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The SOURCE-PATH-GOAL image schema in gestures for thinking and teaching

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This article examines SOURCE-PATH-GOAL image-schematic structure in gestures used to solve counting problems (gesture for thinking) and to teach children how to read a clock (gesture for teaching). The analyses illustrate how path schemas inherent in idealized cognitive models are exhibited in gesture forms and in gesture sequences and combinations, manifesting conceptual content beyond that articulated in speech. While at times the path structure is incidental, enacting part of a cognitive model that is not the focus of discourse, at other times the path structure is essential, in that listeners must perceive the SOURCE-PATH-GOAL structure in the gesture in order to construct the proper understanding. The examples support the view that image schemas at the heart of cognitive models partly motivate and structure gestures for cognitive and communicative purposes, and that listener attunement to this structure contributes to intersubjective understanding and the perpetuation of cultural practices for distributed cognition.

Keywords: image schema, cognitive model, gesture, instructional discourse, distributed cognition

1. Introduction

When people interact, they make lively movements of the hands. They gesture with and over objects and in the air in front of their bodies, and these movements appear to be integral to their thinking (Kita, Alibali, & Chu, 2017) and communicating (Hostetter, 2011). Though patterned, gestural movements are generally not pre-planned but improvised to help achieve a goal-of-the-moment in a situation-at-hand. This article considers gestures produced during problem-solving and communication (specifically, during instruction), what motivates and structures their forms (from a cognitive linguistics perspective), and what role they play in distributing cognition and achieving intersubjective understanding.

Researchers in gesture studies and cognitive linguistics have advanced several possible bases for gestural movements which, in serving the communicative goal of an utterance, contribute to giving gestures their particular forms. One likely basis for gesture forms is *entrained motor patterns* from practical actions (LeBaron & Streeck,

2000) that are repurposed as communicative actions (McNeill, 2015, pp. 38-53). A raised hand prevents a moving object from colliding with the body or halts a line of argumentation (Kendon, 2004, pp. 251-255). A sweeping movement brushes away crumbs or dismisses ideas (Calbris, 2003; Tessendorf, 2014). In the latter cases, schematic movement forms distilled from practical actions on actual objects are employed as metaphorical actions on ideational objects in the flow of discourse. The forms are easily interpreted because they are likewise in the body and mind of the listener (Streeck, 2011).

While familiar motor patterns are evident in many gestures, the use and shaping of these patterns for communicative purposes may be grounded in *mimetic schemas* derived from linguistic practices as well as bodily actions (Zlatev 2005, 2014). Andrén (2010) and Zlatev (2014) find that young children's early iconic gestures consist mainly of performances of typified actions such as kicking, kissing, or dancing; of re-enactments such as applying imaginary lotion to parts of the body; or of demonstrative actions on or with objects such as kissing a doll or moving a toy car back and forth (examples from Zlatev, 2014). These early iconic gestures were enacted primarily from a first-person perspective and often without speech; the few gestures performed from a third-person perspective appeared to result from imitation.

A likely source of conventional gestural forms among older children and adults is well-learned *cultural practices*, such as ways of using the hands in problem solving. A familiar example is counting (Williams 2007a; 2013): touching or pointing to objects while reciting number tags, or raising fingers while reciting object names, as a way of computing quantity or assigning sequence. These are cognitive actions, employed for problem solving when no interlocutor is present, and they can also be communicative actions, enumerating points of an argument or, in moments of instruction, enacting a problem-solving process for another. The forms are again readily interpretable by members of the culture because they are ingrained in the body and mind through practice.

While familiar motor patterns, bodily mimesis, and cultural practices are evident in gestural forms, a particular gesture is also shaped by how it is *fitted to the setting*—to the position and orientation of interlocutors and to objects that are the focus of interaction—while it is *directed toward some purpose* in the activity. In counting, a sequence of touches or points must conform to an arrangement of objects to produce an accurate result (Williams, 2013). In collaborative work, gestures may highlight or annotate structures on a representational artifact as participants jointly construct and share meanings (Goodwin, 2007). Situation and setting provide impetus and constraint to hand movements and their interpretation.

The above together account for many visible aspects of gestural form, yet a robust understanding of what motivates and structures gestures and how they accomplish their purposes will elude us unless we also consider the *conceptual* *structures and processes* at play as gestures are produced and interpreted, and it is here that the field of gesture studies intersects with cognitive linguistics. Cognitive semanticists take the perspective that knowledge is structured by idealized cognitive models intersubjectively shared by members of a culture. As hypothesized by Lakoff (1987), an idealized cognitive model may incorporate propositional or image-schematic structure and metaphoric or metonymic mappings, forming a complex structured whole or gestalt (p. 68). Cognitive models are claimed to frame the mental spaces that interactants construct and elaborate as they think and talk (Fauconnier 1985/1994; 1997) and to be fitted to particular circumstances through conceptual integration or blending (Fauconnier & Turner, 1998; 2002). Cognitive linguists studying gesture have pointed out that gestures can ground elements in the blended mental spaces constructed during discourse (Liddell, 1998; Perrill & Sweetser, 2004). In my research on situated activity, I have claimed that gestures are used to anchor conceptual entities and guide conceptual mapping to focal objects, providing material support to thinking and communicating that contributes to intersubjective understanding (Williams, 2007b; 2008a; 2008b), and I have argued that these movements are more than expressive—more than the exteriorization of interior mental life—in that they are an integral part of distributed cognition: of solving problems, of sharing thinking, and of guiding the thinking of others (Williams, 2013).

