the Carleton University Ethics Committee for Psychological Research, as well as your child's principal. It involves no physical or psychological risks for the children who take part in it. In this letter, we will describe the project and request your permission for your child to participate. The purpose of an informed consent is to ensure that you understand the purpose of the study and the nature of your child's involvement.

To investigate how children use and create symbols, we will ask children participate in a number of games. For example, in one game, children will be asked to create a legend that would help a friend put items back where they belong. Children will be given stickers as thanks (even if they decide to stop playing part-way through). All games will be played with university students with current police record checks, who are experienced in working with children, and will be sensitive to the children at all times.

We will meet with each child each child twice, approximately 25 minutes each time, in the school during regular school hours. Participation in this experiment is completely *voluntary*. Children will be asked if they want to participate, and if they don't, they will not be pressured into participating. Children can stop playing at any time during the sessions. The information collected in this study is confidential and will be coded such that a child's name is not associated with their responses, and the information provided will be used for research purposes only, and will only be accessible to the researchers directly involved in the project. Results will not be associated with your child's school record. The consent form will be kept separate from the data in a secure environment and will be destroyed after 2 years.

The research supervisor of this project is Dr. Deepthi Kamawar and she may be reached at 613-520-2600, ext. 7021 or deepthi_kamawar@carleton.ca. The primary researcher involved in this project is Andrea Astle, M.A. and she can be reached at 613-520-2600, ext. 2885 or andrea_astle@carleton.ca. If you have any ethical concerns about this study, please contact Dr. Shelley Brown (Chair, Carleton University Ethics Committee for Psychological Research, 613-520-2600 ext. 1505). The ethics protocol number for this study is 13-018. Should you have any other concerns about this study, please contact Dr. Anne Bowker (Chair, Dept. of Psychology, 613-520-2600 ext. 8218).

Your consent is required for your child's participation in this project. Kindly sign the attached consent form indicating whether your child may participate in this research and return it to your child's teacher. If you would like a summary of the research results once the study is completed, please contact Andrea Astle. However, please note that individual feedback regarding the children cannot be provided.

Thank you for your consideration.
Sincerely,

Deepthi Kamawar, PhD

Appendix M Continued

Carleton University Symbol Study

Carleton UNIVERSITY Canada's Capital University

I have read the attached description of the study on cognitive development (understanding symbols) and I understand the conditions of my child's participation. My signature indicates that I agree to let my child participate in the study.

Child's Name: ____

Child's Date of Birth: Year 200___ Month ________ Day ________

Parent's/Guardian's Name: _____________________________________

Signature: _______________________________ Date: ______________

Appendix N: Legend Creation Task Protocol

Legend Creation Task

Shape Check: **See these shapes? Can you show me the MOON?...CLOUD?... STAR?...** *(randomize; indicate accuracy below; repeat max 3x*)

MOON_______ CLOUD _______ STAR _______

PRE-TEST (square, circle, triangle boxes)

See these boxes? They each have something on top, and they each have shapes inside. I have three different boxes. Each box goes with a different kind of shape.

See this box? It has moons inside. Let's put them here so that we remember moons belong in this box *(set out in front).* **Here is another box; it has stars inside. Let's put them here so that we remember stars belong in this box** *(set out in front).* **Here is another box; it has clouds inside. Let's put them here so that we remember clouds belong in this box** *(set out in front).*

We are taking these shapes out so we can look at them. Later on, someone else has to put the shapes away. She has never seen these boxes before. She doesn't know what shape goes inside each box. But, she will need to put the shapes back in the right boxes.

See these? *[show paper and pencil]*. **You can use these to make something that will help her put the shapes back into the right boxes.**

If produce effective, terminate task: **Great job, now we're going to do something else.**

If ineffective, remove current drawing and continue with follow-up.

Appendix N Continued

Legend Creation Task Continued

EXPOSURE CONDITION FORM 1

Ok! Now your job is to look at some things I brought and tell me if they will help my friend put the shapes back into the right boxes.

[Point to effective #1 legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N
Can you tell me [how it will help/why not]?

"Yeah!" *or* **"Oh, see", "It helps because…"**
Point to each item as you go. State explanation regardless of accuracy:
This has the square and the moon, so it shows that the square box has moons inside.
This has the circle and the star, so it shows that the circle box has stars inside.
This has the triangle and the cloud, so it shows that the triangle box has clouds inside.

