Gestures Alter Thinking About Time

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Abstract

Can gestures alter thought? Thinking about time is deeply interlinked with actions in space, and gestures are abstracted actions. Four experiments showed that gestures alter thinking about time. Participants heard the same speech accompanied by different gestures. The viewed gestures biased listeners toward circular or linear thinking, toward parallel or sequential thinking, toward moving-ego or moving-time perspectives. Gestures can abstract and show mental models more directly and succinctly than speech.

Keywords: Gesture, space, time, metaphor, diagram

Introduction

As they say, life is just one thing after another. But there is more complexity to thinking about events in time. Historical and autobiographical events are often regarded as on a timeline, but events can also happen simultaneously, not a simple single sequence. Repeating events like seasons, days, and the cell cycle can be regarded as circular. Moreover, reasoning about events in time entails taking a perspective on the timeline. Two common perspectives are *moving-ego*, thinking of yourself as moving along a timeline (we're approaching summer), or *moving-time*, thinking of yourself as stationary on a timeline with events moving past you (summer is approaching) (e. g., Clark, 1973). These perspectives are analogous to a route or intrinsic or egocentric perspective in space; the viewpoint is embedded in space or in time, with ego as the reference (e.g., Levinson, 1996; Tversky, 1996). But just as it is possible to take an external or survey or absolute perspective on space, it is possible to take an external or absolute or calendar view on time, an outside perspective regarding events as ordered by dates. In the case of survey/absolute spatial perspective, the reference points are landmarks and the terms of reference are typically north-south-east-west. For external/absolute/calendar temporal perspective, the reference points are dates or events, and the terms of reference are earlier/later.

Whatever the perspective, how people think about events in time is highly interlinked to actions in space (Talmy, 2000; Tversky, 2011). The strong association between action, space, and time is reflected in the language people use when talking about time, the diagrams they draw when conveying events in time, and the gestures that accompany narratives of events in time. People say time "marches on", we "move through" time, one event occurs "before" another, "time has passed", and "the future is ahead of us" (e. g., Clark, 1973; Evans, 2003; Lakoff and Johnson, 1999, Moore, 2006; Nunez, 1999). People's diagrams of events in time, such as the meals of a day, are typically ordered in reading order on a horizontal line (Tversky, Kugelmass, & Winter, 1991). When relating events in time, English speakers often move their hands from left to right, event by event (e.g. Cienki, 1998); they point frontwards for the future and backwards for the past (e.g. Cooperrider & Nunez, 2009). Language, diagrams, and gestures are ways of externalizing thought, and are congruent with thinking (Tversky, 2011).

If people use actions in space to express their conceptions of events in time, will seeing different forms of actions in space change their understanding of time? We address this question here, by explaining temporal events with identical language but different gestures.

Speakers everywhere gesture while they speak. Most gestures are redundant with the speech they accompany (McNeill, 1992), but gestures sometimes express information that is not expressed in speech (e. g., McNeil, 1992; Church & Goldin-Meadow, 1986; Goldin-Meadow, Alibali, & Church, 1993; Perry, Church, & Goldin-Meadow, 1988). Although some have questioned the communicative significance of gestures (Krauss, 1998; Rauscher, Krauss, Chen, 1996; Rimè & Shiaratura, 1991), there is good evidence that speakers often intend their gestures to be communicative (e. g., Cohen, 1977; Cohen & Harrison, 1973; Alibali, Heat, & Myers, 2001; Emmorey & Casey, 2001), and that gestures, whether redundant or mismatching, influence addressees' comprehension (Goldin-Meadow & Sandhofer, 1999; Thompson & Massaro, 1994).

Can the unique information in gesture alter listeners' mental models of a highly abstract yet familiar concept? In a series of studies on reasoning about time, we demonstrate that gestures affect addressee's conceptions of time by keeping speech constant but altering gestures.