The present study focuses on the conceptual underpinnings of gesture, examining the relationship between gesture forms and image-schematic structure in cognitive models that are employed in problem solving or that frame the content of the discourse. The research questions to be explored are: First, does image-schematic structure in cognitive models motivate gestures and partly structure their forms? In addressing this question, I will examine gestures for evidence of image-schematic structure related to one or more cognitive models active in the discourse while also considering whether the gesture exhibits aspects of the model not evident in speech. And second, if image-schematic structure is manifest in gesture, then is apprehension of this structure by the listener necessary for successful communication? This question bears on whether we should view and study discourse as inherently multimodal versus as purely or primarily linguistic. It also relates to our understanding of how intersubjective understanding is achieved and how cognitive practices are perpetuated in our culture.

To narrow the scope of the study, I focus on a single, widely acknowledged image schema that is claimed to structure conceptualization of motion events: the SOURCE-PATH-GOAL image schema or "path schema." Drawing on data from cognitive ethnographic and quasi-experimental studies of time-telling (Williams, 2004) and counting (Williams, 2007a), I examine how path-schematic structures are evident in gestures used to solve counting problems and to teach children how to read a clock. In presenting my findings, I address the following:

- how the SOURCE-PATH-GOAL image schema partially structures idealized cognitive models for counting and clock-hand motion;
- how this structure is manifested in gestures for thinking, specifically for problem-solving involving counting;
- how this structure is enacted in gestures for teaching, that is, for explicitly guiding the conceptualization of others;
- how the image-schematic structure in gesture makes aspects of the speaker's conceptualization visible to the listener (including aspects that are not the current focus of discourse); and
- how at times—but not always—the apprehension of this structure by the listener is essential to proper understanding.

Toward the end of the article, I present examples of SOURCE-PATH-GOAL image-schematic structure in gesture sequences and combinations, showing how gestures like those described earlier are fitted together in unfolding discourse. I end with discussion of how my findings relate to other studies of image schemas in instructional gestures and conversational gestures.

2. Image schemas, cognitive models, and gesture

2.1 Image schemas and cognitive models

The conceptual basis for the gesture analysis is the cognitive linguistic construct of an image schema and the role that image schemas are hypothesized to play in the cognitive models that structure conceptualization. Image schemas have played a central role in theories of cognitive semantics since they were first described by Johnson (1987) and Lakoff (1987). While researchers differ in their specific claims about image schemas, the various views coalesce around the idea that image schemas are experiential gestalts that structure our conceptualization of events. The image schemas described by Johnson, Lakoff, and others are believed to derive from recurring patterns in spatial relations, motion, and force dynamics we perceive in object interactions and experience as embodied beings. Examples include PART-WHOLE, CENTER-PERIPHERY, CONTAINMENT, PROXIMITY, SUPPORT, BALANCE, SELF-MOTION, CAUSED MOTION, SOURCE-PATH-GOAL, CYCLE, DIVERSION, BLOCKAGE, ENABLEMENT, and others described by Johnson (1987) and Lakoff (1987) and summarized in Hampe (2005). Mandler (1992; 2004; 2005) claims that image schemas arise from 'perceptual meaning analysis' and structure the preverbal conceptual system. In a more recent elaboration of the argument, Mandler & Cánovas (2014) emphasize the primacy of spatial event structure—"motion along paths, how motion starts, and what happens when it stops" (p. 514) and objects going into or out of containment or occlusion (pp. 515-516)—in the preverbal formation of the earliest image schemas, with embodied experience of force dynamics adding structure to image schemas through schematic integration.

Cognitive linguists claim that image schemas provide inferential structure to conceptualization and that they are central to conceptual metaphor and conceptual blending. Without employing Lakoff and Johnson's term "image schema," Talmy (2000, chapter 1, a revised and expanded version of a 1988 chapter) presents the compatible argument that grammatical or closed-class forms specify the schematic structure of cognitive representations. Lakoff (1987) claims that knowledge is organized by idealized cognitive models that incorporate image schemas with metaphoric and metonymic mappings and (1993) that the set of correspondences that constitute a conceptual metaphor allow the image-schema structure of the source to be used to make inferences about the target (to the extent that it does not violate the image-schema structure of the target, the so-called invariance principle). In their research on conceptual integration networks, Fauconnier and Turner (1998; 2002) claim that shared image-schematic structure provides a basis for cross-space mapping, selective projection to a blended space, and pattern completion and elaboration to support novel inferences.

If it is true that image schemas structure our conceptualization of events, are inherent in the structure of cognitive models, and are at the core of conceptual metaphor and blending, then we ought to find evidence of image-schematic structure in the gestures produced as humans think and communicate. In particular, we would expect image-schematic structure to be apparent in iconic gestures produced when describing events involving physical objects and their locations, dynamics, and interactions, and in metaphoric gestures where interlocutors move their hands while discussing abstract objects, ideas, and relationships (McNeill, 1992; Cienki, 2005; Mittelberg, 2010; *inter alia*). Gesture forms ought to embody image-schematic structure inherent in the cognitive models that frame the discourse content (the conception of what is being discussed) and the social interaction (the conception of the communicative situation).