[Point to effective #2 legend]
Do you think this will help my friend put the shapes back in the right boxes? Y / N
Can you tell me [how it will help/why not]?

"Yeah!" *or* **"Oh, see", "It helps because…"**
Point to each item as you go. State explanation regardless of accuracy:
This has the triangle and the cloud, so it shows that the triangle box has clouds inside.
This has the circle and the star, so it shows that the circle box has stars inside.
This has the square and the moon, so it shows that the square box has moons inside.

Appendix N Continued

Legend Creation Task Continued

POST TEST A
See this? *[show new paper]*. **You can use this to make something new that will help my friend put the shapes back into the right boxes.**

Remove items and take out new boxes with line symbols.

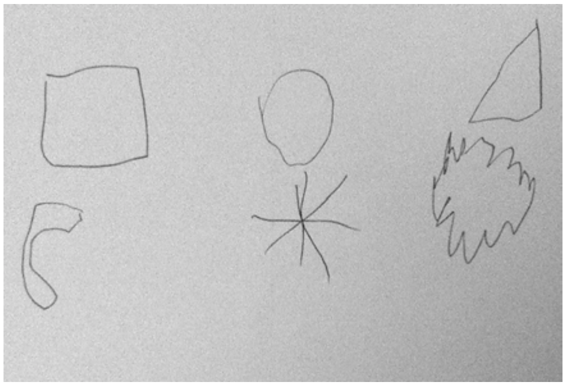
POST TEST B
Now see these boxes? And look, they each have something on top. These boxes have shapes inside, just like the ones we saw before. Each box goes with a different kind of shape. See this box? It has moons inside. Let's put them here so that we remember moons belong in this box *(set out in front).* **Here is another box; it has stars inside. Let's put them here so that we remember stars belong in this box** *(set out in front).* **Here is another box; it has clouds inside. Let's put them here so that we remember clouds belong in this box** *(set out in front).*

We are taking these shapes out so we can look at them. Later on, someone else has to put the shapes away. She has never seen these boxes before. She doesn't know what shape goes inside each box. But, she will need to put the shapes back in the right boxes. You can use this *[show new paper]* **to make something that will help my friend put the shapes back into the right boxes.**