1: Circular vs. Linear Thinking: Diagram

Prior work (Kessell & Tversky, submitted) has shown that people are biased towards linear thinking. Participants were asked to diagram four-step *cyclical* or *sequential* processes. Most participants drew linear diagrams even for cycles. Expecting congruency between conception and visualization, Kessell and Tversky concluded that circular

thinking is harder or less natural than linear thinking. Regarding time as a cycle is difficult because it requires abstraction from a particular instance of an event (i.e. a seed to a flower) to general classes of events. Thinking of time cyclically also requires ignoring the forward progression of time to thinking of time as traveling in a circle with no beginning, middle, or ending.

Even though participants did not produce a preponderance of circular representations for cycles, they did comprehend circular diagrams (Kessell & Tversky, submitted). Could circular hand gestures prime cyclical thinking?

Method

Participants. 63 (40 female, 23 male) volunteers, mostly graduate students from Columbia University, participated.

Procedure and Design. All participants consented verbally to participate in the study. An experimenter said to each participant: "I will tell you about some events. I'd like you to think about these events and then construct a simple schematic diagram to convey them." One-third of participants were then told twice about one of the three cycles below:

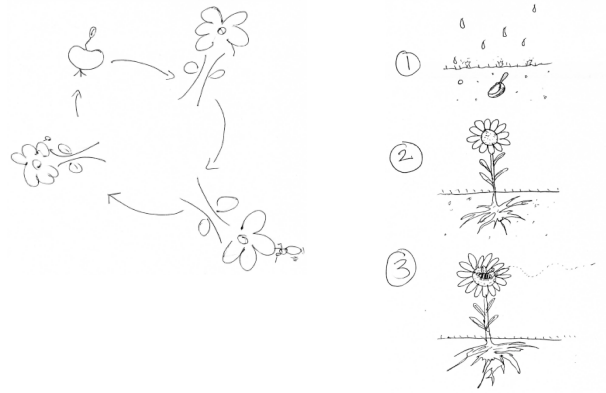
Cycles
Seed to flower: • A seed germinates • A flower grows • The flower is pollinated • A new seed is formed
Events of a day: • Wake up • Go to work • Come home • Go to sleep
Clothing Cycle: • Take clothes out • Wear clothes • Wash clothes • Put clothes away

Figure 1: Cyclical Stimuli

Each example was identically worded but accompanied by linear, circular, or no gestures. For the *linear* condition, the experimenter made 4 discrete slicing gestures right to left for the 4 stages in the spoken text. For the circular condition, the experimenter made 4 pointing gestures at 12, 9, 6, and 3 o'clock for the 4 stages in the spoken text. The right-to-left and counter-clockwise directions were from the experimenter's point of view so compatible with the subject's perspective. For the *no-gesture* group, the experimenter kept her hands in pockets.

Results

Coding the diagrams. Participants' diagrams were coded blindly as either linear, or circular. In circular (or repeating) diagrams the last event was connected back to the first, but not in linear (or ending) diagrams. Two of the diagrams from the circular-gesture condition, and 2 from the no-gesture condition were coded as "other" (see Figure 2).



Circular Diagram Linear Diagram

Figure 2: Examples of Diagrams

Findings. Of those who saw circular gestures, 66.7% drew circular diagrams. Of those who saw linear gestures, only 14.3% drew circular diagrams whereas 85.7% drew linear ones. As expected, of those who saw no gestures, 66.7% drew linear diagrams. Figure 3 shows the percent of linear, circular, and "other" types of diagrams for the three gesture conditions.

The form of gesture participants saw influenced the diagrams (excluding "other" diagrams) they drew; in a log-linear analysis, the two-way association between gesture condition and diagram type was significant, $\chi^2(2)=17.668$, $p=.000$.