2.2. Image schemas and cognitive models in gesture

Image schemas in conversational gestures have been studied by Cienki (1998a; 1999), Ladewig (2011; 2014), and Tessendorf (2014), among others, and these gestures appear to be structured by cognitive models employed for referential and pragmatic purposes. Cienki had pairs of undergraduates at American (1998a) and Russian (1999) universities talk about academic honesty, and their rigid, downward chop of a vertical flat hand with words like "honest" and "moral" appears to reflect a cognitive model for moral behavior based on the STRAIGHT image schema (1998b) and its metaphorical projection MORAL IS STRAIGHT. The gesture depicts the image-schematic structure of the source domain (straightness) while the speech refers to the target domain (student behavior), making the gesture metaphoric or abstract-referential. Ladewig (2011; 2014) comes to a similar conclusion in her analysis of the 'cyclic gesture' (a repetitive circular motion of a lax hand) in German conversations: she claims that the various uses of the gesture reflect a cognitive model based on the CYCLE image schema and its metaphorical projection to continuation of a process. The gesture appears not only when the speaker is referring to something ongoing (abstract reference) but also, and more commonly, when the speaker is searching for a word or idea or encouraging continuation by the addressee. In Tessendorf's (2014) study of the 'brushing aside' gesture in Spanish conversations, she also finds the gesture used at times for abstract reference ("They brushed them aside") and more commonly to dismiss a topic or idea. Tessendorf claims that the 'brushing aside' gesture derives from the motor action of brushing or shooing away something small and annoying, like an insect. While the gesture form appears to be structured by this familiar motor schema, I would argue that its abstract use to dismiss ideas is rooted in a cognitive model based on the CENTER-PERIPHERY and PROXIMITY image schemas and their metaphorical projections, so that the degree to which topics are taken up or views are held by the speaker is associated with their closeness to the speaker's deictic center, and undesired topics or views are brushed away from the center into the periphery. Moreover, they are brushed to the side or over the shoulder so as not to lie in the speaker's path, reflecting a cognitive model in which a line of discourse is understood metaphorically as a path, and pursuing a line of discourse is moving forward along that path. As in the previous examples, the cognitive models consist of image schemas and their metaphorical projections. In the studies by Cienki, Ladewig, and Tessendorf, the gestural forms manifest image-schematic structure in cognitive models that frame the content of the discourse or aspects of the interaction itself. These models are intersubjectively shared by members of the culture, which undergirds gesture creation and interpretation in the ongoing communication.[1]

A counterpoint to this research is the view advanced by Zlatev (2005) and Andrén (2010) that young children's gestures are structured primarily by mimetic schemas rather than image schemas. Zlatev and Andrén find that children's early iconic gestures mimic adult actions and are enacted from a first-person perspective (what McNeill [1992] calls "character viewpoint"; see pp. 295-328 for his discussion of children's gestures). The few third-person-perspective (McNeill's [1992] "observer

[1] In a recent article in *Cognitive Semiotics*, Mittelberg (2018) provides evidence for image-schematic structure in gestures from analysis of motion-capture data, which she considers from the perspective of dynamical systems and attractors in a state space. The present article keeps to a more cognitive/conceptual level of description. Interested readers are referred to Mittelberg's article for more discussion.

viewpoint") gestures they observed were actions with toys, and these appeared to be learned and emulated directly as communicative acts. Zlatev (2014) argues that practical actions become typified and differentiated into signs, concluding that the mimetic schemas underlying young children's gestures are shaped by both bodily actions and linguistic practices. Zlatev also allows for the possibility that older children and adults' gestures could be shaped to a greater extent by image schemas in cognitive models that frame the content or structure of a discourse. Cienki (2013) suggests that mimetic schemas could continue to underlie pantomimic gestures in adults, while image schemas (presumably in cognitive models) underlie iconic or metaphoric gestures used for referential or pragmatic purposes in conversational interaction, an argument I take up toward the end of the article.

In contrast with the aforementioned studies of conversational interactions, the study described here examines image schemas and cognitive models in gestures produced during individual problem solving (thinking) and overt instruction (teaching), and the focus is on referential content rather than the pragmatics of the interaction.

3.1 The present study

3.1. Focus of the study: The SOURCE-PATH-GOAL image schema ("path schema")

The present study centers on the SOURCE-PATH-GOAL image schema (Lakoff, 1987, p. 283; Johnson, 1987, pp. 28, 113-117), which may be the most agreed-upon image schema in the cognitive linguistics literature. According to Mandler & Cánovas (2014), this image schema starts as a PATH-GOAL schema in early development and expands into the SOURCE-PATH-GOAL schema of complete motion events as source information becomes more salient; even after the full schema emerges, paths continue to be referenced primarily to goals (PATH TO) rather than sources (PATH FROM) (pp. 517-518). In the present study, the term "path schema" refers to the full SOURCE-PATH-GOAL structure.

Figure 1 depicts the path schema as it encapsulates the basic schematic structure of a motion event: a moving object (the TRAJECTOR) begins its motion at some initial location (the SOURCE), occupies a series of contiguous locations while it moves (the PATH), and ends its motion at some final location (the GOAL). At any given moment during the motion event, the trajector occupies some position along the path from source to goal. At that moment, it has already occupied all the locations from the source to the present position, and it has yet to occupy the locations from the present position to the goal. This relational structure, perceived as a gestalt, can be used to reason about what is happening, what has happened, and what is about to happen. The full path schema is not simply a perception of motion; it is the conception of a full motion event: an object moving from X to Y, from origin to destination. This distinction will prove important as we consider how path schemas are evident in gestures and what role they play.

