Parental construction of spatial associations:

Origins of culturally-mediated left-to-right spatial associations in toddlers

Christina J. Caldera

Barnard College of Columbia University

Dr. Koleen McCrink

Senior Research Thesis

Professor Larry Heuer

April 2012

Abstract

The mapping of numbers in space to form a "mental number line" has been consistently found in adults in many different number situations. Typically, this mapping goes in a culturally-consistent direction mediated by the direction of writing, and has also been found to generalize to other non-numerical, ordinal stimuli such as the alphabet. The primary theory regarding the origins of this spatial-mapping is a causal role of the visuo-motor process of automatically scanning and reading language. Yet, more recent findings demonstrate that this directional orientation begins to develop prior to formal reading, suggesting that other earlier experiences might also be responsible for the structuring of this attentional bias. The current study investigates if and how caregivers structure the environment for their child in a culturally-congruent direction prior to any formal reading instruction. The structure of pointing behavior was observed and scored as caregivers to one- and two-year-olds described images in a slideshow task, told stories via placement of tiles with objects on them, and created scenes for their child using magnets. These children had not yet entered preschool, but were old enough for caregivers to have begun to extensively describe the environment to them. Caregivers showed a left-to-right directional preference when leading their child's attention in the slideshow task. Caregivers displayed a trend of left-to-right tile structuring during the tile placement task, and showed no preferred structuring in the magnet scene-construction task.

Many studies have demonstrated that adults obtain a tendency to mentally organize objects in space in a linear direction. These spatial associations are best observed in the Spatial-Numerical Association of Response Codes (SNARC) effect, defined as the association of low-magnitude numbers with the left side of spatial field and large-magnitude numbers with the right spatial field. The SNARC effect supports the theory of a mental number line; adults mentally visualize numbers in space. The origins of these associations in adults remains unclear, yet studies done with Arabic-speaking participants suggests that they result from the direction of writing in that culture (Dehaene, Bossini, & Giraux 1993).

Studying the development and progression of this directional association may provide insight to how children learn and comprehend math and numbers. By understanding the origins and developmental process of a directional bias, educators might productively tailor and design lesson plans targeted toward children with an impaired understanding of numbers and other ordinal objects. By recognizing how broad and generalized these directional associations spread and how they can promote better information processing, educators might also design lessons in a manner more consistent with the way children may already be processing information. Lastly, by understanding how caregivers use verbal, gestural, and other techniques in helping their child understand the world, educators may also be able to adapt such techniques for teaching young preliterate children.

The SNARC effect was first discovered by Dehaene et al. (1993). Participants in their study were shown a series of numbers, which were presented to them on a computer screen. They were then asked to indicate if the presented number was either odd or even by pressing a key with either the left or right hand, including a condition in which the participants switched hands to eliminate a handedness bias. It was discovered that reaction time to smaller-magnitude numbers was faster with the left hand, and reaction time to larger-magnitude numbers was faster with the right hand. These results demonstrated that when presented with numbers, humans automatically evoke magnitude associations, even when it is not imperative for the task. Based on these results Dehaene et al. suggested that adults have a "mental number line", oriented in a left-to-right direction. In this mental number line, the left side of space is associated with small magnitudes and the right side is associated with large magnitudes.

These space-number associations have also been shown to affect attentional processes (Fischer, Castel, Dodd, & Pratt, 2003). In Fischer et al. (2003) participants were asked to do a dot probe task that had them look at a target number in the center of a computer screen. A stimulus then appeared on the either side of the screen, and participants were asked to press the space bar as soon as the stimulus was detected. Fischer et al. observed that participants were faster at detecting the stimulus on the right side of the screen when the target number was large. Conversely, participants were faster at detecting the stimulus on the left side of the screen when the target number was small. These results demonstrated that spatial placements that are mentally associated with number magnitude shifted attention, thereby decreasing reaction time for participants to detect the dot probe stimulus when number and associated side were consistent.

The directional spatial associations as demonstrated in the SNARC effect have also been demonstrated with non-numeric but still-ordered stimuli (Gevers, Reynvoet, & Fias, 2003). Gevers et al. (2003) conducted a study in which participants were asked to determine if a month was before or after the target month July by pressing a key with either hand. Participants were faster with indicating earlier months with the left hand, and later months with the right hand. This study has been duplicated with other ordinal sequences such as days of the week (Gevers, Reynvoet, & Fias, 2004) and even with relational reasoning tasks (Prado, Van der henst, &

Noveck 2008). In Prado et al. (2004) participants were asked to memorize a spatial reasoning scenario (e.g. Anne is to the left of Louise, Claire is to the left of Eve, etc.). They then responded to a series of True/False statements about where certain people were seated in relation to one another by pressing a key with either hand. Participants were faster in responding with the left hand when prepositions involved pairs on the left, and faster with the right hand when prepositions involved pairs on the right. Similar results were found when the reasoning scenario was created in a vertical direction with the prepositions "above" and "below." Participants responded with upper pairs significantly faster with the left hand, and the lower pairs significantly faster with the right hand. Together, these studies suggest that adults tend to mentally organize objects as well as numbers, and relational objects in a left-to-right horizontal direction. The SNARC effect is therefore not simply a way in which humans perceive numbers and magnitudes, instead it appears to be the result of a more basic tendency toward processing information in a horizontal direction.

The orientation in which humans mentally organize and structure items has been also been demonstrated to be culturally influenced through the direction of writing. In research done with participants from cultures that read from right-to-left, researchers have been able to show a reverse or depletion in the SNARC effect (Dehaene et al., 1993; Zebian, 2005). Dehaene et al. (1993) also noted that depletion of the SNARC effect was related to the length of time these participants had lived in a country that used a left-to-right language. Iranian subjects, who read in a right-to-left direction in their native language, but studying in a French school that wrote in the reverse direction, displayed a reversed SNARC only when they were late language learners, or recent residents. In contrast, Iranian participants who had lived in France for several years displayed a slight left-to-right directional bias consistent with the left-to-right SNARC effect

(Dehaene et al., 1993). Therefore the direction this directional bias takes appears to be influenced by the direction of language and can be reversed or weakened through exposure to a language written in the opposite direction.

