Advanced Review

Using symbols: developmental perspectives

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The frequent and fluent use of symbols is a distinguishing characteristic of human thought and communication. Symbols free us from the bounds of our own direct experience and allow us to learn about the world from others. To use a symbol, children need to (1) understand the intention that led to the creation and use of the symbol, and (b) how the symbol relates to its referent. For example, to use a map, children need to know that it is intended to communicate spatial information, and how locations on the map correspond to locations in the world. In some cases, even very young children are capable of meeting both requirements. For example, infants quickly learn that people intend to communicate when they use words. Moreover, they quickly learn the meanings of many specific words and the objects or concepts that they stand for. In other cases, such as learning to use maps of large-scale space, children may struggle to understand what the symbol is intended to communicate and the specific relations between elements of the symbol and their referents in the world. Here we review the development of children's understanding of words, photographs, scale models, maps, and text. We consider when and how children gain insight into the communicative intent of each of these symbols and how they learn to establish connections between the symbol and what it represents. This review helps to integrate research on the development of children's understanding of a variety of symbol systems.

How to cite this article:
WIREs Cogn Sci 2014, 5:295–304. doi: 10.1002/wcs.1280

INTRODUCTION

Using symbols is one of the defining characteristics of what it means to be human. Almost all children develop the capacity to use a variety of symbols and they fail to do so only under conditions of extreme deprivation. In contrast, only with extreme effort can non-human species understand and use the most basic human symbol systems.[1] Not surprisingly, the acquisition of a variety of symbol systems is a major focus of early childhood education; within a few short years, children are expected to master numerals, letters, and often musical notation, computer icons, and many others. Children who master these symbol systems early in their education tend to do well, not only in elementary school but also in high school and even college.[2] In contrast, struggling to master symbol systems is a clear warning sign for poor academic achievement.

The purpose of this article is to provide a review of the development of children's use of symbols. We review and integrate research on the development of a variety of symbol systems and point out both similarities and differences in the process of symbolic development in different domains. We begin with a working definition and theoretical perspective on what symbols are. We then apply this theoretical perspective to a review of the literature on the development of children's understanding and use of words, photographs, scale models, maps, and text.

DEFINITION AND THEORETICAL PERSPECTIVE

Defining what makes something a symbol is a notoriously difficult task, and this issue has been the

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Conflict of interest: The authors have declared no conflicts of interest for this article.

focus of a great deal of work in a variety of fields, including philosophy, semiotics, linguistics, and many more.[3,4] A full discussion of these perspectives is beyond the scope of this article. We begin this section by briefly reviewing some of the major philosophical perspectives on what symbols are. This discussion then motivates our own definition of symbolness.

Philosophical Perspectives

Some philosophers have attempted to define symbols in terms of the relation between symbols and their referents. For example, Saussure proposed that all symbols have two components: a signifier (e.g., the word TREE) and a signified concept (e.g., the mental representation of a tree).[5] According to Saussure, the relationship between the sound pattern of words and the concepts or objects they refer to is arbitrary and constrained by cultural conventions. For example, whether a real-world tree is named TREE or FREE depends entirely on the culture in which the word is created and used in communication. This definition seems intuitive, but it raises several important questions. For example, is the relation between signifier and signified always arbitrary? What roles do the symbol creators and readers play in the process of understanding symbols?

Other philosophical models go beyond this definition of symbols and point out the important role intention plays in understanding symbolic representations. For example, Peirce[6] included in his definition of symbols the act of interpretation. According to Peirce, nothing is a sign unless it is interpreted as a sign and anything can be a sign as long as someone interprets it as 'stand for' something other than itself.[6] Under this definition, the meaning of symbols relies heavily on the part of the symbol reader during the sense-making process. For example, after looking at some abstract painting, different viewers might have different interpretations about the symbolic meanings of the painting. Thus, the symbol (painting) is assigned different meanings according to the symbol readers' intention.