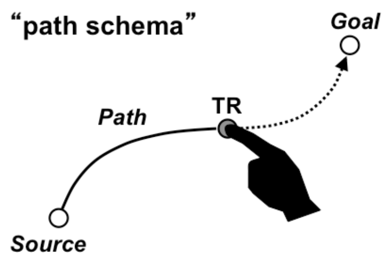


Figure 1. The SOURCE-PATH-GOAL image schema or "path schema" with the tip of the index finger marking the trajector (TR)

From the perspective of conceptual metaphor, the path schema structures our conception not only of physical movements but also of any process—any conceived change from an initial state to an end state—as metaphorical motion from one state to another (Lakoff, 1993, pp. 220-222). For the purposes of this article, I will focus on gestures where an actual or implied path of motion is part of what is being conceptualized or depicted rather than change in this abstract sense. Path schemas also play a fundamental role in communicative action more generally, namely in performing or perceiving the gesture "stroke"—the meaningful part of the gesture (Kendon 2004, p. 112)—as a delimited movement distinct from the hand's movement to or from its rest position. In this article, I will take it for granted that speakers produce gesture strokes and that listeners perceive them, focusing my attention on the specific forms of gesture strokes and their conceptual basis.

3.2 Sources of the data

The examples analyzed in this article come from two sources. The first is a cognitive ethnography of time-telling instruction (Williams, 2004) in which lessons in clock-reading were recorded in 1st-, 2nd-, and 3rd –grade classrooms at two elementary schools. As part of this study, episodes of instruction were subjected to detailed micro-analysis to identify the roles of teacher talk, gesture, and object manipulation in guiding the construction of meaning in instructional discourse (see Williams, 2008a and 2008b, for examples). The second source is a study of counting as situated practice (Williams, 2007a) in which episodes of counting recorded in naturally occurring activity and in quasi-experimental problem-solving situations were analyzed from the twin perspectives of distributed cognition and cognitive semantics, emphasizing the role of gestures and object manipulations in coordinating functional systems for determining quantity and in anchoring and manipulating conceptual categories in the performance of the activity. For the present study, I reviewed the recordings from these prior studies and identified gestures that exhibited path structure from one or more cognitive models that were the subject of discourse, as determined in part by the prior ethnographic studies from which the examples were drawn. I analyzed this set of gestures and their accompanying speech from the perspective of conceptual integration theory (as in Williams, 2008a and 2008b), identifying conceptual inputs and mappings evident in the gesture and speech, and I examined the role of path structures in gestures at these moments in the discourse.

4. Findings

4.1. Path schemas in gestures for thinking

By gestures for thinking, I mean gestures that serve the speaker, who may be alone, by playing a functional role in solving a problem at hand, rather than gestures related to linguistic formulation (thinking for speaking) during communication with another. An example of gesture for thinking would be raising fingers while reciting "*A, B, C…*" to identify the 18th letter of the alphabet (a task inspired by Smith, 2007). Problems that involve determining quantity or sequence are likely to invoke gestures as part of their solution.

To see why this is so, consider different ways to count objects. Common ways include touching objects in succession while reciting number tags ("*one, two, three…*"); pointing to objects in succession while reciting number tags; or just looking from object to object while reciting number tags subvocally (examples from Williams, 2007a); some examples are illustrated in Figure 2. All three appear to be variations of a common cultural practice for linking number tags to objects through bodily action. The actions in every case, whether performed with the hands or eyes, are arguably gestural, and the pointing version is prototypically so. Other variations are possible—touching pairs of objects with extended index and middle fingers while reciting "*two, four, six…*," for example—as are other ways of counting that involve different actions and anchored conceptual blends (discussed in Williams 2007a; 2013). What is important to our discussion is that in every variation of the sequential touch, point, or look method of counting, a path schema is required to structure the counting action to produce an accurate result: to ensure that every object is included but tagged only once during the counting process. The trajector might be a fingertip (for touching), the endpoint of an imagined vector extending from the fingertip (for pointing), or a gaze fixation point (for looking). The trajector begins at some source location; moves along a path through the collection of objects, alighting momentarily on each (a distinct manner of motion); and ends at a goal location coinciding with the last object counted. The number tag recited at the goal corresponds to the total quantity of objects in the set under consideration. The shape of the path can be arbitrary, so long as it encompasses every object, but in practice the path is fitted to the arrangement of objects—to the affordances of moving the trajector through the setting—to minimize the likelihood of losing track along the way. Experienced counters often re-arrange objects where possible before counting to facilitate a smoother counting path. Where the order of the objects matters, the shape of the path is non-arbitrary, as we will see below where two paths are combined in one gestural form.

