The Time is at Hand:
Literacy Influences Children's Gestures About Time

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1. Introduction

Learning language involves not only mastery of native speech patterns, but also acquisition of native gesture patterns. However, we do not yet know when gesture shows evidence of native patterns in the expression of more abstract concepts, such as metaphors. In this study we focus on spatial metaphors for time—an abstract domain that shows variability in its expression both in speech and in gesture. Adult English speakers predominantly express **time in speech** by placing it on a *sagittal axis* in relation to the speaker, with the future ahead ("2016 is ahead of us") and the past behind ("2014 is behind us"). In contrast, they frequently express **time in gesture** along a *lateral axis* by placing past to the left and future to the right of the speaker—congruent with their exposure to the left-to-right writing system of English (Casasanto & Jasmin 2012). In this study, we ask how early we see evidence of a left-to-right bias in young children's gestures about time. If the left-to-right bias in gestures about time is largely a by-product of literacy in a particular language, then we would predict that pre-literate children will not show a left-to-right bias in their gestures about time, producing relatively fewer lateral gestures. In contrast, we would predict emergent-literate children to show a left-to-right bias in their gestures, at rates higher than preliterate children, because of their increasing exposure the left-to-right writing system of English.

Adults' production of gestures about time

In English we commonly talk about time as moving toward and away from the self (e.g. "Christmas is fast approaching", "Summer is behind us"), placing the trajectory of motion on a sagittal axis (toward and away from the body; Gentner, Imai, & Boroditsky, 2002; Moore, 2006). However, the most frequent way that English speaking adults *gesture* about time is on a lateral axis, from left to right, with the past to the left and the future to the right, similar to the system of reading and writing in English (Casasanto & Jasmin, 2008). In fact, previous

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research that examined speakers' processing of time metaphors has shown that English speaking adults conceptualize time as moving from left to right, mirroring the patterns observed in their gestures. In one such study, Boroditsky, Furhman, and McCormick, (2010) examined reaction times in a group of monolingual English speakers in a task that tested left-to-right lateral bias in spatial representations of time. They presented adults with a picture of a famous celebrity in the middle of a computer screen. After a set amount of time, another picture of the same celebrity would appear in place of the stimulus picture, which was either a picture of their younger self or older self. Adults indicated whether it was an 'earlier' or a 'later' picture by pressing a button on the keyboard. For half the participants the 'earlier' button was on the left and for the other half the 'later' button was on the left. Participants identified the correct picture significantly faster if the 'earlier' key was on the left and the 'later' key was on the right than vice versa, showing an effect of the left to right lateral orientation in processing temporally related events among English speakers.

Similar effects of writing systems have been shown for adult speakers' conceptualization of time across languages with writing systems that differ in directionality. One study compared Spanish-speaking adults (left-to-right) to Hebrew-speaking adults (right-to-left) in their spatial representation of time (Ouellet, Santiago, Israeli, & Gabay, 2010). In this study native Hebrew and Spanish speakers put on headsets and listened to words spoken into either their left or right ear. Some of the words had a direction towards the past (e.g., ''dijo'': he said), while others had a direction towards the future (e.g., ''dira'': he will say); the participants were asked to identify the temporal direction of the word that they heard. Spanish speakers were significantly faster to identify the direction of the word if a past word was spoken into their left ear and a future word was spoken into their right ear, thus showing a left-to-right bias consistent with the Spanish writing system. Hebrew speakers, on the other hand, showed the opposite pattern in their reaction times, showing a right-to-left bias, consistent with the directionality of the writing system in Hebrew.

These findings were replicated and extended to several other languages, using a variety of nonlinguistic tasks. Chan and Bergman (2005) compared literate adult native English speakers (left-to-right system) to Taiwanese and Chinese adult speakers, who rely on top-to-bottom and right-to-left writing system, respectively. Adults were asked to arrange a set of pictures depicting the growth of living things (e.g., seed-sapling-mature tree) in chronological order. They found that Taiwanese individuals were significantly more likely to arrange the pictures top-to-bottom than both the English-speaking and Chinese-speaking individuals. In fact, none of the English-speaking adults and only a

small percentage (15%) of Chinese-speaking adults arranged the pictures in top-to-bottom orientation; instead, they predominately arranged them from left-to-right (Chan & Bergman, 2005). Similar orthography-consistent biases have been shown for Italian (left-to-right) and Arabic (right-to-left) (Maass & Russo, 2003). In addition, native Dutch speakers, who generally map time as moving from left-to-right reflective of the Dutch writing system, when shown mirror-reversed Dutch phrases during a task in which they must quickly judge directionality (past or future), showed the reverse pattern after the exposure by mapping time from right-to-left (Casasanto & Bottini, 2010). Most importantly, this effect was also replicated in speakers' gestures. In sum, these studies suggest that adults' expression of time in gesture is largely shaped by the directionality of the reading and writing system of their language.