In summary, philosophical definitions of symbols have pointed out three important components that maybe involved in symbolic understanding: a symbol, its referent, and the human interpretation that links the symbol with its referent. Building on these conclusions, we argue that the intention of both symbol creators and symbol readers contribute to the final understanding of symbolic representations. Consider again the example of the word TREE. The creation of this symbol starts with the intention of the person who created the word. Upon seeing the word TREE, if the reader's interpretation of the word aligns with the intention of the word creator, then we can say that the reader understands the symbolic meaning. Thus, symbolic understanding is influenced by a combination of factors, including the symbols and referents, as well as the intentions of the symbol creators and readers.

Current Definition

On the basis of this analysis, we have chosen to use a definition that is inherently psychological: A symbol is something that someone intends to stand for something else.[7] This definition is inherently psychological because 'symbolness' is defined in terms of psychological processes, such as intention and representation. Any object can become a symbol if someone intends for it to be. For example, imagine that you are at a dinner, and someone asks for directions back to their hotel. You could make a makeshift map on the tablecloth, using silverware to represent the locations of the restaurant, the hotel, and perhaps other locations. The silverware items become symbols when you make clear that you intend for them to represent locations.

It is equally true that conventionalized symbols, such as letters or numerals, are not symbols in the minds of young children until they understand what they represent. Although the symbolic nature of letters and numerals is obvious to most adults in modern, Western societies, the relation may be much less obvious, perhaps even opaque, to young children. Children must understand the communicative intent that motivates the use of symbols. This does not mean that children have to figure out the exact correspondences between words and meanings (e.g., how to spell the word DOG). Children may possess some nascent understanding of texts before they know how to read and write. For example, a child may scribble on a piece of paper when asked to write his/her name. Although this child may not know how to write, he/she understands the intention of using words to represent sounds. This understanding is qualified as a rudimentary level of symbolic understanding under our definition.[8]

Critical Elements of Symbolic Understanding

Based in part on these analyses, our definition of symbols implies two critical elements of symbolic understanding. The first is understanding the intention behind the symbol—knowing *that* someone *intends* for something else. The second is the *stands-for* relation—knowing *how* a symbol stands for its referent. For example, how does text stand for spoken language? We suggest that these two components may

be at least in part separable, and that considering them separately may shed light on the developmental processes that are the focus of this article.

Understanding Intention

Although a full understanding of other people's intention is a prolonged developmental process,[9–11] we now know that even infants interpret both actions and words on the basis of assumptions about others' intentions.[12–21] They understand, for example, that other people's actions are motivated by the desire to achieve a goal,[22] and they use indicators of intention (e.g., gazes and points) as cues for learning and distinguishing the meaning of words.[23,24] Importantly, young children's use of intentional information is almost always in richly social situations and thus is a form of *shared* intention.[25] For these reasons, we assume that young infants understand enough about intention to grasp this element of early symbolic understanding.

Understanding the Stands-For Relation

Children also need to understand *how* a symbol stands for its referent. For example, understanding that text is a representation of language is not enough to allow a child to read; he or she also has to figure out the system that specifies *how* written text corresponds to spoken language.[26] Similarly, even if a child understands that maps represent spaces, he or she may still struggle to figure out how a map represents different features of the environment. Indeed, some adults, with full knowledge that maps are intended to represent particular places still struggle to interpret complex or poorly designed maps.

Particularly for young children, understanding *how* a symbol relates to its referent often involves establishing correspondences between elements on or in the symbol and aspects of the referent. As is often true in young children's developing understanding of relations, these correspondences are often established on the basis of physical similarity.[27,28] For example, 3.0-year-olds rely heavily on perceptual similarity when establishing correspondences between scale models and the spaces that they represent.[28] Children successfully locate hidden toys in a room using its corresponding scale model, only when furniture in the model and in the room look very similar. Children fail completely when the similarity is reduced. As we will see, young children seem to persist with this 'faith in similarity' even when this belief is false—when there is no physical correspondence between the symbol and its referent. For example, young children may believe that there should be size correspondence between the length of words and the size of the objects they represent in the world (e.g., a long word should represent a big object).[29,30]