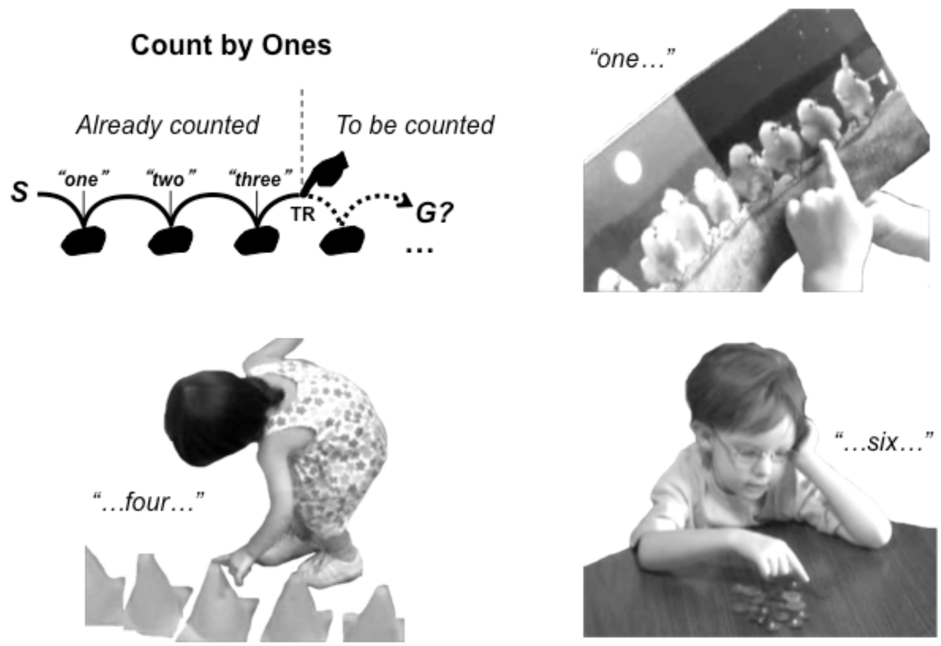


Figure 2. Using gesture to coordinate number tags with objects while counting

4.2. Path schemas in gestures for teaching

Gestures for communicating—what we commonly think of as gestures—are produced in discourse with others. These expressive movements in concert with spoken language help shape conceptualization as speaker and listener work to establish common ground (Williams, 2007b). Where there is a sizeable asymmetry in knowledge or understanding, as between an expert and novice, gestures can take on a more deliberate or performance-like quality as a speaker-qua-instructor tries to guide a listener toward a conception that the speaker has in mind (Williams, 2008b). These are what I refer to here as "gestures for teaching," and I see them as fundamental to the perpetuation of the distributed cognitive practices that mark the cognitive sophistication of our species.

Because gestures can directly embody movements through space, gesture as a representational medium is ideally suited to depicting paths of motion in the speaker's conceptualization and providing perceptible structure to shape the listener's conceptualization. An example of such a conceptual path is the minute-hand cycle shown in Figure 3, which is part of the set of cognitive models associated with the artifacts used for time-telling in many cultures—here, the analog clock. At the start of a clock hour, the tip of the minute hand points to the *12*; this is the source. As the hour proceeds, the location indexed by the minute hand (the trajector) proceeds clockwise around the dial until it reaches the *12* again, which is then the goal that marks the end of the clock hour. This is clearly a *conceptual* path: it is the location on the clock dial indexed by the minute hand and not the hand itself that is the trajector. Moreover, a minute hand moves continuously and imperceptibly around a clock face, never starting or stopping, so it does not itself have a source or goal of motion. Any movement once around the dial—from the *4* to the *4*, for example—corresponds to the interval of an hour, while the *12*-to-*12* path is salient because it marks the passage of a conventional clock-hour, say from 1 o'clock to 2 o'clock. At the top of the hour, the *12* is construed as the source, while at the end of the hour, it is construed as the goal (and the source for the next clock hour). This understanding of the cycle of conventional clock hours may be conceptual, but it is also, importantly and essentially, anchored by the material structure of the clock face. And because the mechanisms that turn the minute and hour hands are linked by gears, the path of the minute hand's pointed-to location moving once around the dial from *12* to *12* corresponds with the path of the hour hand's pointed-to location (another trajector) moving from one numeral on the clock face to the next (source to goal); indeed, establishing the conceptual link between these two SOURCE-PATH-GOAL structures is a critical goal of clock-reading instruction (see Williams, 2012, for more discussion). A minute-hand cycle is thus a familiar example of a conceptual path that can be made manifest in gesture and that likely *must* be if children are to learn to read a clock correctly.

While working on the cognitive ethnographic study of time-telling instruction in elementary school classes, grades 1 to 3 (Williams, 2004), I frequently observed the minute-hand cycle being enacted in teacher gestures, most commonly over the face of a teaching clock (a manipulable clock face with geared hands but no time-keeping mechanism) and also in the air in front of the teacher when no teaching clock was nearby, with the gesture evoking the familiar clock face. Representative samples of these gestures are shown in Figure 3. These teaching gestures demonstrate several distinctive features of human cognition. First, they show how we use our bodies to make conceptual structure manifest to one another. Second, they show how gestures link the conceptual structure of cognitive models to the physical structure of artifacts created by our species for purposes of representation and computation. Third, they show how these gestural enactments are crucial to perpetuating cognitive functional systems across generations, whether for everyday activities like time-telling or specialized activities like team ship navigation (Hutchins 1995, the classic study of distributed cognition), thus sustaining the cognitive sophistication of our species (see Williams, 2013, for a full discussion of distributed cognition and gesture). In moments of teaching, gesture maps conceptual content profiled by speech onto structure in the world, whether actual or virtual (implied by the gesture), while, in a dialectical relationship, speech construes the gestural movements, imbuing them with significance. The ensemble of gesture and speech couples the world of mental experience to the world we inhabit and, by extension, to situations we and others can imagine. I hypothesize that the greater the difference between the speaker's and listener's conceptions—or between the speaker's conception and ascertainment of the listener's conception—the more likely we are to see gesture take a prominent role in the discourse, weaving the conceptual and material in search of common ground (Williams, 2007b).