1.2 Children's production of gestures about time

Earlier work suggests that children begin to understand the mapping between space and time at a very young age (perhaps even at birth; e.g., De Hevia, Izard, Coubart, Spelke, & Streri, 2014; Lourenco & Longo, 2010). The initial mapping is initially broader, but is gradually narrowed down over development to reflect the patterns of the language the child is exposed to. In fact, the mapping between space and time begins to show language-specific patterns beginning in early school years. Tversky, Kugelmass, and Winter (1991) examined kindergarten through 5th grade Arabic-, English-, and Hebrew-speaking children's preference for temporal order in two-dimensional space. Arabic and Hebrew have a right-to-left writing system, as opposed to the left-to-right writing system found in English. To test for directionality of children's use of space to represent time, an experimenter placed a sticker in the middle of a blank sheet of paper and told the participant that the sticker represented 'lunch'; the children were then asked to place stickers to represent 'breakfast' and 'dinner' on the same sheet of paper. This procedure was repeated for different times of the day (morning, afternoon, evening); as control the authors also included non-temporal domains, such children's preferences (favorite food to least favorite food), and quantities (a backpack full of books, a backpack partially full, and an empty backpack), which they expected not to have any relation to the writing directionality of the child's native language. Tversky and colleagues (1991) found that English-speaking children were significantly more likely than Arabic or Hebrew speaking children to place the stickers from left to right for temporal events only, but showed no preference for other types of domains. However, all the children in the study were literate, thus leaving the question about the effect of literacy on the organization of space-to-time mapping unanswered.

A more recent study that explored lateral biases in spatial representations of action on event sequencing (Dobel, Diesendruck, and Bölte, 2007) further suggested that lateral bias becomes evident only after exposure to writing systems and systems of temporal sequencing within a culture. Dobel, Diesendruck, and Bölte (2007) examined German-speaking (left-to-right system) and Hebrew-speaking (right-to-left system) preliterate children's and adults' directional biases in spatial representation of action. The participants were read aloud a series of sentences containing noun phrases; in three of the phrases the agent came first ("The mother gives the boy a ball") and in the other three the recipient came first ("The boy gets a ball from his mother"). Participants were then asked to either draw the contents of each sentence; or they were given three transparencies and asked to arrange the transparencies to depict the contents of each sentence. The direction that the participants arranged the three referents (agent, object, recipient) was recorded. The results showed strong left-to-right directional bias in German speaking adults and the opposite bias in Hebrew-speaking adults, consistent with the direction of reading and writing in each language. However, more importantly, this pattern did not hold true for preliterate children (Dobel, Diesendruck, and Bölte, 2007). The preliterate children did not show a preference for either left-to-right or right-to-left spatial orientation (Dobel, Diesendruck, and Bölte, 2007). This same pattern of directional bias emerging after literacy has also been shown for French (left-to-right) and Tunisian (right-to-left) children (Fagard & Dahmen, 2003). Taken together, these studies suggest that children do develop a lateral bias in their spatial thinking about temporally organized events consistent with the reading and writing direction of their language, but only after they obtain formal literacy training in early school years. However, we still do not know how early children begin to use metaphorical gestures to express time in ways consistent with the writing system of their native language.

In this study we focus on the metaphorical gestures children produce as they talk about past and future events and ask whether these gestures change with the onset of formal schooling and exposure to literacy skills. More specifically, the first question we ask is whether exposure to written English will influence the *types* of metaphorical gestures children will produce (i.e., lateral versus sagittal gestures). We predict that literacy will influence children's metaphorical gestures. Younger children (i.e., preschoolers) with limited knowledge of conventions of written English will predominantly rely on sagittal gestures (e.g., moving finger away or toward body; see Fig.1, panels A_1-A_2) that construct time's movement in relation to one's body; while older children (i.e., kindergartners) will rely more on lateral gestures (e.g., moving finger left-to-right or right-to-left; see Fig.1, panels B_1-B_2) that construct time independent of one's body.