In a later study (Shaki & Fischer, 2008), Russian-Hebrew bilingual participants were instructed to do a parity task after they had read a text in either Hebrew (read from right-to-left) or in Russian (read from left-to-right). The SNARC effect was evident when participants had read a text in Russian, and was significantly weakened when they had read a text in Hebrew. These results strongly suggested that the SNARC effect is flexible and influenced by the direction of reading and language. It can also be argued through these findings that the directional bias displayed in SNARC is by default organized in the direction of written language predominantly used in that culture.

Yet, SNARC can also be influenced by other situational factors that may influence processing in a reversed direction. In an early study on the topic, (Berch, Foley, Hill, & Ryan, 1999) researchers found that children did not display a traditional parity task SNARC effect until 9 years of age, which supported prior claims (Dehane et al., 1993) that self-directed, automatic reading was the contributing factor for the development of the mental number line. However, more recent studies that used a different paradigm emphasizing ordering, had pre-literate children learn the verbal-numbers of 5 linearly placed compartment rooms in a large “sample box” (e.g. “one room,” two room,” “three room…”). Children then had to then use those verbal labels to find objects hidden in another set of similar compartment rooms in the “matching box.” Children were faster and more accurate when the compartments were numbered in an increasing left-to-right direction both the “Sample box” and “matching box.” This was taken to suggest that pre-literate children in western cultures also display a tendency to code numbers left-to-right

(Opfer, Thompson, & Furlong, 2010; Opfer & Furlong, 2011). These findings indicate that left-to-right mapping of ordered objects in space as seen in adults begins to develop prior to formal reading instruction. The speed and accuracy displayed when coding information in a left-to-right direction also seems to give children a boost in processing information.

The current study is designed to observe if and how spatial associations begin to develop though early interactions with the environment. Early in a child's life, caregivers play a significant role in teaching them about the world and how it works. If these spatial biases are present in young children, as observed in previous studies, then caregivers may be acting as the vehicle by which this spatial bias begins to develop. Caregivers may be structuring their child's surroundings for them in a preferred direction. The preferred direction is likely to be highly influenced by culturally specific habits, such as reading and writing. In order to capture if and how caregivers are structuring their child's environment, 3 tasks were administered in the current study measuring if and how caregivers organized information for their child in a culturally-congruent direction.

In the present study, caregivers and their one- and two-year-old children were each given three different tasks to engage in together. Children at this age have not yet begun preschool or received any formal reading instruction. These assigned tasks were designed to permit us to measure if and how often caregivers structure their child's environment in a particular direction. All 3 tasks were given to participants, and administered in different orders.

In one task, caregivers were presented with a slideshow of images oriented in 3 different types of directions: a right-to-left direction, left-to-right direction, or in an indiscriminate non-ordinal direction (e.g., a line of ducks swimming from left-to-right). Gestural leading (pointing) of 3 different directions (right-to-left, left-to-right, indiscriminate single points) were coded for each type of slide to examine if there was any directional preference in how caregivers drew their child's attention. A second task required caregivers to create a story for their child using foam tiles with different images of objects, characters, and places. This task permitted us to observe if caregivers showed any directional preference for tile placement when conveying the story to their child. Whether or not caregivers stacked tiles was also measured. A third task had caregivers create a scene for their child using a magnetic board with 9 magnet figures they could place on the board. We examined if caregivers constructed scenes/images for their child in any consistent direction (e.g., placing magnets initially on the left and ending the magnet placing on the right). In order to observe whether or not caregivers are organizing the information in a culturally-congruent direction for their *child*, or out of habit for *themselves*, we manipulated whether caregivers were sitting on the same side as their child, or across from their child in both the story tile and scene-creation task.

If caregivers are shaping their child's focus in a culturally-influenced direction, it is expected that in all tasks they will lead their child's attention, or arrange objects in a direction congruent with the direction of language in their culture (left-to-right for our English-speaking dyad population). Thus, caregivers should display a culturally-influenced left-to-right directional bias when engaging in the tasks with their children, and switch the directionality of their structure in order to be congruent with the child's viewpoint when they are sitting across from (and not with) him/her.

Methods

Participants

A total of 32 participants completed this experiment (*N*=32). Due to various complications presented throughout the study (e.g. child fussiness, time limitations, completion of only a few of the tasks, etc.) the amount of participants in each task varies. Caregivers in this sample consisted of mothers, fathers, or grandparents. For the Slideshow task, 27 participants were sampled (*n*=27). The average age of child participants in the Slideshow task was 2.06 years; age range was from 1.27-2.99 years. For the Story tiles task, 20 participants were sampled (*n*=20). The average age of child participants in the Story tiles task was 2.22 years; age range was from 1.32-2.99 years. For the Create-a-scene task, 17 participants were sampled (*n*=17). The average age of child participants in the Story tiles task was 2.06 years; age range was from 1.26 to 2.99 years.

Participants were recruited though two methods. Some participants were recruited and participated in the study at The Children's Museum of Manhattan or were recruited through the Barnard Cognitive Development Center database, and later run at the center. Sessions with participants recruited at the museum were conducted in a private room at the museum with a similar set up as sessions conducted at the center. When recruited, caregivers were asked if they would like to participate in a short study concerning how children learn about space and number though parent-child interactions.

Slideshow task

In the slideshow task, all participants were presented with a slideshow consisting of images oriented in one of three directions (right-to-left, left-to-right, or indiscriminate), in order to prompt pointing in general as well as many different types of points. Three behaviors (right-to-left pointing, left-to-right pointing, or indiscriminate pointing) were measured for each slide type (Left-to-right slides, Right-to-left slides, Indiscriminate slides). Right-to-left slides had images with stimuli organized in a right-to-left direction, Left-to-right slides had images with stimuli organized in a left-to-right direction, and Indiscriminate slides had images with stimuli organized in no particular direction (See Figure 1).