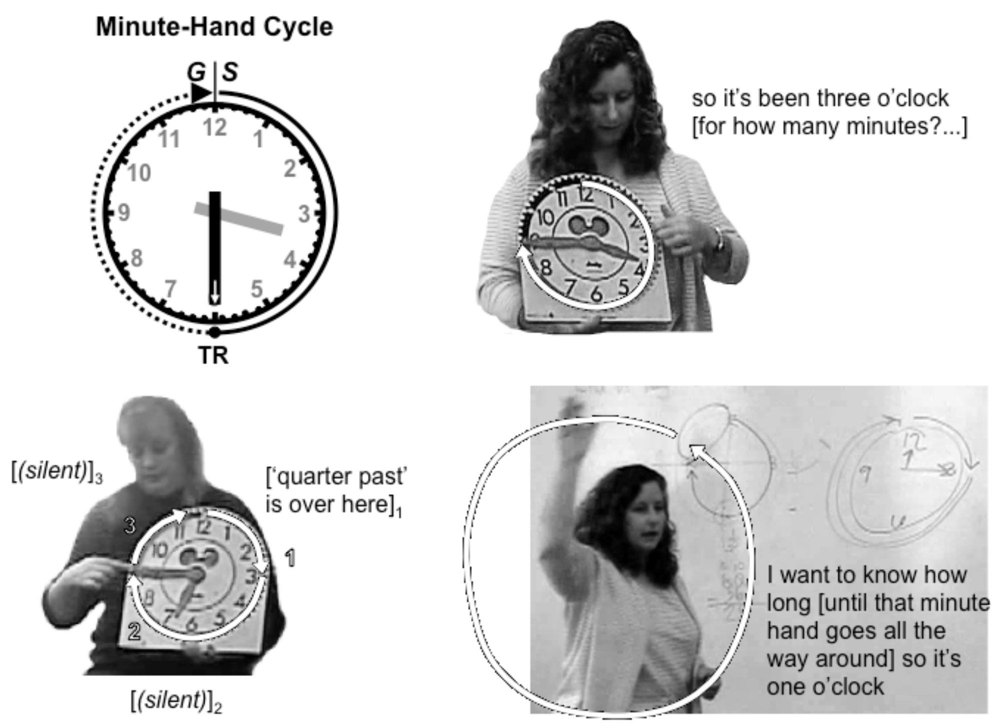


Figure 3. Gestures depicting the minute-hand cycle [bracketed speech co-occurs with gesture]

4.3. Incidental vs. essential path structure

The foregoing discussion raises considerations about the purpose of gesture. Some hold that gestures are mainly for the speaker: they are largely involuntary movements of the hands whose primary function is to help transform imagistic thought into sequential speech and are thus part of linguistic formulation or thinking-for-speaking. Others hold that gestures are primarily for the listener: they are more-or-less voluntary acts deliberately aimed at affecting the listener's thought or behavior. McNeill (2005) lists sample references on both sides (p. 53). My own views are that gesture serves both cognitive and communicative purposes and can do so simultaneously to varying degrees and that the impulse to gesture is a largely involuntary part of communicative action (of forming and producing utterances) while the specific form of a gesture is affected by both internal states and external (situational) factors. Moreover, I believe that gestures vary in the extent to which they are within the speaker's awareness and subject to conscious control, and that gestures can be deliberately employed to accomplish particular aims: to reason and solve problems (such as computing quantities), to represent overtly (depicting in the air or on-and-over objects), and to affect others (to direct attention and guide thinking or behavior). These more deliberate uses of gesture are the focus of this article, and even when gesture is used to compute or instruct and when the form of a gesture is carefully controlled, we nevertheless expect most of gesture formation to proceed automatically as for fluent speech production. This implies that some aspects of gesture forms might be present because the speaker wants or intends them to be, while others might emerge with little or no intent on the part of the speaker.

With this in mind, we can consider to what extent image-schematic structure is present in gesture forms because the speaker intends for it to be there and to what extent listeners apprehend that structure as part of the process of communication. A full answer is beyond the scope of the present work, but a closer look at path schemas in gestures for teaching provides evidence that image-schematic structure evident solely in gesture (not in speech) can be either incidental or essential to the communication. Even incidental structure provides access to aspects of the speaker's conceptualization that may be picked up by listeners, leading to more intersubjectivity in the communication.

Consider the tracing gesture depicted in Figure 4. Just before this moment, the teacher was showing her 1st grade class how to divide a circle into quarters. She then sat down and picked up the teaching clock while saying, "If I take my clock." In the moment shown in the figure, she says, "It's the same circle shape," while she traces with her right (dominant) index finger around the perimeter of the clock dial.