The second question we ask is whether exposure to formal literacy in school will influence the *directionality* of the lateral metaphorical gestures that children will produce. We predict that there will be an effect of schooling (preschool versus kindergarten) on children's gestures. We predict that preschoolers will be equally likely to use the left-to-right or right-to-left directionality in the lateral gestures that they produce. In contrast, we predict that kindergartners will use left-to-right directionality more frequently in their lateral gestures than the younger children, mirroring the directionality of the writing system in English. We do not expect any effect of schooling on children's sagittal gestures.

2. Method

2.1. Participants

Twenty-four monolingual English-speaking children participated in the study. Children were divided into two groups: the younger group included 12 preschoolers (M_{age} = 3;6, range = 3;2-4;4, 7 females) and the older group included 12 kindergartners (M_{age} = 4;6, range = 4;4-5;9, 4 females). The reason for the choice of this particular age range was thatages 3 to 6 represent a time period during which we observe the emergence of an initial set of literacy skills.. The children were recruited from schools and a university participant database in an urban metropolitan city in the Southeastern United States. The participants were predominantly Caucasian (50%) or African-American (25%); majority of the families (92%) had college or postgraduate degrees. The children received a small toy for their participation in the study.

2.2. Data Collection

Children were interviewed individually in their homes, at their schools, or in our laboratory. Each child completed two short tasks about past and future events aiming to elicit metaphorical gestures and a standardized concepts-of-print task that assessed their literacy level. Parents were also asked to provide basic demographic information on themselves and their children.

The first task consisted of a clinical interview about a personal event the child had participated in recently (e.g., "Tell me what happened in your visit to your grandparents last winter") and an event that s/he was going to participate in in near future (e.g., "Tell me what your plans are for your beach trip next summer"). The two events for each individual child were culled from a short questionnaire completed by the parent of the child, and varied by child. In addition, each child was interviewed about a standard event (i.e., birthday), both for past experience (e.g., "Tell me what happened in your last birthday") and for future expectations (e.g., "Tell me what your plans are for your next birthday").

The second task consisted of a structured interview with a set of predetermined questions eliciting child response about the meanings of metaphorical statements about time (e.g. "If your mom said to you, summer is coming, what would she mean?"; "Can bedtime follow dinnertime?").

The concepts of print task assessed children's familiarity with basic concepts about literacy. Children were given a book ("Honey for Baby Bear", by Beverly Randall) and asked a set of questions about how one would read the book, directionality of written words, and other related of information about reading the book (e.g. "Where would I start reading this book?", "Where would I read after that?").

2.3. Data Coding and Analysis

All responses produced during the two interviews about past and future events were video recorded, transcribed, and segmented into clauses. A clause was defined as a segment of speech, with a unified predicate in the form of a verb, along with arguments associated with the verb. (e.g. "I ate ice cream", "He was funny"). Each clause was further coded into two as either conveying temporal information ("We went to the park", "We are going to see the elephants at the zoo") or as not conveying temporal information ("The park is fun"). The gestures that accompanied each clause conveying temporal information were further coded for gesture *type*—as either sagittal ("We went to the zoo" + child moves hand toward her body; Fig.1, A_1) or lateral ("We are going to the beach" + child moves hand from left-to-right; Fig.1,A_2). The lateral gestures were further coded for *directionality*, as either conveying movement from left-to-right; e.g., "We are going to a movie" + child moves hand from right-to-left) or from right-to-left; e.g., "We went to the park"+ child moves open hand from left-to-right). Reliability was assessed with a coder naïve to the hypotheses of the study. Agreement between coders was 92% for detection of gesture, 90% for gesture type and 87% for gesture directionality. The children received one point for each question on the Concepts of Print task that they correctly answered, resulting in a maximum possible score of 13 for literacy level. Data were analyzed with linear regression and Mann-Whitney U tests.