Post-hoc analyses showed significant effects of circular vs. linear gesture, $\chi^2(1)=16.851$, $p=.000$, and circular vs. no-gesture, $\chi^2(1)=10.556$, $p=.001$, on diagrams. No significant differences were found for linear vs. no-gesture conditions, $\chi^2(1)=0.902$, $p=.342$. The number of circular diagrams was significantly higher than the number of linear diagrams in the circular-gesture condition, $\chi^2(1)=4.439$, $p=.035$. As expected, the number of linear diagrams was significantly greater than the number of circular diagrams in the linear-gesture, $\chi^2(1)=11.872$, $p=.001$, and no-gesture conditions, $\chi^2(1)= 4.439$, $p=.035$.

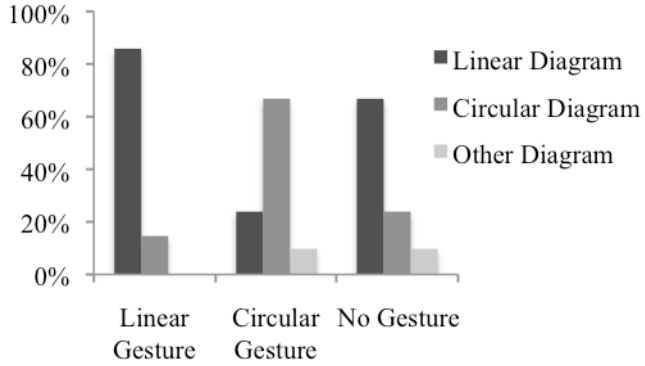


Figure 3: Proportion of linear, circular, and "other" diagrams by gesture conditions

Discussion

Gestures had powerful effects on people's diagrams of events in time. People were asked to diagram a cyclical sequence of four events. Without gestures, a majority of participants drew linear diagrams. However, with circular gestures, a majority drew circular diagrams. If the way people diagram reflects the way they think, and there is considerable evidence for this (e. g., Tversky, 2011; Tversky, et al., 2002), then we can conclude that gestures affect the way people think about temporal events. However, it could be argued that participants copied the diagram the experimenter drew in the air. The next study obviates that objection by asking participants to make inferences.

2: Circular vs. Linear Thinking: Next Step

If seeing circular gestures induces cyclical thinking about time, then when participants are asked what comes after the "last" step they should tend to respond with the "first" step. This tendency should be reduced if linear gestures promote linear thought.

Method

Participants. 60 volunteers, mostly graduate students from Columbia University participated in this study.

Procedure and Design. The procedure and design were the same as the previous experiment except that the no-gesture condition was eliminated, only the seed cycle was used, and instead of being asked to produce a diagram, participants were asked: "What comes after the new seed forms?"

Results

Coding. Participants' answers to the question "what comes after?" were coded as linear or circular. Circular answers included repeating the first or any other stage and saying words such as *repeating* and *cycle.* Any other answers, such as "that was the last stage," "nothing," or "a fruit" were coded as linear.

Findings. In the circular gesture condition, 90% responded with circular answers, but in the linear gesture condition, only 60% responded circularly (Figure 4). In a log-linear analysis, the two-way association between gesture condition and answer type was significant, $\chi^2(1)= 7.595$, $p=.006$. Interestingly, 30% of those who answered circularly in the linear gesture condition seemed unsure about their answers as they answered with a question tone.

Discussion

The previous experiment had shown effects of gesture form on diagram form. Here, we found effects of gesture on inferences. When asked "what comes after?" once hearing the last of four stages of a cycle, participants who saw circular gestures were far more likely to respond with the first or subsequent step of the cycle than those who saw linear gestures. Will gesture affect other kinds of thinking about time?

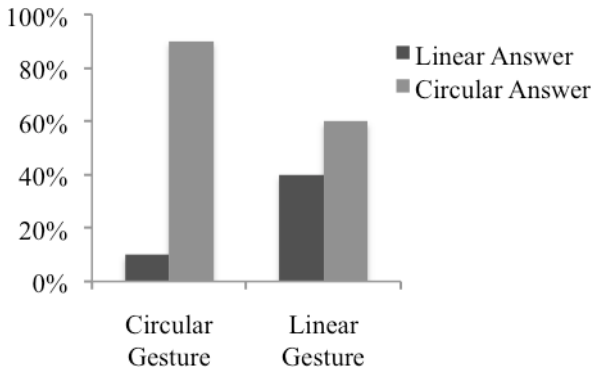


Figure 4: Proportion of linear and circular answers for each gesture condition

3: Perspective: Moving Ego/Time

The first two experiments showed that circular gestures promoted cyclical conceptions of time. The next experiment asks whether gestures can bias perspectives on time.

