

ABSTRACT

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Preschoolers' Understanding of Arrows as Directional Indicators

(Under the Direction of Dr. Janet Frick)

Arrows are very commonly used as directional indicators for both adults and children. Research has found that children are cued to look faster when cued by valid vs. invalid arrow. Yet, for such a common directional symbol, it is still largely unknown how children understand this directional indicator. They may be using the symbolic meaning of the arrow, or perhaps children are cued by more perceptual aspects like the visual weight of the arrow. This study presented children with 10 various arrow stimuli that differed in direction and distribution of weight. We asked children to use the arrow cue to find a hidden animal and recorded their eye movements as they were exposed to the various stimuli. Our results indicated that children 3 years and older were cued to look to the side indicated by the weight of the arrow but not to the side indicated by the direction. Children younger than 3 years of age were not cued by the weight or the direction of the arrow. These findings are consistent with past research on this topic and may have implication for the understanding of abstract symbols in general, such as written language.

INDEX WORDS: Arrows, visual orienting, directional indicators, visual weight, symbolic understanding, cue attention, reaction times, looking behavior

PRESCHOOLERS' UNDERSTANDING OF THE ARROW AS A DIRECTIONAL
INDICATOR

by

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A Thesis Submitted to the Honors Council of the University of Georgia
in Partial Fulfillment of the Requirements for the Degree

BACHELOR OF SCIENCE

in PSYCHOLOGY

Athens, Georgia

2009

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ACKNOWLEDGEMENTS

I would like to thank the children who participated in this study and their parents. I would also like to thank the undergraduate research assistants who helped schedule participants, run trials, and code data. Special thanks also go out to Dr. Krisztina Varga and Dr. Janet Frick for all of their guidance throughout the research process.

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CHAPTER ONE INTRODUCTION

Visual attention is a key aspect of cognitive development for children. As they age, children learn to orient their attention in response to cues like another person's eye gaze, hand gestures, and other symbolic cues. One important directional symbol, the arrow, is commonly used by adults in their day to day lives; it's on street signs, painted on roads, even plastered on the walls of our psychology building as a way to direct parents to the infant lab. Children may also come in contact with this symbol anywhere from books to movies to toys. Yet, it is probably rare that an adult specifically explains the meaning of this symbol to pre-school age children. For a symbol that is so commonly used as a directional indicator, it is still largely unclear how young children learn to understand this cue. Do they know what it means? Can they interpret and use this symbol? Are they attending to its symbolic meaning, or rather the perceptual information it provides?

The present study seeks to investigate young children's understanding of this common and useful symbol. We will first look at the current research on visual orienting in response to eye gaze, hand gestures, directional words, and finally arrows. Research on symbolic understanding of young children will also be discussed leading us to question whether or not the symbolic nature of arrows is fully understood by young children. Finally, this paper will propose a method for testing children's understandings of arrows and the findings will be reported and discussed.

Literature Review

The study of visual orienting was greatly influenced by Posner's visual orienting task, which measures participant's reaction times in response to valid and invalid visual cues (Posner & Cohen, 1984). Valid cues, which direct participants' attention to the target location, result in faster reaction times than invalid cues, which direct participant's attention away from the target location. Research has shown that adults and children orient their attention in response to cues like eye gaze (Langton & Burce, 1999), pointing (Woodward & Guajardo, 2002), directional words (Hommel, Pratt, Colzato & Godijn, 2001), and arrows (Tipples, 2002). In other words, participants respond faster to valid versus invalid cues across all of these domains. These studies indicate that human attention can be directed through both social and symbolic cues. It has also been found that attention can be cued by a stimulus that is shown very briefly and does not predict the location of the target (Friesen & Kingstone, 1998). These findings suggest that the cue is triggering reflexive orienting, which is an automatic response in the direction of a cue, rather than endogenous orienting, which is a more deliberate interpretation of the cue followed by a conscious response.

Eye gaze has been found to cue the attention of adults (Langton & Bruce, 1999), children (Ristic, Friesen & Kingstone, 2002; Chawarska, Klin & Volkmar, 2003) and infants (Brooks & Meltzoff, 2002; Hood, Willen, & Driver, 1998). Evidently, people learn to use eye gaze as a directional cue, even at a very young age. The understanding of another person's eye gaze is crucial for engaging in joint attention, which occurs when social partners mutually direct their attention to a particular place or object (Scaife & Bruner, 1975). The ability to engage in joint attention is key for many other social and cognitive skills. Thus, eye gaze is an important contributor to the child's developmental process. Other social cues, such as pointing have been

found to have similar effects on attention as eye gaze. Woodward and Guajardo (2002) found that 12-month-old infants were cued to look at an object when an adult pointed toward it. This study shows that social cues other than eye gaze can also be used to cue attention, even at a young age.