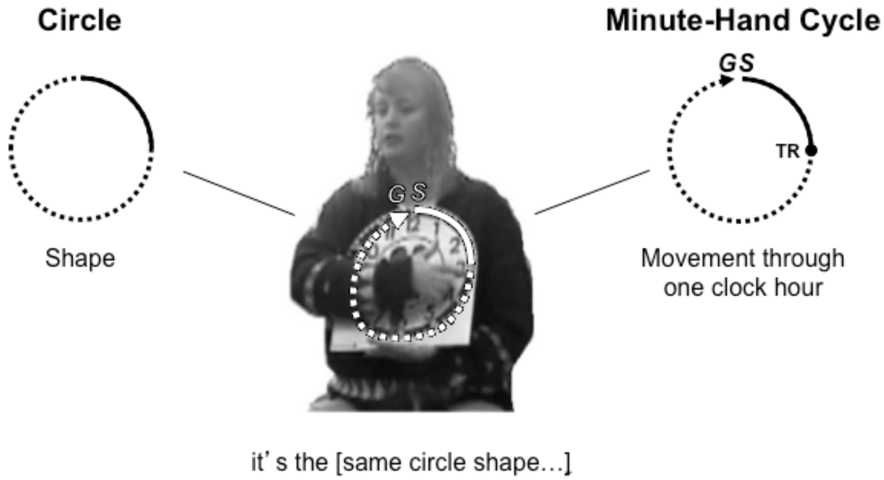
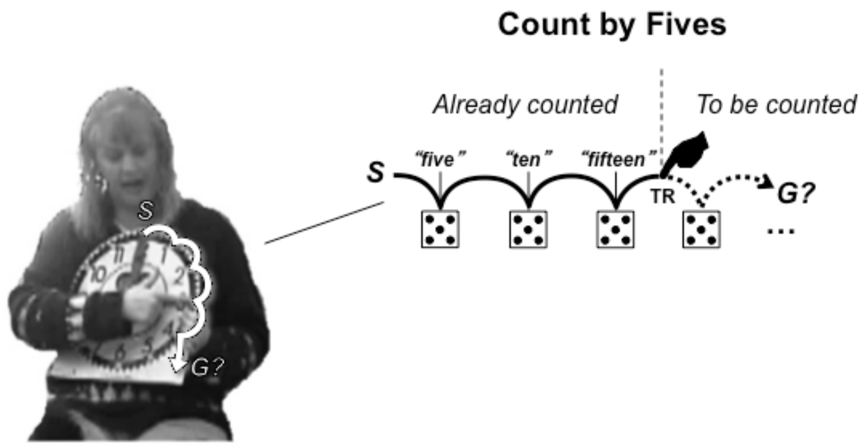


Figure 4. Gesture depicting circle shape (explicitly) and minute-hand cycle (implicitly) [bracketed speech co-occurs with gesture; dotted line indicates continuation of the gesture after the cessation of speech]

There are several things to note about this gesture's form, its relation to the accompanying speech, and its ostensible function in the discourse. The gesture stroke begins at the *12*, a considerable distance from the prior rest position (the hand was holding the bottom of the clock near the *7*); this long preparation phase provides evidence of intentionality in initiating the stroke precisely at the *12*. The stroke itself is a steady tracing motion in a clockwise direction, bringing the tip of the index finger all the way around the dial, and this movement continues unabated after the offset of speech (indicated in the figure by the shift from a solid to a dotted line) and without acceleration until the fingertip reaches the *12* again, at which point the stroke is released and the hand returns to a rest position. The portion of speech that accompanies the stroke is "same circle shape," where "same" profiles a relation between the clock and the circle that was the focus of discourse a moment earlier; "circle" highlights the previous object in the relation while students are looking at the clock face; and "shape" identifies the characteristic in common (it is the same shape, not the same circle). The tracing gesture is both indexical and iconic (as in Goodwin, 2007): it highlights a structure on the clock face (the dark band that forms the perimeter of the dial) while it draws a virtual circle on top of that structure. The effect is to superimpose the conceptual circle profiled in speech onto the physical structure of the artifact in view and in attentional focus; this is a prototypical example of a conceptual mapping gesture as described in Williams (2008a). At the same time, however, there is clear evidence in the form of the gesture—the location where the stroke is initiated, far from the hand's initial position; the direction, path, and steady manner of motion; the continuation of steady motion after the cessation of speech;

and the location where the stroke is released—that the gesture is partly structured by a path schema inherent in the cognitive model for clock-hand motion: namely the minute-hand cycle discussed earlier: the movement of the minute hand through one conventional clock hour. Nothing in the teacher's speech refers to this structure. Indeed, the circular shape could have been highlighted by starting the stroke near the hand's initial position, by tracing in either direction, by circling rapidly so the stroke would match the length of the utterance, or by releasing the stroke anywhere beyond the completion of a full circle, even after multiple revolutions around the clock face—all of which are variations observed in teachers' gestures while describing the circular shape of the clock face during the ethnographic study of time-telling instruction (one example will be discussed below). In sum, then, this gesture appears to be structured by two idealized cognitive models: one for the geometric shape of a circle and one for the minute-hand cycle in our culturally conventional system of time-telling. Only the former is connected with speech and important to the immediate communication: to identifying the part of the clock face being described and establishing the conceptual correspondence with a circle. The latter is incidental to the communication, but the SOURCE-PATH-GOAL structure of the minute-hand cycle is clearly evident in the gesture and available for the listener's apprehension. The listener is likely to apprehend this structure only if the listener's knowledge incorporates the cognitive model for clock-hand motion; otherwise, that model would need to be constructed in separate instructional discourse with its own combination of gesture and topic-focused speech, as in Williams (2008b).