UNDERSTANDING WORDS AS SYMBOLS

Children comprehend the meaning of many words by their first birthday, and some researchers have argued that even 6-month-olds have a clear and general understanding of the meaning of several highly familiar words, such as those for body parts.[31] Production of both words and gestures usually begins around the first birthday and develops rapidly after approximately 18 months.[32,33]

Can we say that infants' comprehension of words constitutes a form of symbolic understanding? We believe that the answer is yes. At least by their first birthday, children understand that others (e.g., their parents) use words to communicate ideas, and that words refer to objects or concepts.[20,12,34] Exactly *how* children figure out the correspondence between words and their referents is a subject of intense debate. Some researchers have argued that the set of possible references is so large and ambiguous that children must possess innate constraints that limit their generalization about the meanings of individual words and the range of inferences that can be drawn.[35,36] Other researchers have suggested that need for constraints in assessing the meaning of words is given by cues to the intention of the interlocutor. Looking, pointing, and other cues can greatly reduce uncertainty regarding the meaning of a word.[16,23,24,37,38] Still others have suggested that there is enough information available in the linguistic environment for children to figure out the correspondence between individual words and specific objects. For example, Yu and Smith[39,40] have suggested that children can learn the meaning of words by computing consistencies in references across different contexts. A few multiple references across different situations may be sufficient to allow children to correctly assess the meaning of words without *a priori* constraint on the inferences that can be drawn. Computational simulations suggest that infants may use both the intention of the speaker and the distribution of references across multiple situations to constrain and determine word meaning.[41]

THE DEVELOPMENT OF CHILDREN'S UNDERSTANDING OF PHOTOGRAPHS

At first glance, the notion that photographs are symbols may strike the reader as counterintuitive. At least to an adult, it may seem that the photograph

is more like a copy of reality than a symbolic representation of it. However, philosophical[42] and cross-cultural[43] work suggests that photographs need to be understood as representations, and that children therefore must learn to use them as they learn to use other symbolic representations. Our perspective on the components of symbolic understanding and its development helps to shed light on the development of children's understanding of photographs.

There has been substantial debate regarding whether infants interpret photographs as symbolic representations. Much of the focus of this debate has been on demonstrations that infants attempt to grab at photographs of objects. For example, DeLoache, Uttal, and Rosengren[44] found that 9-month-olds consistently grasped at the objects in photographs as if the photographs were the actual objects. In the original studies, infants were presented with picture books that showed one highly realistic photograph on each page. The photographed objects, such as bottles or plastic keys, were familiar to infants. Every infant made at least one attempt to grasp at one of the photographs, and some persisted across most of the photographs. There was also a large developmental change; 18-month-olds behaved dramatically different than the 9-month-olds did. The older children almost never grasped the photographed object. Instead, they often pointed to the represented object, making sounds ('proto-labels') that might indicate that they were trying to communicate something about the represented object.

Some researchers[45,46] have suggested that grasping behavior actually occurs much less often than DeLoache et al. suggested. For example, Youniss et al. argued that the behaviors were not actually grasps and thus were not relevant to the debate regarding children's understanding of photographs as symbols. For example, these researchers found that children often scratched at the objects in photographs rather than attempted to grasp the photographs. Youniss et al. also suggested that the infants behaved similarly toward photographed objects and textures, suggesting that their 'grasps' were not specifically targeted toward an object. Recently, French et al.[47] have found that whether infants grasp at photographs depends greatly on the features of the photograph and the age of the children. However, this research strongly confirms that infants often do grasp at represented objects, and that these grasps can be reliably distinguished from other behaviors such as scratching or patting.

From our perspective, grasping errors occur because the infants have not yet understood that the photograph is intended to be a representation. The objects in the photographs look like objects with which they are familiar, and they behave accordingly; they sometimes try to pick the photographed objects up. The high degree of similarity of the photograph to its referent is something of a dual-edged sword: It is very easy for the child to establish correspondences between the photographed object and a real object, simply on the basis of perceptual similarity. But the strong degree of similarity may also make it harder for the child to realize that the photographed object is not the object itself. By 18-months, children have begun to realize, perhaps through their experience with picture-book reading,[48,49] that the photographs are representations rather than the objects themselves. By pointing to and attempting to talk about the represented objects, they are trying to establish the shared intention that characterizes parent–child conversations.