When people are asked "Next Wednesday's meeting has been moved forward two days; when is the meeting now that it has been rescheduled?" half say Friday, and half say Monday (Boroditsky, 2000; McGlone & Harding, 1998). Those answering Friday see themselves as moving through time, taking an ego-moving perspective. Those who answer Monday see themselves as stationary and time as moving past them, taking a time-moving perspective (Boroditsky, 2000; McGlone & Harding, 1998; McTaggart, 1908). In a series of clever experiments, Boroditsky & Ramscar (2002) showed that although people have strong intuitions about which answer is correct, their answers change dramatically depending on how recently they have moved or seen movement in space. For example, people who have just landed at an airport are more likely to take an ego-moving perspective than those waiting to meet passengers. People sitting still but watching things move are more likely to take a time-moving perspective. Will seeing actions in space, notably gesture, have similar effects on temporal perspective taking?

Method

Participants. 40 volunteers (25 female, 15 male), mostly graduate students from Columbia University participated in this study.

Procedure and Design. All participants consented verbally to participate in the study. While standing side by side, an experimenter told each participant: "Next Wednesday's meeting has been moved forward two days. What day is the meeting, now that it has been rescheduled?"

Participants were divided into two conditions: (1) forward sagittal gesture, and (2) backward sagittal gesture. In both conditions, the experimenter made a slice in the space in front of her body, with her palm facing her, while saying "next Wednesday's meeting", and then moved her hands away from her body for the *forward-gesture,* and towards

her for *backward-gesture* condition while saying "has been moved forward". Note that participants and experimenter had identical points of view.

Results

The majority of participants who saw the forward gesture answered that the meeting was moved to Friday whereas the majority who saw the backward gesture answered that the meeting was moved to Monday (Figure 5). One participant answered "not sure" and another, "Based on your gesture I'd say Friday, but based on your words, Monday"; these were coded as "other" and not included in the statistical analysis. In a log-linear analysis, the two-way association between condition (forward versus backward sagittal gesture), and answer type (Friday versus Monday) was significant, $\chi^2(1)=21.510$, p=.000.

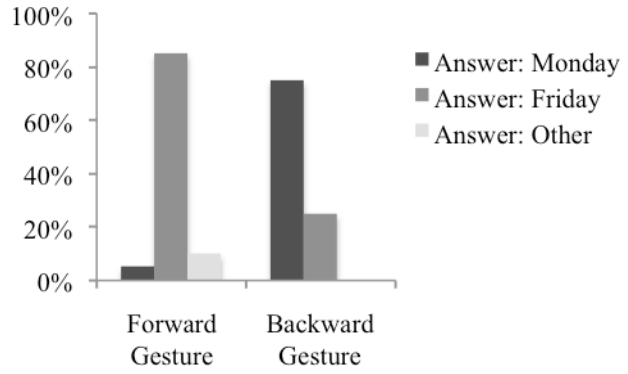


Figure 5: Proportion of participants answering "Friday" and "Monday" in each gesture conditions

Discussion

When people are told that Wednesday's meeting was moved forward two days and asked when the meeting is now, half spontaneously take an *ego-moving perspective*, answering Friday, and half take a *time-moving perspective*, answering Monday (e. g., Boroditsky, 2000; McGlone & Harding, 1998; McTaggart, 1908). Actually moving in space biases respondents toward the ego-moving perspective and watching movement from a stationary position biases the time-moving perspective (Boroditsky & Ramscar, 2002). Here, we found that observing representational actions, namely, gestures, also dramatically affected temporal perspective-taking. The experimenter first established a reference point for Wednesday in front of her body. When she gestured in a frontwards direction away from her body, a majority of participants responded that the meeting was moved to Friday, taking an ego-moving perspective, and when she moved her hand in a backwards direction towards her body, a majority of participants responded that the meeting was moved to Monday, taking a time-moving perspective.