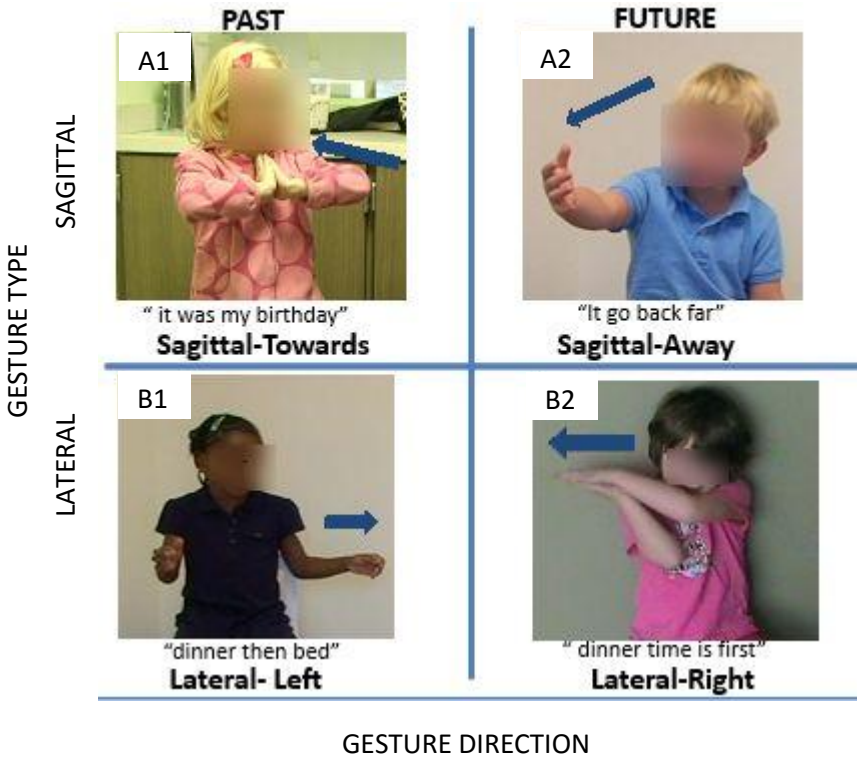

Figure 1. Children's gestures about the metaphorical motion of time varied by type, as either sagittal (top) vs lateral (bottom panels) and by directionality—with sagittal gestures moving either away (A_1) or toward body (A_2) and lateral gestures moving either left-to-right (B_1) or right-to-left (B_2).

3. Results

Does children's exposure to literacy influence the *types* of metaphorical gestures that they produce?

Not surprisingly, younger children differed from older children in their performance on the concept of print task ($M_{preschool} = 7.17$, SD = 2.72 *vs.* $M_{kindergarten} = 9.55$, SD = 2.46; Mann–Whitney $U = 35.5$, $p = .05$). The two groups of children also differed in their preference for sagittal vs. lateral gestures. While younger and older children were comparable in their production of sagittal gestures ($M_{preschool} = 1.25$, SD = 1.2 vs. $M_{kindergarten} = .5$, SD = .9; Mann–Whitney $U = 66.5$, $p = .76$), older children produced significantly more

lateral gestures than younger children ($M_{preschool}$ = .9, SD = 1.3 vs. $M_{kindergarten}$ = 1.6, SD = 1.73; Mann–Whitney U = 35, p = .03). More importantly, children's scores on the concepts of print task were positively correlated with their use of lateral gestures in the two interview tasks that they completed on past and future events. Children with higher scores on the concept-of-print task and consequently with higher familiarity with print concepts were also more likely to produce greater number of lateral gestures (R = .48, B = .5, $t(21)$ = 2.62, p = .02; see Fig 2).

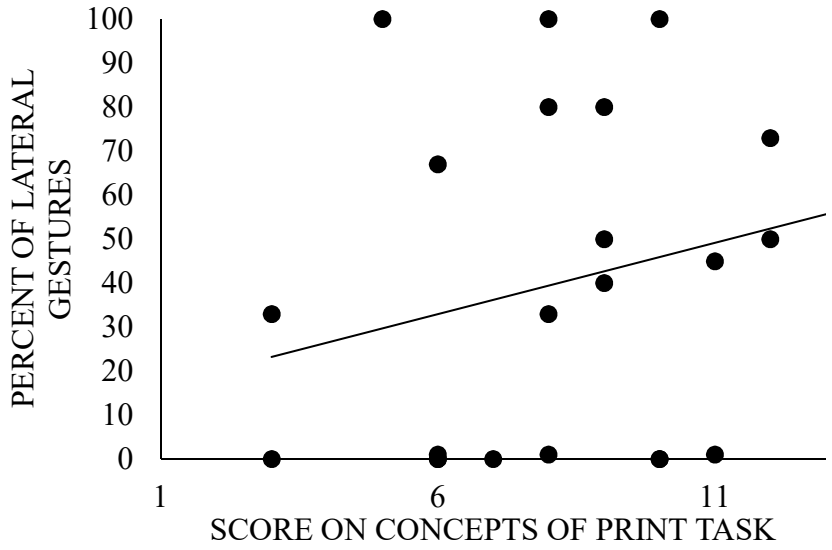

Figure 2. Distribution of lateral gesture production in relation to scores on the concepts of print task; each dot represents an individual child

Does literacy influence the *directionality* of the metaphorical gestures that children produce?