Development Beyond 18 Months

It is important to point out that children's understanding of the symbolic nature of photographs is not complete at the age of 18 months. Even though children may understand that photographs are representations, they still need to learn some of the intricacies of *how* photographs relate to their referents.[50] For example, 3-year-olds may believe that photographs must resemble their referents, even if something is changed in the scene after the photograph is taken. That is, 3-year-olds persist in the belief that the photograph will somehow update to reflect a change in the represented scene. Similarly, children also seem to believe that changing a photograph (such as adding a sticker to one of the represented locations) should lead to a change in the represented scene.[51] In both cases, children seem to believe that photographs should *always* look like the original referents, even when the referent (or the photograph) changes.

From our point of view, these sorts of errors make sense because children know that the photograph is intended to be a representation of the scene. This knowledge is, in fact, paramount in their minds. From the child's point of view, the best representation will be one that maintains the strongest possible fidelity and similarity between the photograph and the referent scene. They still need to learn the constraints of photography, precisely what information photographs do and do not maintain in relation to their referents.

THE DEVELOPMENT OF CHILDREN'S UNDERSTANDING OF SCALE MODELS

Scale models have played a very important role in the study of symbolic development. In a typical

task[52] children are asked to use a scale model to find a toy that is hidden in the room that it represents. Children are first told that a toy stuffed dog ('Big Snoopy') will be hidden in a room, and that the child will be asked to find it. Then the experimenter introduces a scale model of the room, which looks exactly like the larger room except for the difference in size; the model is one sixth the size of the room. The experimenter also introduces a miniature version of the stuffed dog, 'Little Snoopy', and tells the child that Little Snoopy will be hidden in the same place in the model as Big Snoopy is hidden in the room. On a test trial, the experimenter hides Little Snoopy behind or near a piece of furniture in the model (e.g., the miniature chair) and asks the child to find Big Snoopy in the room. Finally, regardless of the child's success in the room, he or she is asked to return to the model and point out where Little Snoopy was hidden. The child's performance provides a measure of their memory for the original location in the model. If the child fails to find Big Snoopy but successfully finds Little Snoopy after returning to the model, then the problem cannot be attributed to forgetting where Little Snoopy was hidden.

DeLoache's[46] early research revealed a dramatic developmental change in children's ability to use the model to find the hidden toy in the room. Three-year-olds performed well, averaging approximately 75% correct searches. In contrast, children only 6 months younger (2.5-year-olds) performed much worse, performing around chance levels (25%). A memory check confirmed that the poor performance of the 2.5-year-olds could not be attributed to forgetting where the toy was hidden in the model. The memory check consisted of asking children to return to the model and indicate where the miniature toy was hidden. Almost all children performed very well on the memory check, regardless of whether they were able to use the model to find the hidden toy in the room.

The Fragility of Children's Understanding of the Model–Room Relation

Subsequent research has revealed that despite their initial success in the standard model task, 3-year-olds' understanding of the model–room relation is actually quite fragile. What might strike an adult as trivial changes to the model, the room, or the procedures have led to catastrophic failure. The results of these manipulations reveal a great deal about what children need to know to use the model as a symbol.

One good example concerns the effects of reducing physical similarity between the model and the room. In the standard model task, the miniature furniture in the model and the corresponding larger items in the room were covered with the same fabric. DeLoache, Kolstad, and Anderson[28] reduced the level of physical similarity by covering the furniture in the model and the corresponding referents with different fabric. For example, the chair in the room was covered with solid blue fabric, and the chair in the model was covered with rust-colored fabric. Under this condition, 3-year-olds' performance dropped to chance levels.