Materials and Procedures

A 17" Macbook Pro laptop or a 21.5" screen iMac computer was used to view the slideshow. Slideshows were created and presented using the Apple iWork Keynote program. The slideshow consisted of twelve slides with 3 different slide types (Right-to-left slides, Left-to-right slides, Indiscriminate slides). 4 slides were Right-to-left slides that presented stimuli in a right-to-left direction (See Figure 1.1). Another four were Left-to-right slides that presented stimuli in a left-to-right direction (See Figure 1.2). Another four were Indiscriminate slides that presented stimuli with no particular direction (See Figure 1.3).

Images were created either on iWork Keynote, or were obtained from the Internet. Each slide was shown on the screen for 15 seconds with a 2 second transitional slide in between. Transitional slides displayed only the text "Ready?" in the center with an accompanying audio clip stating the slide presentation number (e.g. "slide one," "slide two," etc.). During the actual presentation of slides, all types of slides were intermixed. Three slideshows were created with each presenting all of the slides in different arbitrary orders. One third of the participants were randomly assigned to view one of the three slideshows.

Children were asked to sit on their caregiver's lap in front of the computer screen. A Camera was positioned above the participants' head giving an above view of the area between the participant and the computer screen. Caregivers were asked to explain the images on the screen to their child as they would anything else they saw in their everyday lives.

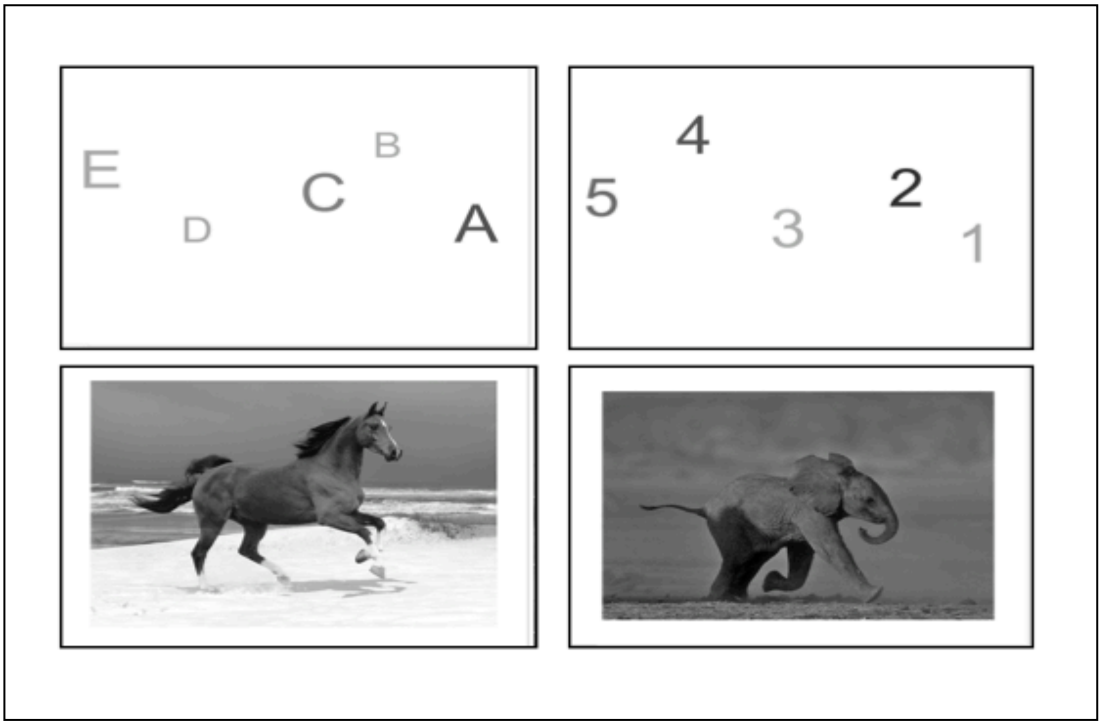

Figure 1.1: Stimuli used for Right-to-left slides. Letters and numbers were ordered starting on the right and ending one the left. Animal images were determined to be right-to-left with the head on the right side of the image, and the tail on the left side of the image.

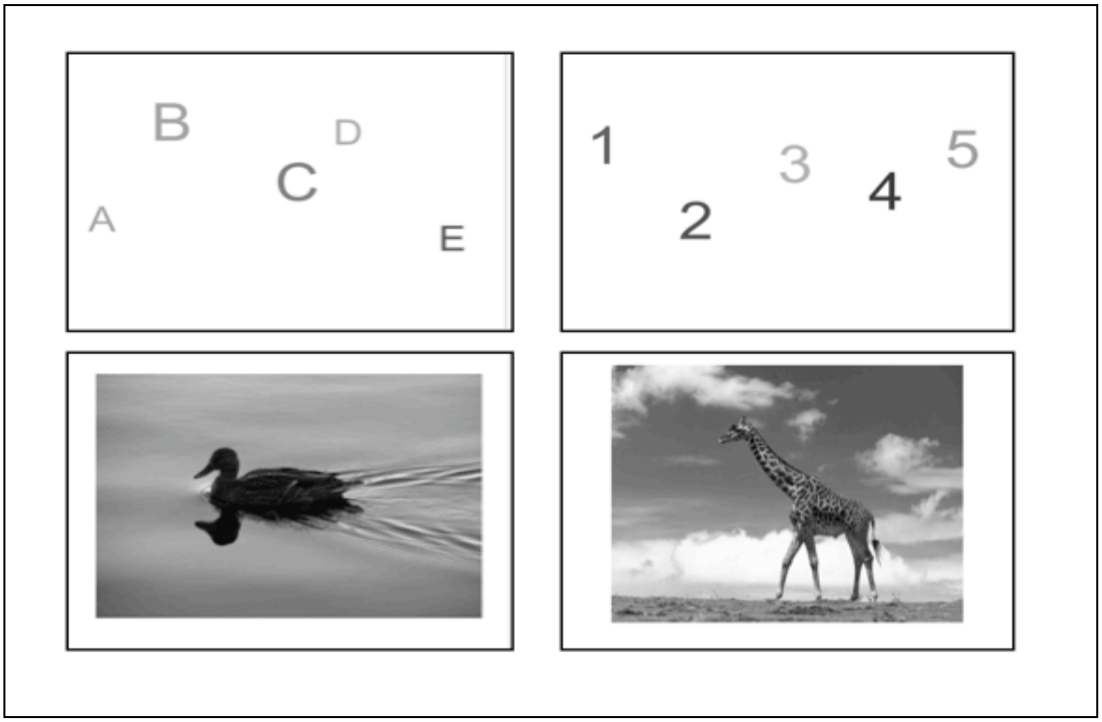

Figure 1.2: Stimuli used for Left-to-right slides. Letters and numbers were ordered starting on the left, and ending on the right. Animal images were determined to be left-to-right with the head starting on the right side of the image, and the tail the right side of the image.