Notably, the gestures were along the sagittal front-to-back axis of the body. For English speakers, the ego is the reference point, with future in the front of ego and the past behind (Cooperrider & Nunez, 2009). Here, the experimenter made a new reference point by placing her hand in front of her body saying "Next Wednesday's meeting," so the reference is Wednesday rather than the ego. Then, the experimenter moved her hand along the axis either to the front of the reference point or to the back of the reference point with respect to the body. There is another possible account for the effects of the gestures, and some participants could have adopted one, some the other. Participants could have taken an external or calendar perspective, with the saggital axis as a timeline and Wednesday as the reference point, with later events away from the body and the earlier events closer to the body. Either way, the gestures disambiguated the language and determined participants' responses.

4: Parallel vs. Sequential Thinking

So far our experiments have shown that gestures alter the way people think of a sequence of events in time. Yet in life, people often have to keep track of events that happen simultaneously, a task that can be difficult (e. g., Bauer & Johnson-Laird, 1993). In one study, students had difficulties comprehending that the two middle steps of a four-step procedure for writing a paper were simultaneous. A diagram showing the simultaneous events side-by-side helped (Glenberg & Langston, 1992). Like diagrams, and in contrast to serial language, gestures can organize things in space and show simultaneity (e. g, Tversky, Heiser, Lee, & Daniel, 2009). Might gestures help people think about parallel events in time?

Method

Participants. 60 volunteers, mostly graduate students from Columbia University participated in this study.

Procedure and Design. After receiving verbal consent for participation, an experimenter said to each participant: "I will tell you about a procedure, and then ask you a quick question about it". Participants were then told the following procedure for writing a paper (based on Glenberg & Langston, 1992): "There are four steps to be taken when writing a paper. The first step is to write a first draft. The next two steps should be taken at the same time: One of the steps is to consider the structure; the other step is to address the audience. The final step is to proofread the paper."

Participants were divided into two conditions: (1) parallel-gesture, and (2) sequential gesture. For the *parallel-gesture condition*, the experimenter made a slice in the air in front of her face, with her right hand palm facing down, while saying "the first step is to write a first draft". Next, she made two slices with two hands simultaneously below her first hand gesture, while saying "the next two steps should be taken at the same time". Next, she moved her right hand back and forth from her wrist, in place, with her left hand still in the air, while saying, "one of the steps is to consider the structure". Then, she reversed those hand actions while saying, "the other step is to address the audience". Next, she took away her left hand and made a slice with her right hand facing down, below its previous spot, while saying, "the

final step is proof read the paper." For the *sequential-gesture* condition, the experimenter made 4 slices with her right hand facing down, from top to bottom on a vertical line in front of her, for the 4 steps in the procedure.

After hearing the description twice, participants were asked: "Here is the question now: According to the procedure I just gave you, what should one do immediately after writing the first draft/ before proof reading the paper?" Half of the participants in each condition were asked about steps *after* writing the first draft, and the other half were asked about steps *before* proof reading the paper.

Results

Coding. Participants' answers to before/after questions were coded as sequential, parallel, or other. Answers that mentioned only one of the two steps (*considering the structure* or *addressing the audience*) were coded as sequential. Answers that mentioned both steps were coded as parallel. Any other answer was coded as "other".

Data analysis. In the *parallel-gesture* condition, 76.7% mentioned both steps while only 56.7% in the *sequential-gesture* condition gave *parallel* answer. Forty percent of participants in the sequential-gesture condition but only 10% of subjects in the *parallel-gesture* condition mentioned a single step (Figure 6). Four participants in the parallel-gesture condition, and one in the sequential-gesture condition mentioned other steps and were excluded from the data analysis.