Different manipulations have yielded similar results. For example, deleting instructions regarding the model–room relation has a similarly catastrophic effect on 3-year-olds' performance. In the typical model task, the experimenter both points out the overall correspondence between the model and the space and demonstrates that individual objects correspond to their referents in the room. If either instruction is deleted, children's performance again falls to chance levels. In fact, it is not until age 5 that children can succeed on the task without any instructions.[53]

Finally, experiencing a delay between when the instructions are given and when children are asked to search for hidden objects can have a detrimental effect on children's performance. Uttal, DeLoache, and Schreiber[54] inserted delays between the time when the child saw the toy hidden in the model and his or her subsequent search for the toy in the room. In a within-subjects design, children waited 1, 2, and 5 min on different searches, and the order of delays was counterbalanced across subjects. Children's overall performance was determined by which delay they received first. Those that had the 1-min delay did well throughout, even on the subsequent 5-min delays. The results for the children who experienced the 5-min delay first were exactly the opposite; these children did poorly on the first (5-minute delay trial), and they also continued to do worse even subsequent shorter delay trials on which they otherwise would succeed. Something about experiencing the 5-minute delay first greatly diminished children's ability to use the model as a symbol of the room. Children lost sight of the relation between the model and the room and were not able to regain it.

The Dual-Representation Hypothesis

To explain these results, DeLoache formulated the *dual-representation hypothesis*.[55,56] The fundamental notion is that all symbols have a dual nature; they are simultaneously objects in their own right and representations of something else. For children to succeed in the model–room task, they must focus on what the model represents, rather than on its properties as an object in its own right. Manipulations, such as letting children play with the scale model before engaging in the searching task, increase the

salience of the model as an object make it harder for the child to use it as a representation.

The dual representation hypothesis has been tested in several ways. For example, it predicts that manipulations that make the model *less* attractive or interesting as an object in its own right should make it *easier* for children to use it as a symbol. Conversely, manipulations that make the model *more* interesting or attractive as an object should *decrease* children's performance. Both predictions have been confirmed. In one experiment[55] the model was placed behind a plane of glass, and the experimenter pointed out the correct location rather than showing the child directly. This manipulation decreased the salience of the model as an object and led to increased levels of performance. Conversely, allowing children to play with the model before they were asked to use it as a symbol actually led to decreased levels of performance, because playing with the model increased its salience as an object and made it harder for the children to use it as a representation.

Perhaps, the most convincing and well-known test of the dual representation hypothesis comes from an experiment in which the need to think of the model as a room was eliminated. The children were told that the experimenter had a shrinking machine which could shrink the room and the toy. The experimenter 'demonstrated' the functioning of the shrinking by placing a large toy troll near the machine and leaving the room. Researcher assistants surreptitiously replaced the large troll with a miniature replica and played a tape of mechanical sounds to help convince the children that the shrinking machine was working. From the child's perspective, the machine did work; when he or she returned to the room, the child saw the miniature toy and believed that the machine had caused the dramatic reduction in its size. The experimenter also demonstrated that the machine could work in the opposite direction, turning miniature replicas into full-sized objects.

With the child now convinced of the veracity of the shrinking room, the experimenter then explained the search task, saying that he or she would hide the larger doll in the room and then leave the room while the shrinking machine operated. While the experimenter and participant were out of the room, several research assistants quietly replaced the miniature room with a (much) smaller room that was made out of the same fabric—a portable room. Two and a half-year-olds, who normally fail the typical model task, now performed much better.

At one level, the shrinking room task is identical to the model task, in that the child must use the location of the toy in one room to find the toy in another. But conceptually the two tasks are very different. In the original model task, the child needed to think of a representational relation between the model and the room. In contrast, in the shrinking room task, there was no need to think of one room as a representation of the other. In the mind of the child, the two rooms were the same. In essence, the shrinking-room procedure removed the needs for dual representation, and hence the children can succeed when they would otherwise fail.

Intention and Dual Representation

The research reviewed thus far indicates that for children to perform well in the model task, they must see it as a symbolic representation of the room. We believe that understanding the experimenter's intention may play a very important role in this process. To succeed, the child needs to understand that the experimenter intends for the model to stand for the room. Adults are very familiar with this 'stands for' relation, and simply mentioning that something is a model of something else is probably sufficient for an adult to grasp how the symbol can be used.