Figure 1.3: Stimuli used for Indiscriminate slides. Indiscriminate images contained stimuli structured in no particular order.

Coding

Point types were categorized as going in a left-to-right direction, right-to-left direction, or indiscriminate direction. Indiscriminate pointing typically consisted of pointing once at the screen and then removing the hand. Videos were subsequently employed to measure Point type (right-to-left pointing, left-to-right pointing, indiscriminate pointing) for each slide type (Right-to-left slides, Left-to-right slides, Indiscriminate slides). As to not create bias, coders were blind to the image that was presented to participants.

Create-a-scene task

In the Create-a-scene task, participants were presented with a magnet create-a-scene board and 9 magnet figures. Caregivers were asked to create a scene for their child using the figures. The amount of times that caregivers placed a magnet to the right of a previously placed magnet (left-to-right direction) or to the left of a previously placed magnet (right-to-left direction) was measured for each participant. The caregiver side, or side in which children were placed relative to their caregiver, was manipulated to observe whether caregivers continued to order the magnets in a preferred direction for their children and not because it is how they view the world. Children were randomly assigned to sit either across from their caregiver, or on the same side directly in front of their caregiver. Participants were given 9 magnets, which equally prompted different types of structuring behavior from the caregiver; 3 suggest left-to-right motion, 3 right-to-left motion, 3 suggest no directional motion at all. To control for any influence the magnet board itself might have on directionality of magnet placement, 3 different create-a-scene boards were used.

Materials and Procedures

Three 18" x 14" magnetic Create-a-scene boards were used. Create-a-scene boards are a product of Patch products. 3 different scenes were used: Zoo scene, Town scene, and Trains scene. Participants were randomly assigned to receive one of the three scenes. 9 magnet figures were selected from the array of 33 figures available for each scene. Three of the magnet figures were animate objects faced towards the right implying a left-to-right motion (e.g. car faced toward the right); three were animate objects faced toward the left implying a right-to-left motion (e.g. dog faced toward the left); and the last three figures were non-animate objects with no directionality (e.g. picnic basket).

Caregivers were randomly assigned one of the three create-a-scene boards with its appropriate magnets. Children were also randomly placed either on the same side of their caregiver, or sitting across their caregiver with the create-a-scene board oriented in their direction. Create-a-scene boards were placed in front/between participants. A camera was positioned above with a clear view of the magnet board. Caregivers were instructed to simply create a scene for their child using the 9 magnet figures provided.

Coding

For each video, coders measured the frequency of figures placed to the right of, or to the left of a previously placed figure. If a figure was placed to the right of a previously place figure, then they were given a score of 1 for left-to-right placement. If a figure was placed to the left of a previously placed figure, then they were given a score of 1 for right-to-left placement.

Story tiles task

Participants were given 10 tiles of different images, and asked to tell a story to their child using the tiles. Placement direction was recorded for 4 different types of placement (left-to-right,

right-to-left, stacking, vertical above and below) for each participant. The caregiver side, or side in which children were placed relative to their caregiver, was manipulated to observe whether caregivers continued to order the tiles in a preferred direction for their children and not because it is how they view the world. Children were randomly assigned to sit either across from their caregiver, or on the same side directly in front of their caregiver. To control for possible confounds resulting from the order in which tiles were stacked, participants were randomly assigned one of two possible orders for the tiles (each order was the reverse of the other).

Materials and Procedures

Ten 6” x 6” foam tiles were used. Each tile had a cartoon image of an animal (e.g., a squirrel), or an object (e.g. picnic basket), or a setting (e.g. park) in the center of the tile. Images were obtained though the Internet, and were selected to be as symmetrical as possible with no implied directionality. A camera was positioned above capturing a clear view of the area in front of the participants. Caregivers were then given the Story tiles in a stack and asked to simply create a story for their child using the tiles.

Coding

For each video a coder measured how many times caregivers structured tiles left-to-right, right-to-left, vertically, or stacked them on top of one another. Placing a tile to the right relative to a previously placed tile was scored as left-to-right. Placing a tile to the left relative to a previously placed tile was scored as right-to-left. Placing a tile above or below a previously placed tile was scored as vertical structuring. Placing tiles on top of one another with no spatial direction was scored as stacking.

Results

Slideshow Task

In order to observe if caregivers were structuring slides in a preferred left-to-right direction we tabulated the number of points (pointing frequency) and the point type (left-to-right, right-to-left, indiscriminate) for each slide type (Right-to-left slides, Left-to-right slides, and Indiscriminate slides). 4 dyads were eliminated from the final sample due to participants' incompletion of the slideshow (*n*=3) or from not pointing at all (*n*=1). In order to observe if caregivers are structuring slides in a preferred direction we measured pointing frequency for each point type (right-to-left pointing, left-to-right pointing, and indiscriminate pointing) for each slide type (Right-to-left slides, Left-to-right slides, and Indiscriminate slides). An omnibus repeated measures ANOVA on pointing frequency with slide type (Right-to-left slides, Left-to-right slides, Indiscriminate slides) and point type (right-to-left, left-to-right, indiscriminate) as within-subjects factors, and child gender (male, female), age (1-year-old, 2-year-old), slideshow presentation order (order in which slides were presented in an arbitrary order a, b, or c), location (where subjects were run: at lab, at museum in Tuesday room, at museum in Thursday room) as between subject factors.