There are many symbolic indicators of direction, such as directional words and arrows, that also cue attention (Hommel et. al, 2001). Arrows have been found to produce faster reaction times for adults (Tipples 2002) and children as young as 4 years of age (Ristic et al., 2002; Senju, Tojo, Dairoku & Hasegawa, 2004). Studies like these show that a directional cue does not have to be social in nature to trigger visual orienting. Because of their symbolic nature, directional cues like words and arrows require slightly more interpretation than more social cues like eye gaze.

It is clear that arrows can cue the attention of young children, but does this necessarily mean that they understand the symbolic meaning that arrows denote? According to Judy DeLoach (1987), symbolic understanding typically emerges between 2 ½ and 3 years of age. This symbolic realization is important to children's understanding and interpretation of written language, pictures, and signs. As symbolic understanding develops, children become more adept at interpreting these symbols. This would suggest, then, that the full understanding of arrows must also develop over time. Therefore, we must ask: when young children and infants are cued by arrows, how well do they understand their symbolic nature? It may be that young children are not attending to the symbolic meaning of the arrows, but are instead being cued by the perceptual information it provides. Children may be cued to look in the direction of the arrow because that is the side where its visual weight is heaviest.

Rationale

In order to investigate what properties of an arrow cue attention, Krisztina Varga designed 10 different arrow stimuli (see Figure 1) that would indicate whether participants were cued by the perceptual weight or directional information of the arrow (Varga, Frick, Stansky, Beck, Dengler & Bright, 2009). In Experiment 1, the authors presented each of these different types of arrow stimuli followed by a picture on one side of the screen to children 3 to 5 years of age. This study measured the children's reaction times by coding their eye movements. Their results showed that the 3- to 5-year-olds were cued by the weight of the cues, but not their direction. The authors were hesitant to say, however, that children 5 years of age do not understand the directional information of an arrow. Because the arrows were presented for only 1000 ms, children may not have had time to process the directional information presented in the cues. Perhaps these children were reflexively cued by weight because they did not have time to interpret the symbolic meaning of the arrow.

Experiment 2 was then conducted using a more interactive methodology to investigate how children would perform if they were given as much time as necessary to process the arrow. (Beck, Swindler, Stansky, Johnson, Varga & Frick, 2009). Preschoolers and infants were presented with a weighted arrow (Figure 1a) placed between two buckets. Children were instructed to use the arrow and point at the bucket that they thought was hiding a small toy. They found that children as young as 2 ½ years of age were able to use the arrow to find the hidden toy which confirms that children are cued by the arrows. However, because the weight and direction of the arrow pointed toward the same side, this finding does not answer the question of whether children were cued by the weight of the arrow or its direction.

The current study is designed to answer some of the question presented by these two studies. The authors of Experiment 1 questioned whether children were able to extract the directional information from the arrow in the short amount of time that it was displayed. In order to address this question, we displayed the arrow cue for the entire duration of the trial to give the child as much time as necessary to process and use the cue. Similar to Experiment 2 described above, children are asked to use the picture in the middle (the cue) to decide where an animal is hiding. These directions further encourage the children to use the cue instead of relying solely on reflexive orienting. Instead of asking children to simply watch the screen as in Experiment 1, we instructed them to point to the side where they thought the animal was. Because pointing is a deliberate decision, it should give a more accurate representation of how the children are using the arrow. Overall, this method should allow us to more easily examine children's true understanding of the arrow.

Hypothesis

We expected to find that between 2 and 5 years of age, children will develop an understanding of the directional meaning that arrows indicate. Therefore, we expected to see younger children being cued by the perceptual weight of the arrow and older children being cued by its directional information. If this is the case, we would observe that older children more consistently look to the side indicated by the directional aspects of the arrow. On the other hand, we would observe that younger children will more consistently look in the direction indicated by the visual weight of the arrow.

CHAPTER TWO METHODS

Participants

We tested 34 preschoolers, age 2-5 years old with a mean age of 3.5 years. The mean age for kids younger than 3 was 2.8 (N=14) and the mean age for kids older than 3 was 4.1 (N=20). We recruited interested participants using our existing database and contacted them by phone. Both the child and his or her guardian were told about the study and asked to provide their written consent or assent. In addition, the guardian was asked to fill out a health and demographics form. The participants were each assigned a number, which was used to identify them from that point forward.

Apparatus

A computer and a Sharp rear projector (model XG-C55X) were used to display images on a screen in front of the children. As the participants watched, they were videotaped using two Panasonic VHS cameras (model LT75). One camera was focused on the child's face while the second camera videoed the images on the screen. The two video images were combined using a Videonics Digital Video Mixer (model MX-1) to display them both in a split screen view. Trials were later coded using Noldus Observer 5.0.