Specific evidence to support the role of instructions as communicating intention comes from work by Sharon.[57] She specifically manipulated whether the experimenter's intention influences children's performance. 2.5- and 3.0-year-olds were told, 'I made something to help to you to find Big Bear'. (Sharon used a stuffed bear rather than a stuffed dog).[57] A control group did not receive these instructions. Those children who heard the instructions performed substantially better than those who did not. Sharon's instructions communicated directly the experimenter's intention to have the model help the child find the toy in the room.

It is also possible that instructions often serve the function of communicating the experimenter's intention to have the model stand for the room, even when the instructions do not directly mention the intention. In the standard model task, the instructions focus on the correspondence between the model and the room; the experimenter points out, for example, that the chair in the model is just like the chair in the room. These typical instructions thus do not directly communicate the experimenter's intention, but pointing out the correspondences between the model and the room may be enough for the child to grasp what the experimenter intends. Deleting these instructions thus causes a catastrophic failure, because the child no longer understands that the model is intended to be a symbol of the room.

THE DEVELOPMENT OF CHILDREN'S UNDERSTANDING OF MAPS

In some ways, maps are like scale models, in that they are used to represent particular places or configurations of places in the world. There are, however, important differences between maps and scale models. First, maps often are used to communicate and think about spatial locations and patterns. Second, maps often represent much larger spaces than scale models do. Third, scale models are three-dimensional spaces, whereas maps are almost always two-dimensional, and using a map therefore may require that children think about how a two-dimensional representation corresponds to three-dimensional referents in the world. In these regards, we find important differences between children's understanding of scale models and of maps.

Young children can use maps of small-scale spaces, and they can take advantage of some of the spatial properties of these maps. For example, 4-year-olds can use the scale information in maps in both one and two dimensions.[58,59] In addition, very young children can also use the geometry of the configuration of locations as a basis for finding a hidden toy.[60,61] In contrast to most scale model tasks, on a pure geometrical map, there are no distinctive objects; each object is identical except for its spatial position.[60,61] For example, Winkler-Rhoades et al.[61] asked 2.5-year-olds to use a map with three small circles representing the positions of three identical places in a room. Children could use these purely geometric maps to successfully locate hidden objects in the corresponding space without explicit instructions or feedback. These results are important because they indicate that young children can take advantage of the spatial properties of maps and that doing so does not require formal training or extensive experience.

Using Maps of Larger Spaces

In contrast to their success with maps of small-scale spaces, children often experience substantially more difficulty interpreting maps of larger-scale spaces, such as cities or countries. For example, Liben and Downs[62–64] found that children often have great difficulty interpreting representations of locations or objects on large-scale maps. For example, a preschooler said that a red line on a map could not represent a road (when in fact it did represent a road) because roads in the world are not red. Similarly, children may correctly recognize a blue section on a map as water and then claim to see fish in the water, which would not be possible on a map of the scale that was used.

Why do these errors occur? We suggest that the fundamental problem concerns the challenges of learning *how* large-scale maps relate to the spaces that they represent. The child has some insight that the map is intended to communicate something about space but has little idea how the abstract symbols on maps correspond to their referents in the world. Moreover, in some cases the child may not even understand the *referents* themselves. For example, a 6-year-old has little knowledge of the differences between interstate and local highways. In this situation, the child defaults to physical similarity; he or she takes the best guess as to what the objects on a map might represent. In addition, as was true with photographs, the child may believe that the map should capture all aspects of a represented scene, and thus, for example, fish should be found on a map that depicts water.