A significant main effect of point type was also revealed $F(2,14)=8.08$, $p<.01$; pairwise comparisons corrected for multiple comparisons and illustrate that there was significantly less Right-to-left pointing demonstrated by caregivers (M=1.98) relative to Left-to-right pointing (M=4) or Indiscriminate points (M=3.67; both $p<.05$). Left-to-right and Indiscriminate point means do not significantly differ.

A critical interaction was also shown between slide type and point type, $F(4,28)=3.03$, $p=.03$; Caregivers adjusted their type of point as a function of the type of slide. Caregivers were equally likely to exhibit all 3 types of points (right-to-left, left-to-right, indiscriminate) when viewing Right-to-left slides (*M*=3.8, 3.7, 3.5, respectively; see Figure 2). When viewing Left-to-right slides, caregivers were least likely to point right-to-left (*M*=1.02), most likely to point left-to-right (*M*=5.2), and intermediately likely to exhibit indiscriminate pointing (*M*=3.6; see Figure 3). Lastly, when viewing Indiscriminate slides, caregivers pointed most frequently in an indiscriminate direction (*M*=3.9), intermediately left-to-right (*M*=3.2), and least right-to-left (*M*=1.08; see Figure 4).

In order to statistically quantify these relationships for each slide type, a series of follow-up repeated measures ANOVAS with point type (right-to-left, left-to-right, indiscriminate) as within-subject variable and gender, age, slide presentation order, and location, as between-subject variables were performed to observe pointing behavior within each individual slide type. No main effects were observed for any of the variables for Right-to-left slides; caregivers exhibited equal amounts of all pointing types. For Left-to-right slides, as well as Indiscriminate slides, caregivers were significantly less likely to demonstrate right-to-left pointing than either of the point types, left-to-right and indiscriminate (which did not differ from each other). There were no main effects or interpretable interactions of gender, slide presentation order, or location. These variables are not further examined in following analysis. There was a significant main effect of age, $F\,(1,7)=5.86$, $p<.05$, with caregivers pointing slightly more to 1-year-olds than 2-year-olds (3.7 points vs. 2.8; $p=.09$ for the follow up pairwise comparison).

A marginal main effect of slide type $F\,(2,14)=3.09$, $p=.08$, on pointing frequency was revealed; a test of with-subjects contrasts showed that this trend was driven by a linear trend of maximum overall pointing in Right-to-left slides (*M*=3.8 points), middling overall pointing in Left-to-right slides (*M*=3.3), and least pointing in Indiscriminate slides (*M*=2.7).

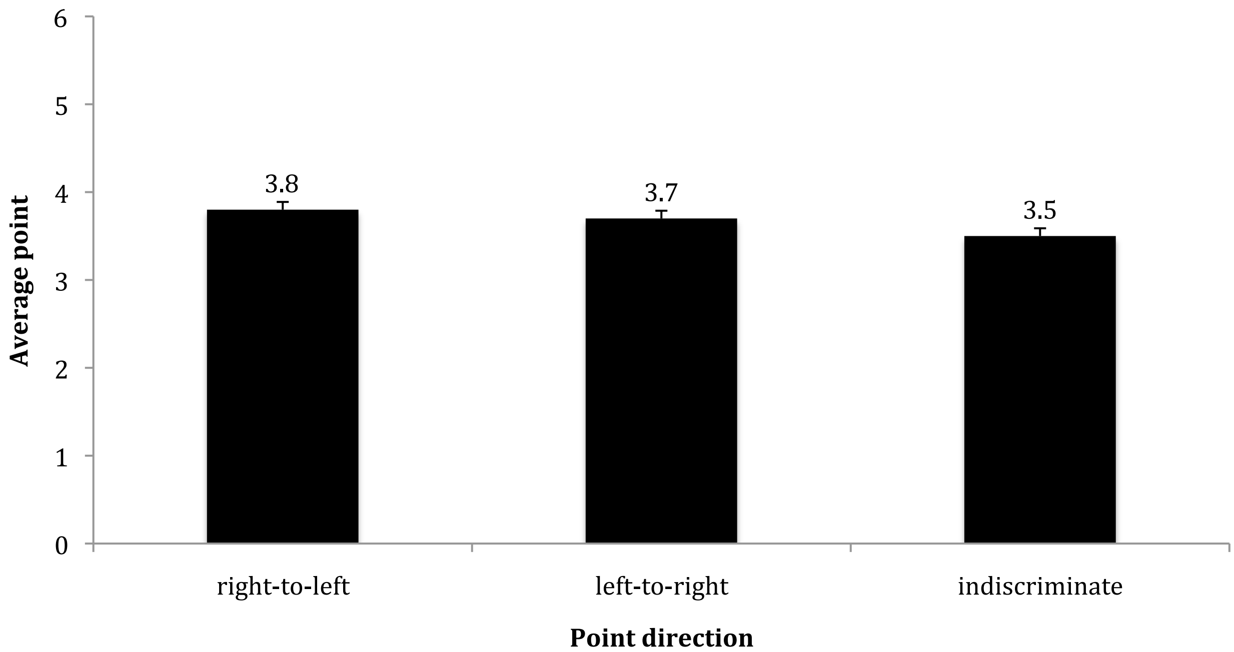

Figure 2: Slideshow task: Average of directional pointing for Right-to-Left slides. Right-to-left, left-to-right and indiscriminate pointing was calculated for Right-to-left slides for each participant, and then averaged. Error bars represent standard error.