In a log-linear analysis, the two-way association between gesture type and answer was significant, $\chi^2(1)= 6.276$, p=.012. However, the two-way association between question type (before vs. after) with answer (parallel vs. sequential) was not significant, $\chi^2(1)= 1.988$, p=.159, nor was its three-way association with condition (parallel- vs. sequential-gesture) and answer type, $\chi^2(1)= 0.114$, p=.736.

In addition, significantly more participants in the parallel-gesture condition gave parallel answers than sequential answers, $\chi^2(1)= 17.447$, p=.000. There was no significant difference between number of parallel and sequential answers in the sequential-gesture condition, $\chi^2(1)= 0.866$, p=.35.

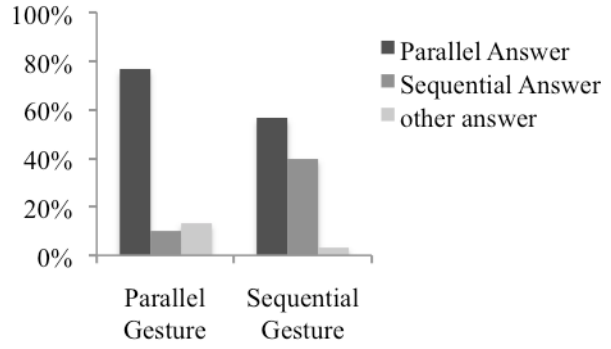


Figure 6: Proportion of parallel, sequential, and "other" answers in parallel- and sequential-gesture conditions

Discussion

We have shown yet again that gesture influences how people think about time. Previous research (e. g., Bauer & Johnson-Laird, 1993) had shown that people find it difficult to conceptualize parallel events. Here we showed that gestures that indicate the parallel structure of events help people to reason about simultaneity of events.

General Discussion

One way that people think of events in time is through space, as dots, representing events, on a line, representing time. The line can be regarded as straight, a linear sequence of events, perhaps, as in most narratives, having a beginning, middle, and end. For events that repeat, like the parts of the day or the seasons of the year, the line can be regarded as circular. Simultaneous events can be thought of as parallel lines. The mental time lines typically have a spatial orientation and a perspective. When straight, that line can be regarded as horizontal in reading order, vertical in top-down order (Boroditsky 2001; Tversky, et al., 1996) or saggital from front to back (Cooperider & Nunez, 2009). Thinking and talking about time use target and reference events and a perspective on time, just like thinking and talking about space (e. g., Talmy, 2000). People can take an external perspective on the line, as in looking at a calendar or a timeline, much like taking an overview of an environment or looking at a map. Alternatively, they can see themselves embedded in time just as they can see themselves embedded in space. The ego can serve as a reference point, located on the timeline. In the ego-moving perspective, ego moves along events on the timeline; in the time-moving perspective, ego is stationary and events move past ego. Either way, changes in time are conceived of as actions in space. If changes in time are conceived of as actions in space, then actions in space might affect conceptions of time. Indeed, Borodtisky and Ramscar (2002) showed exactly that, that moving in space or watching movement in space alters temporal perspective. Here we found that information in gestures but not in speech could also alter people's conceptions of time. Circular gestures biased thinking about a series of events as a cyclical rather than linear. Frontwards gestures away from the body biased taking an ego-moving perspective on time and gestures toward the body biased taking a time-moving perspective. Finally, gestures that traced parallel paths helped people think about simultaneous events.

Why do gestures have such powerful effects on thought? Many gestures are miniature actions in space that represent actual actions. For representing time, the gestures traced temporal paths in space, and indicated specific events along the paths. In representing paths as lines and events as dots, gestures are like diagrams (Tversky, 2011; Tversky, et al., 2009). The set of gestures both abstracts a model of time and shows it, a more direct way to communicate than purely symbolic speech.

Acknowledgments

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