CONVENTIONALIZED SYMBOLS

In this final section, we briefly consider the development of children's conceptions of conventionalized symbols. A conventionalized symbol is a one that has a culturally-shared meaning and (often) a well-established set of rules by which the mapping problem can be solved. Numerals, text (e.g., letters, or logographs such as Chinese characters), and written music are all good examples. Here we focus primarily on the development of children's understanding of text (particularly letters) but we note that similar arguments have been made regarding the development of understanding of numerals[65,66] and written music.[67–69]

Most of the focus of research on these topics has been on how children understand the complex rules that relate these conventionalized symbol systems to their referents. For example, a great deal of research on reading development has focused on how children learn grapheme–phoneme correspondences—how written units of sounds correspond to spoken units. This work is extremely important because these emergent literacy skills strongly predict reading achievement.[26] However, there are equally important and interesting developments that must occur before children begin to learn the specifics of how written language corresponds to spoken language. For example, a fundamental insight is to understand *that* text represents language—there is some correspondence between marks on the page (letters) and what people say. This is fundamentally a question about understanding the intention that motivates the use of written language. As is true for all early symbolic understanding, we see that insights about the symbolic nature of text often occur in

rich, social contexts, which provide opportunities for shared intention to develop. A classic example is picture book reading between a child and his or her parent. Children's early awareness that print represents language emerges in these rich, interactive contexts, in which the parent's intention to communicate, and his or her use of print to do so, is obvious.[49,70,71] Children as young as 18 months often begin to show some insight that text is related to what their parent is reading. For example, they may point to the text and move their finger across the letters as the parent reads.[49] Indeed a host of studies has shown that exposing children to print-rich environments (e.g., frequent picture-book reading) leads to increases in vocabulary and early literacy skills.[72–75]

In addition, children are capable of producing some form of writing before they fully understand *how* text corresponds to language. *For* example, by about age 4, many children will make scribbles with a pencil when asked to represent an experimenter's words or actions. Initially, these scribbles are not well differentiated, but children soon come to preserve features of what they are attempting to represent. For example, longer words, or words representing larger objects, may be shown with larger scribbles.[8] Thus in this pre-literate stage, the child is attempting to construct a relation between written and spoken text on the basis of physical similarity, even though in this case this hypothesized relation is not correct. To learn to write, however, the child needs to put aside his or her 'faith in similarity' and learn instead the arbitrary but immutable relation between how words are written and how they are said. Children's early but incorrect assumptions about the correspondences between text and spoken language demonstrate that they are actively trying to make sense of their knowledge that people are using a representation of language when they read. The developmental problem is to figure out *how* the reader derives meaning from the text. As we saw in analyzing the development of children's understanding of maps, physical similarity provides a reasonable, albeit incorrect, assumption regarding the correspondence between written and spoken words.

CONCLUSION

Symbolization underlies much of human communication and interaction. Here we examined the development of symbolization in a variety of different content domains. On the one hand, symbolic development is domain specific, in that it occurs in different domains at very different ages. However, what is required to use a symbol is similar across domains: For all symbols, children need to figure out *that* and *how* symbols relate to what they represent. The first step in learning to use any symbol is to gain insight into the communicative intention that motivates the creation and use of the symbol. This insight is supported in rich, social contexts, in which there is a high degree of shared intention. In these situations, even infants are capable of understanding and (eventually) using symbols such as words and gestures. Almost all early symbol use emerges in situations in which children are constantly aware that another person is attempting to communicate to them through the use of the symbol, such as words or gestures.

The second requirement for using a symbol is to know *how* it relates to its referent; children must figure out the correspondences between elements of the symbol system and the corresponding referents. In some cases, such as using photographs, children can rely on physical similarity, and establishing correspondences between the symbol and the referent is easy and obvious. In other cases, such as learning to understand text or maps of large-scale spaces, children must learn complex systems that specify how the symbol relates to the reference. Fully mastering these rules can often take years, and many children struggle to 'crack the code' of literacy. Before they fully understand how symbols relate to their referents, children often assume that the correspondence should be based on physical similarity. Although this assumption sometimes proves to be false, it provides a reasonable working hypothesis in the absence of more specific knowledge of how the symbol relates to its referent. Insight into the symbolic nature of an object leads children to search for ways to make sense of the symbol–referent relations, and thus all symbolic relations are ultimately created in the minds of the children who are learning to use them.

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