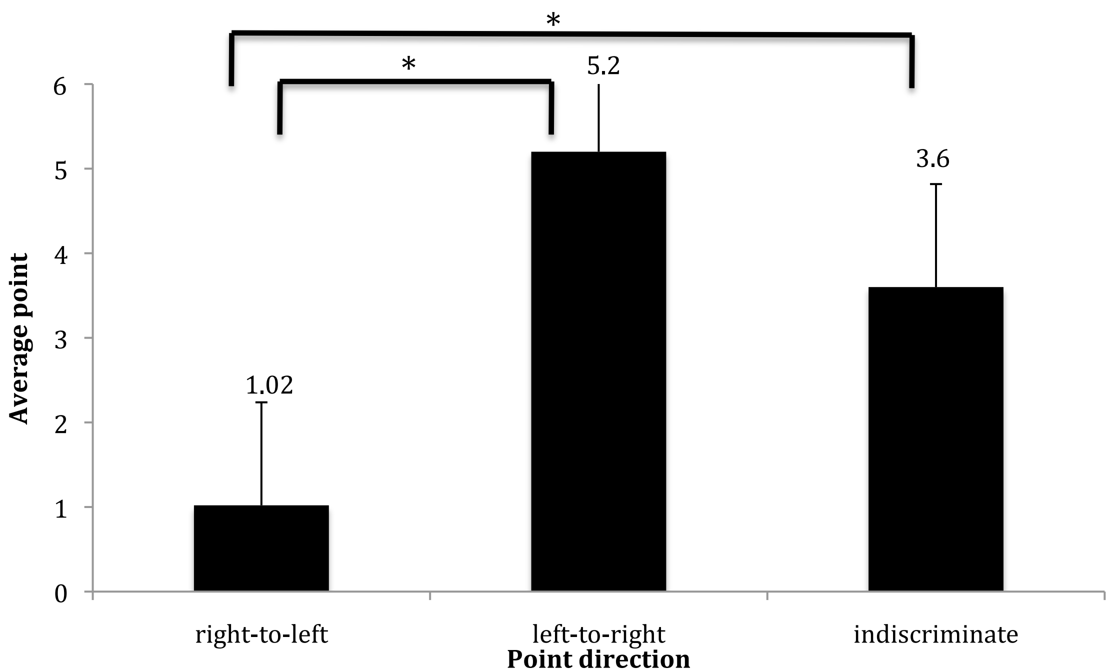

Figure 3: Slideshow task: Average of directional pointing for Left-to-Right slides. Right-to-left, left-to-right, and indiscriminate pointing was calculated for Left-to-left slides for each participant, and then averaged. Error bars represent standard error. Significance is indicated with an asterisk, *p<. 05.

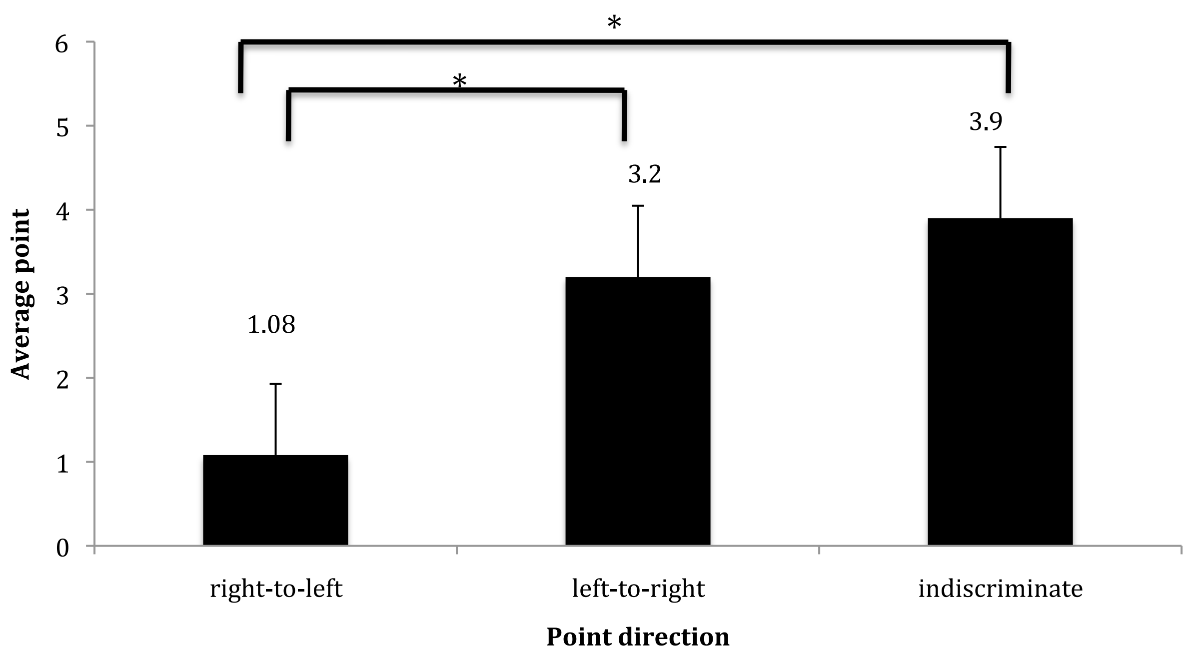

Figure 4: Slideshow task: Average of directional pointing for Indiscriminate slides. Right-to-left, left-to-right and indiscriminate pointing was calculated for Indiscriminate slides for each participant, and then averaged. Error bars represent standard error. Significance is indicated with an asterisk, *p<. 05.

Story tiles Task

In order to observe if caregivers were placing the tiles in a preferred direction, a repeated measures omnibus ANOVA on stacking behavior of caregivers was conducted with direction type (right-to-left, left-to-right, stacking, and vertical) as the within-subjects variables, and gender (male, female), age (1-year-old, 2-year-old), tile stacked order (tile type a or b presented first), caregiver side (with caregiver or across caregiver) and location (where the participant was run: in lab, in museum Tuesday room, in museum Thursday room) as between subject factors. There was no main effects or interactions of the between subjects variables (all $p > .05$), for this reason all following analyses do not follow up on the factors.