Stimuli

In order to investigate whether children are relying on the directional information from arrows or simply the visual weight, we used ten different arrow stimuli to tease apart these two factors (see Figure 1). These stimuli each fit into one of two categories: weighted or balanced cues. The weighted cues hold all of the visual weight on one side of the stimulus, similar to a

typical arrow. The balanced cues have an equal amount of weight on each side. In order for a participant to be cued by the balanced arrows, he or she would have to attend to the directional information because the weight of the stimulus is evenly distributed.

Of the weighted stimuli, there are several different cues to further tease apart weight and direction. We included weighted arrows (Figure 1a) that participants may be familiar with. These arrows will cue children similarly whether they are relying on weight or direction. We also included ambiguous weighted stimuli (Figure 1b), which point in a different direction than the visual weight would suggest. These arrows would cue children differently depending on whether they are relying on directional information or weight. Finally weighted squares (Figure 1e) do not indicate any directional information, and could only be understood using weight.

Balanced arrows (Figure 1c) indicate direction, but not weight since there is equal weight on each side. These stimuli would only cue children who attend to the directional information of the arrows, not weight. The arrowheads on ambiguous balanced arrows (Figure 1d) point in both directions and are equally weighted. These ambiguous balanced arrows would not provide information to children relying on weight or direction. Finally, balanced squares (Figure 1f) also do not indicate any directional or weighted information so participants would not be able to use either understanding.

Procedure

The children sat in a chair or in their parents' lap in front of a screen approximately 60cm away. Before beginning each session, children were told to use the picture in the middle of the screen (the cue) to decide where they thought the animal was hiding. They were then shown one of ten different kinds of arrow stimuli in the center of the screen for 1000 ms. This arrow stimulus remained on the screen and was joined by two identical pictures of a bucket, one on

either side of the stimulus. Children were then asked to point to the bucket they thought hid the animal. We did not use pointing response in our analyses; these instructions were only intended to keep participants engaged in the study. Rather, our dependant variable was the direction of the participant's first look on each trail. Once they made a recognizable point to one side, they were then shown a picture of the animal and asked to name it. Again, this response was not recorded and was only used to make the study more "game-like" and keep the children interested.

Participants were presented with up to 25 trials.

Coding

Each trial was classified as either usable or unusable. In order for a trial to be considered usable, the participant had to be on task for the entire trial. This means that the child watched the screen for the entire time the stimulus was displayed and then made a recognizable look to one side. Trials that did not meet these standards were not coded. The usable trials were then coded for the direction of the participant's first look. A different coder later recoded 20% of the videos for reliability.

CHAPTER THREE RESULTS

One-sample t-tests were used to examine whether the children's percentage of correct responses were different from chance response. We compared the percentage of correct responses on each type of trial to 50%. If the correct responses are significantly different than 50% then we can conclude that children are not responding at chance levels. The results of the t-tests show that children younger than 3 years of age perform at chance levels with both weight, $t(13) = 1.461, p=.168$, and directional cues, $t(12) = 1.508, p=.157$. These results indicate that neither weight nor direction cued children younger than 3 years of age. However, children older than 3 years of age perform at a level that is above chance when using weight, $t(19) = 5.269, p<.002$, but perform at chance level when using direction, $t(18) = 0.119, p=.907$. These results show that weight cues children older than 3 years of age, but direction does not.

The mean percentage of correct responses for children younger than 3 years of age when using weight was 58% ($SD = 22$) and 43% ($SD = 16$) when using direction. For children older than 3 years of age, the mean percentage of correct responses was 66% ($SD = 13$) for weight and 50% ($SD = 13$) for direction (see Figure 2).

CHAPTER FOUR

DISCUSSION

The present study was designed to investigate whether children are cued by the weight of the arrow or the direction it indicates. Our results indicate several interesting findings. First 3- to 5- year-olds are cued by the visual weight of arrows, not the directional information as we had hypothesized. There is no evidence to indicate that children respond to the direction of the arrow more than they would by chance. These results are consistent with the findings of Experiment 1 (Varga et. al, 2009), which also found that children 3 to 5 years old were cued by the visual weight of the arrow, but not the directional information.

There are several possible reasons this pattern has been observed in both studies. Because we presented the children with so many different stimuli, some of which did not have a correct response, children may have been distracted by all of the different aspects of the cues. In future studies it could be helpful to present children with only two stimuli: a balanced and a weighted arrow. This would still provide information about how children are using the two different aspects of the arrow and would not risk confusing the children with too many conflicting stimuli. Individual differences between participants could also play a role in explaining why children don't appear to use the directional aspects of the arrow like we would expect them to. It is very possible that some children use the directional information of the arrow while others do not. These individual differences in children could mask an effect that in fact does exist. Therefore, in the future each child's performance should be examined individually.