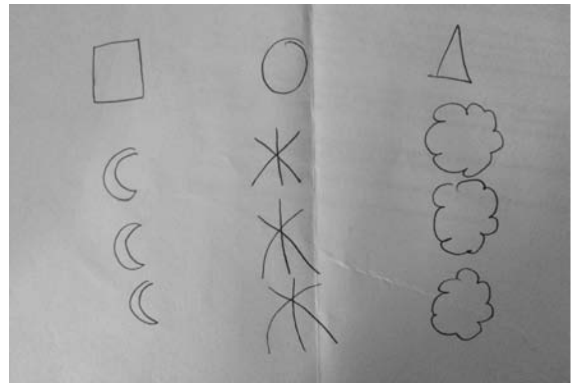
Appendix O: Children's Legend Creations

Examples of Effective Legend Creations

Categorical

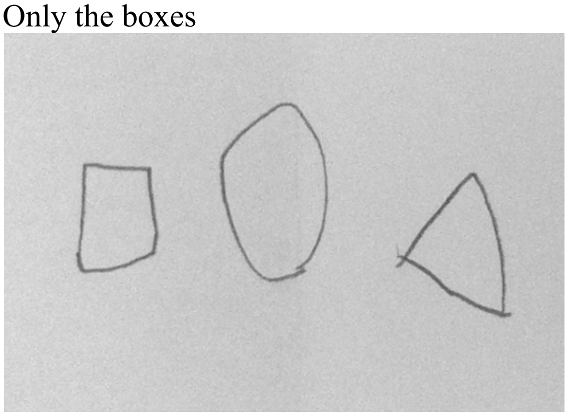


Redundant

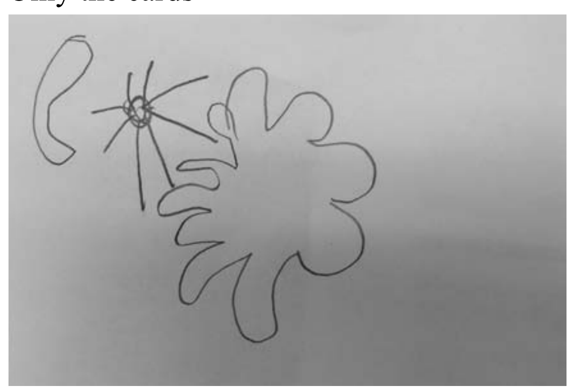


Examples of Common Ineffective Legend Creations

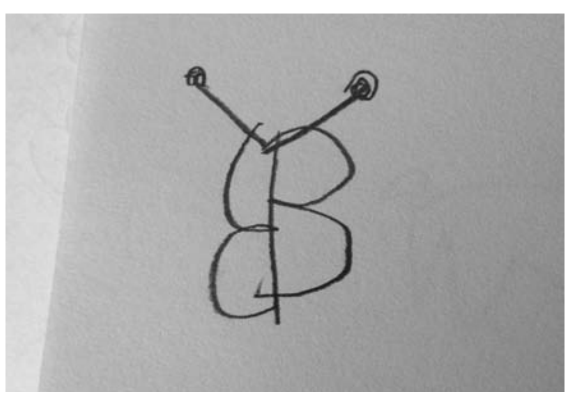
Only the boxes



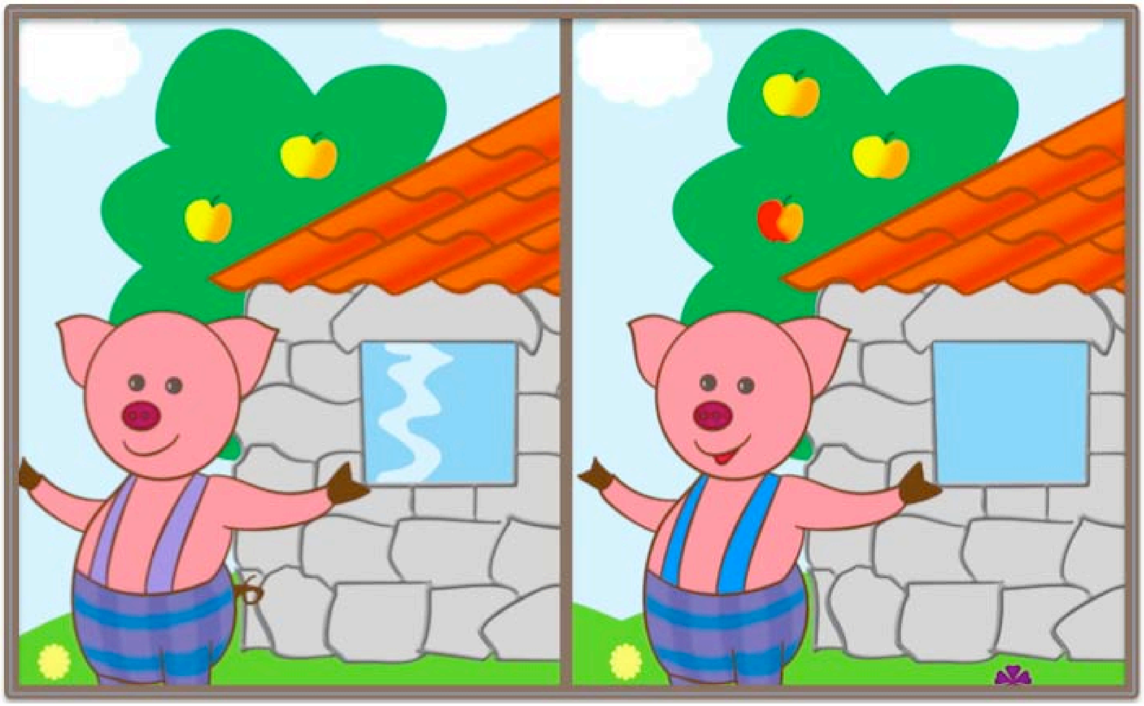
Only the cards



A picture (a butterfly)



Appendix P: Spot the Difference Game (Control for Legend Creation Task)



Now your job is to look at these pictures. They might look like they are the same, but they are not! Can you tell me 3 ways that they are different?

If correct: You're right, great job!
If incorrect or silent, prompt as necessary, then: Great job!