A follow up ANOVA with direction type (right-to-left, left-to-right, stacking, and vertical) revealed a significant effect of direction type, $F(3,57) = 9.46$, $p < .001$; pairwise comparisons, corrected for multiple comparisons, established that caregivers placed tiles Left-to-right marginally more than Right-to-left (2.9 vs. .95, $p = .07$) and significantly more than vertically (2.9 vs. .25, $p = .04$). Caregivers placed tiles Left-to-right and Stacking similarly (2.9 vs. 5.5, respectively, $p = .94$). Caregivers also placed tiles Right-to-left significantly less than Stacking, and comparably to the vertical placements ($p = .14$). Caregivers stacked tiles significantly more than organizing them in a right-to-left, or vertical direction ($p = .01$), and comparably to reft-to-right placement.

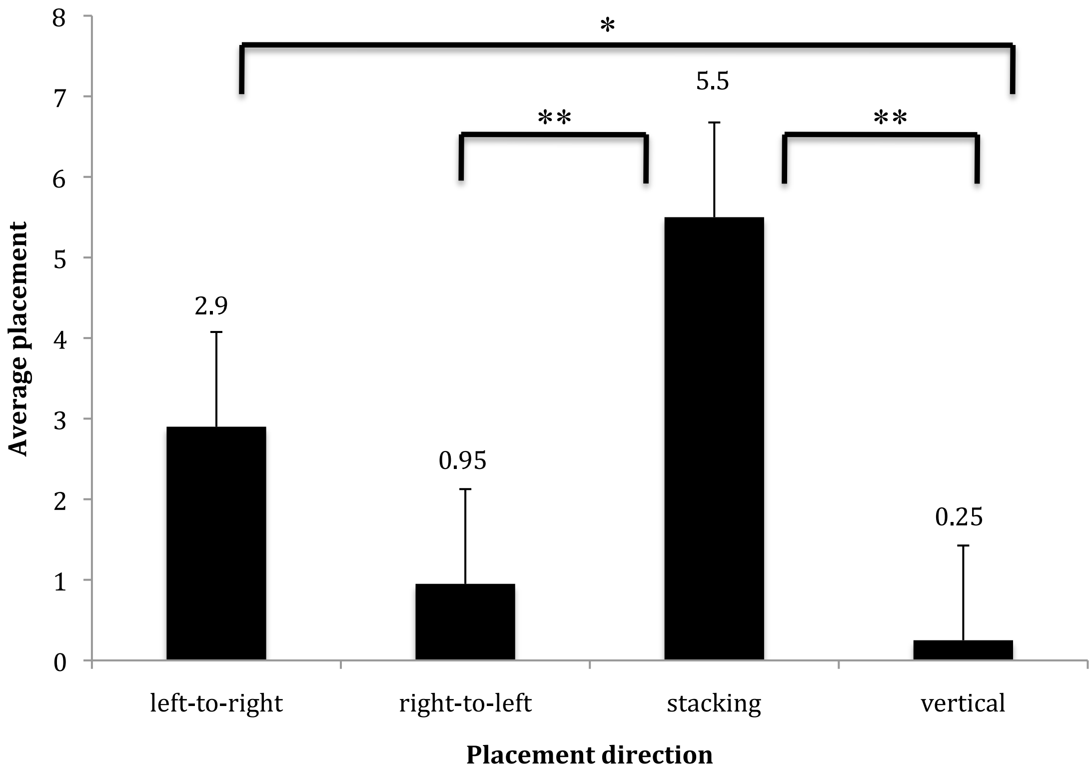

Figure 5: Average directional placement for Story tiles. Left-to-right, Right-to-left, Stacking, and Vertical tile placement was calculated for each participant, and then averaged across all participants. Error bars represent standard error. Significance is indicated with an asterisk, *p<. 05, **p<. 01.

Create-a-scene Task

In order to observe if caregivers were organizing the create-a-scene in a preferred direction, the amount of times they placed magnets to the right of a previously placed magnet (left-to-right direction), and to the left of a previously placed magnet (right-to-left direction) was measured for each participant. It was observed that Caregivers organized magnets in a Left-to-right direction (M=2.53) in equal amounts as Right-to-left (M=2.53). Since there is literally no difference between the direction magnets were placed, no further analysis was conducted.

Discussion

As previous studies have demonstrated, adults and preliterate children have a tendency to spatially encode and organize ordinal information in a horizontal left-to-right direction (Dehaene et al., 1993; Opfer et al., 2010; Opfer & Furlong, 2011). Since preliterate children are displaying these tendencies prior to formal reading education, we hypothesized these biases originate from early spatial-structuring modeled by caregivers. The current study investigated whether or not caregivers structured the environment for their children in a culturally-congruent direction, driven by the direction of language (Dehaene et al., 1993; Zebian, 2005). Caregivers and their children were given 3 different tasks to perform in order to capture any directional modeling performed by caregivers. If participants from a Western culture are structuring their child's surroundings in a culturally-congruent direction, then they are expected to frame that information in a left-to-fight direction significantly more than another other direction. By observing the techniques caregivers use to construct these spatial associations in young children, educators can modify teaching strategies tailored to promote this development, that can later reinforce better encoding of information (Opfer et al., 2010; Opfer & Furlong, 2011).

Slideshow task

For the Slideshow task, in slides oriented in a right-to-left direction, caregivers were equally likely to exhibit all types of pointing. In contrast, Left-to-right slides produced a different pattern of pointing, suggesting that the directional orientation of the stimuli presented on the slides is not the sole mediator of pointing direction. In Left-to-right slides, caregivers pointed significantly more left-to-right than right-to-left. These results illustrate a tendency for caregivers to organize information in culturally-consistent left-to-right direction. When slides were organized in a familiar left-to-right direction, structuring in the congruent direction is significantly increased. Thus supporting the hypothesis that caregivers are leading their child's attention in a culturally-consistent direction, particularly when the presented stimulus encourages that direction of structuring. In contrast, for Right-to-left slides, right-to-left and left-to-right pointing do not differ, demonstrating that when stimuli is organized in a unfamiliar right-to-left direction, caregivers resist their natural inclination to structure left-to-right, in order to accommodate the unaccustomed slide organization. Caregivers also showed more overall pointing in Right-to-left slides. The increase in overall pointing possibly results from caregivers' pointing left-to-right, as per their natural inclination, as well as structuring right-to-left, propelled by the slide type. If caregivers are structuring as they naturally would in a left-to-right direction, but also structuring right-to-left as the slides prompt, this would likely explain the lack of difference between left-to-right points, and right-to-left points in Right-to-left slides.