Our results also indicate that children who are younger than 3 years of age are not consistently cued by either aspect of the arrow. These results are not consistent with the findings of Experiment 2 (Beck et al., 2009) which showed that children as young as 2 ½ years of age were cued by a typical arrow to point in the direction indicated. If 2½ -year-olds can be cued by typical arrows, then we must question why our results would show that they are not cued by either weight or direction of the arrow?

Again, individual differences could account for some of the disagreement between the two studies. Also, our array of various stimuli may have again complicated the results more so than the typical right and left facing arrows used in Experiment 2. Finally, the differences may have been due to our differing methods of data collection in the two studies. The dependent measure for Experiment 2 was the child's reaching or pointing behavior toward a target, while in the present study we were interested in children's looking behavior. Perhaps the physical movement involved in pointing encourages children to provide a more deliberate response than looking behavior would. We have recorded pointing responses and will analyze this data in the future, but for the present study we were only interested in looking behavior.

Though many new research questions have been raised by this study, it has confirmed that pre-school age children who are cued by an arrow are not always using the symbolic meaning it denotes. This study indicates that preschool age children may initially be using the visual aspects of arrows when learning to understand them. It may also have implications for the development of symbolic understanding in general. During the time period that children are learning to use arrows they are also learning about many other symbols like letters and numbers. Perhaps there is a connection between these different symbolic aspects.

FIGURES

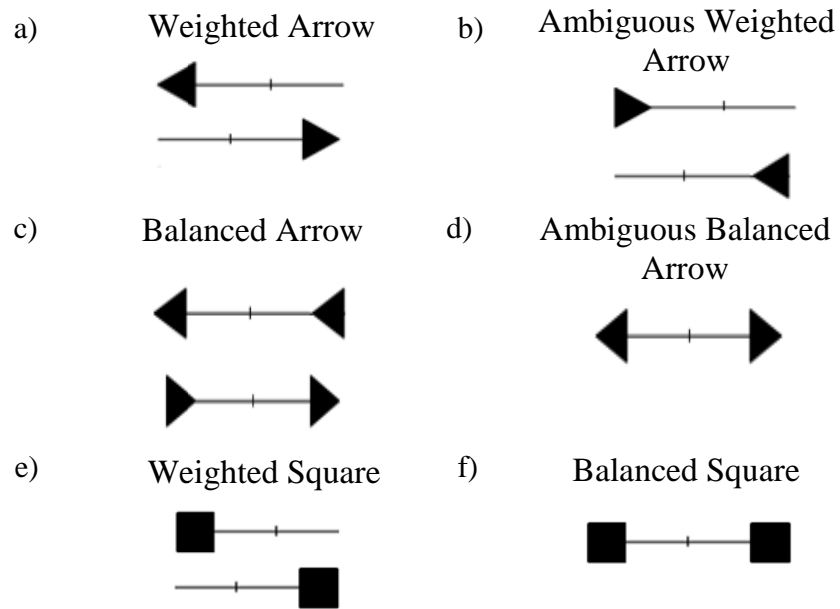


Figure 1: Stimuli

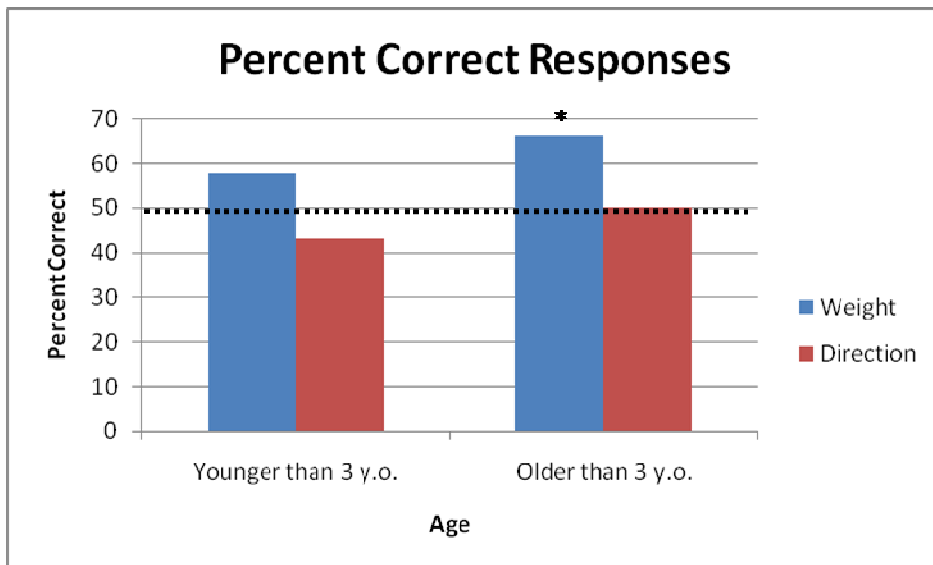


Figure 2: Results

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