The directionality of children's sagittal gestures did not vary by group. Both preschoolers and kindergartners used sagittal gestures that marked time's movement away from body (see Fig.1A2) and at comparable frequencies ($M_{preschool}$ = .25, SD = .4 vs. $M_{kindergarten}$ = .25, SD = .4; Mann–Whitney U = 72, p = 1.0 two-tailed). The directionality of children's lateral gestures, on the other hand, varied by group. Kindergartners produced significantly more left-to-right lateral gestures (past to the left and future to the right) than preschoolers ($M_{preschool}$ = .08, SD = .2 vs. $M_{prekindergarten}$ = .9, SD = .62; Mann–Whitney U = 29.5, p = .01 two-tailed), whoused left-to-right vs. right-to -left directionality in their lateral gestures at roughly equal frequencies.

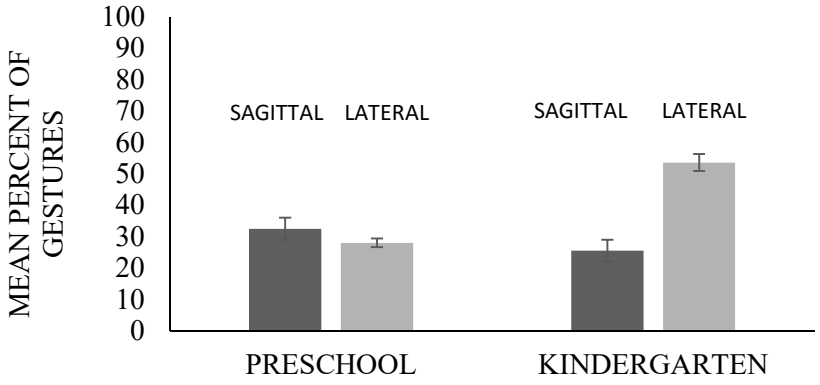

Figure 3. Mean percentage of sagittal (dark bars) and lateral (light bars) gestures produced by preschool and kindergartners.

4. Discussion

The metaphorical gestures adults produce reflect the influence of language, particularly reading and writing direction. When talking about time, English-speaking adults use predominantly lateral gestures, with a direction from left to right ("Exams are over"+ move open palm from right to left of body). However, we do not know how early children begin to show language-specific patterns in their metaphorical gestures. In this study, we examined effect of literacy and formal schooling on children's gestures about time with a group of preschoolers who are preliterate and kindergartners who are beginning to acquire literacy skills. We found that literacy experiences influenced the types of gestures children produced: children with greater literacy skills used more lateral gestures than children with lower levels of literacy. We also found that the level of schooling predicted the directionality of children's lateral—but not sagittal—gestures. Older children, with greater literacy skills and more school exposure, used greater number of lateral gestures, using left-to-right directionality compared to younger children who had lower levels of literacy and less exposure to school-related tasks.

Our findings extend previous work (Dobel et al., 2007) that showed an effect of literacy on the ordering of temporally-organized pictures (e.g., seed-sapling-tree) to the domain of spatial metaphors for time. It shows—for the first time—that young children learning English, who have little exposure to conventions of reading and writing directionality in their native language, do *not*

prefer the lateral gestures commonly produced by adult speakers of English (Casasanto & Jasmin, 2012). In contrast, older children, who have experience with the conventions of reading and writing directionality in English produce lateral gestures that typically construe time as moving from left-to-right.

Our findings also suggest that gesture continues to reflect knowledge relevant to the language learning process as children develop increasingly complex language abilities. Previous research has shown gesture to be closely tied to the child's emerging language system for early language milestones, from *first words* (Bates, et al.,1976; Iverson & Goldin-Meadow, 2005; Özçalışkan, Adamson, Dimitrova, Schmuck, 2015) and *first sentences* (Butcher & Goldin-Meadow, 2000; Özçalışkan & Goldin-Meadow, 2005) to first *similarity comparisons* (e.g., "Butterfly is like rainbow"; Özçalışkan & Goldin-Meadow, 2006; Özçalışkan, Goldin-Meadow, Gentner, Mylander, 2009). Our study extends this to the domain of early metaphors about time, and shows that gesture continues to reflect children's burgeoning understanding of the speech patterns evident in their native language (see also Özçalışkan, 2007 for other metaphorical domains).

Overall, our results suggests that gesture and speech continue to go hand in hand as children develop more complex language abilities (i.e., metaphors); it also shows that the left-to-right bias in children's gestures is a by-product of the patterns of their native language and emerges by age 5—as soon as children get exposure to print materials and begin to acquire literacy in kindergarten classrooms.

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