More revealing is the frequency of point type for Indiscriminate slides. For slides with no particular structure, participants displayed significantly more culturally-congruent left-to-right pointing, than right-to-left. When caregivers were presented with images that provide no directional cues and no contain particular structure, they continue to lead their child's attention in a preferred left-to-right direction. Indiscriminate pointing typically consisted of caregivers pointing a single time at the screen in order to capture their child's attention, resulting in consistent indiscriminate pointing for all 3 slide types. Unsurprisingly, caregivers pointed slightly more to 1-year-olds, than 2-year-olds. This effect is likely due to older children having longer attention span; caregivers thus did not have to point as often to sustain their attention. 2-year-olds are also likely more engaged with their caregivers and have the ability and knowledge to comment and answer questions pertaining to the presented slide, rather than have caregivers continuously describe the slide.

Story tiles task

In the story tiles task, caregivers demonstrated overall more stacking placement when arranging the tiles for their child. Yet, when caregivers do spatially structure the tiles for their child, they do so in a horizontal left-to-right direction more than either right-to-left or vertically. These effects were found irrespective of whether children were sitting on the same side, or across from their caregiver, affirming that when caregivers organize the tiles in a spatial-temporal direction, they do so in a horizontal left-to-right direction for their child's benefit. Therefore, when their child is sitting across from them, caregivers put effort into organizing the tiles in a culturally-congruent left-to-right direction for their child's perspective, and not their own.

During the Story tiles task, caregivers were asked to tell a story to their child using the tiles provided. Caregivers would often individually describe each tile, rather than create a continuous story, resulting in subsequently stacking each tile. Creating a story takes effort, and quick thinking, that some caregivers do not have the motivation to make, or that does not come naturally to them. Children would often get restless and caregivers would describe each tile individually rather than create a full story in order to better keep their child's attention. All of these factors may have contributed to the overall increase in tile stacking.

Create a Scene task

In the Create-a-scene task, caregivers showed no directional preference when constructing the scene for their child. They placed magnets left-to-right and right-to-left equally. The lack of any directional placement is in all likelihood the result of study's create-a-scene board. The create-a-scene boards were folded vertically in the middle for easy storage. This bisection may have encouraged caregivers to place magnets equally on both sides as they were creating the scene. This would result in a back and forth placement in order to keep both sides of the board balanced producing the effects observed in the results. Another factor that may have interfered with caregiver's structuring was the background scene already provided on the magnet board. The create-a-scene boards and magnet figures were selected to control for prompting no particular direction. Although this precaution was taken, the create-a-scene board still displayed a background scene with several different events occurring. Even though create-a-scenes were controlled for, caregivers may have placed more emphasis on the actual context of the scene, rather than automatic initial placement. In future studies, a more innocuous scene with no preexisting scenes occurring may prove to be a better manner in which to capture if and how caregivers are structuring the environment for their child.

This early spatial structuring is a possible origin of left-to-right spatial biases exhibited children and adults. Further work is still required to strengthen the hypothesis that early culturally-mediated structuring in childhood prompts the development for spatial structuring of ordinal information. Following steps would include conducting this study with caregivers from a culture that reads in an opposite right-to-left direction in order to observe if the opposite effect is found. If it were found that caregivers from cultures that read from right-to-left are structuring their own children's environment in a right-to-left direction, then this would further strengthen the claim that this spatial bias in preliterate children is mediated by culture. Further supporting evidence can later be gathered by observing whether or not these same children who participated in this study also display a preference for encoding and organizing ordinal information in a culturally-congruent direction prior to any formal reading direction. Correlational studies can be conducted to see if caregivers who structured their child's surroundings in a culturally-congruent direction more, have children who begin to demonstrate stronger, or earlier spatial bias than children whose caregivers did not structure their surroundings in a preferred direction.

References

Berch, D. B., Foley, E. J., Hill, R. J., & Ryan, P. M. (1999). Extracting parity and magnitude from arabic numerals: Developmental changes in number processing and mental representation *Journal of Experiemental Child Psychology 74*, 286-308.

Dehaene, S., Bossini, S., & Giraux , P. (1993). The Mental Representation of Parity and Number Magnitude *Journal of Experimental Psychology: General 122*(3), 371-396. doi: 0096-3445/93

Fischer, M. H., Castel, A. D., Dodd, M. D., & Pratt, J. (2003). Perceiving numbers causes spatial shifts of attention *Nature Neuroscience 6*(6), 555-556.

Gevers, W., Reynvoet, B., & Fias, W. (2003). The mental representation of ordinal sequences is spatially organized. *Cognition 37*(3), B87-B95.

Gevers, W., Reynvoet, B., & Fias, W. (2004). The Mental Represenation of Ordinal Sequences is Spatially Organised: Evidence fom Days of the Week (abstract). *Cortex*, 171-172.

Opfer, J. E., & Furlong, E. E. (2011). How Numbers Bias Preschoolers' Spatial Search. *Journal of Cross-Cultural Psychology 42(4),* 682-695.

Opfer, J. E., Thompson, C. A., & Furlong, E. E. (2010). Early development of spatial-numeric associations: evidence from spatial and quantitative performance of preschoolers *Developmental Science 13*(5), 761-771.

Prado, J., Van der henst, J.-B., & Noveck , I. A. (2008). Spatial associations in relational reasoning: Evidence for a SNARC-like effect *The Quarterly of Experimental Psychology 61*(8), 1143-1150.

Shaki, S., & Fischer, M. H. (2008). Reading space into numbers --a cross-linguistic comparison of the SNARC effect *ScienceDirect*, 590-599.

Zebian, S. (2005). Linkages between number concepts, sptaial thinking, and directionality of writing: The SNARC effect and the reverse SNARC effect in english and arabic monoliterates, biliterates and illiterate arabic speakers *Journal of Cognition and Culture* 165-190.