Figure 5 presents a similar example with an important difference: here image-schematic structure not profiled in speech is again evident in gesture, but in this case the structure *must* be picked up by the listener for the communication to succeed. The teacher has just finished having the children practice reading "quarter past" times displayed on the teaching clock. Just before the moment in Figure 5, she says, "Now another way that we say it" while moving the minute hand to the top of the dial; here she is preparing to teach the children how to read the same times as "X fifteen." During the moment shown in the figure, she continues by saying, "is we count by fives when we move this from number to number—there's five minutes between each number." While saying "from number to number" she begins enacting a counting motion on the clock face, bouncing the tip of her right index finger from numeral to numeral in sequence around the dial. This movement continues into the middle of the next statement, "there's five minutes between each number," releasing mid-stroke (in the midst of a bounce) during the word "between."



is we count by fives when we move this [from number to number—
there's five minutes be-]tween each number

Figure 5. Gesture depicting counting path [bracketed speech co-occurs with gesture]

Williams (2008a) provides a detailed analysis of this gesture and its dual mapping functions; what concerns us here is the counting path it enacts. The counting-gesture stroke begins when the tip of the right index finger touches the tick mark at the top of the clock above the *12*; this is the source. The stroke moves clockwise around the dial, touching each numeral in succession, enacting the counting path. The manner of this movement, bouncing from object to object, is prototypical for counting and quite unlike clock-hand motion. And while the path is evident in the form of the gesture, the goal is not: the gesture is dropped mid-stroke when the hand is in the air after touching the *4*, with the failure to complete the path perhaps signaling that it continues indefinitely. Only subsequently, when the teacher counts out actual times displayed on the clock face, will it become apparent that the tip of the minute hand indicates the goal: when it points to the *3*, for example, the count by fives ends there with the recited tag "fifteen." The teacher's speech ("move this from number to number") signals that a path of motion is involved and even identifies the source and goal as numbers, but the precise starting point (source), end point (goal), and direction of the counting path are never stated. The specific SOURCE-PATH-GOAL structure is evident only in the gesture, and it must be picked up by the listener to learn to count the time correctly: the child must start at the *12* and count clockwise, touching *1*, *2*, *3* in succession while saying, "five, ten, fifteen," in order to produce a reading of "X fifteen." Any other starting point, direction, or sequence of touching the numerals will produce a false result. A common error observed in the ethnographic study was for children to utter the first tag "five" when they touched the *12* (the source of the counting path), thereby producing a false reading of "X twenty" when they arrived at the *3*. Even in this situation, the children produced the correct path, although they miscoordinated the recitation of number tags with the sequence of objects. In this particular lesson, the subsequent success of the majority of children in naming displayed times correctly showed that they picked up the image-schematic structure that was evident only in the teacher's gesture and incorporated it into their emerging cognitive models for counting clock times. In summary, the teacher's speech ("count by fives") activated a familiar cognitive model for counting that includes a path schema (the counting path), and her "from/to"-construction cued the presence of path structure while her gesture exhibited the source and path (though not the goal). That children were able to learn from this demonstration provides evidence that listeners absorb image-schematic structure from gestures and incorporate it into their conceptualization, supporting a multimodal view of discourse and meaning construction.

These two examples illustrate the presence of image-schematic structure in gesture, and they show how that structure manifests aspects of the speaker's conceptualization and influences the listener's conceptualization, leading to greater congruence of understanding. The image-schematic structure in gesture appears to originate in the cognitive models that frame the speaker's conceptions. How that structure becomes manifest in particular circumstances is likely to depend on multiple factors, including the location and orientation of speaker and addressee, the affordances and constraints of the body producing the gesture, the environmental structure to which the gesture might be fitted or might refer, content established or activated by the immediately preceding discourse, and the immediate goal of communicative action. Depictive gestures manifest image-schematic structure, exposing it to others who, as enculturated human beings, are habituated to interpreting what they see. In this way, gesture contributes to intersubjectivity beyond words alone.

4.4. Gesture sequences and combinations

How cognitive models motivate and structure gestures is particularly evident in gesture sequences and combinations. Two examples from clock-reading lessons are given here. In the first, shown in Figure 6, the speaker performs three distinct gestures over the clock face in rapid succession, each structured by a different cognitive model. The first gesture (circle shape) coincides with the statement, "So we have a circle." While saying "we have a circle," the speaker lifts his right hand from its rest position on the table and sweeps his fingertips rapidly around the perimeter of the clock face two times counterclockwise, stopping near the bottom of the clock and returning to the rest position. In contrast with the example in Figure 4, this rapid double-sweep with a lax hand (as opposed to an extended index finger) is purely indexical, drawing attention to the shape of the clock face without regard to clock-hand motion or how time segments map onto the clock. The second gesture (clock-hand motion) coincides with the speaker saying, "which, uh…, goes in a cycle from, uh…, from the beginning to the end, from twelve all the way back to twelve." During the "uh…" after "cycle," he places his right index finger on the *12*, holds it there briefly, and then as he says, "from the beginning to the end," moves it quickly but steadily around the face clockwise, stopping when he reaches the *12* again. He quickly repeats this gesture form while saying, "from twelve all the way back to twelve." The initial movement of the index finger around the clock face depicts the path of the minute hand moving through one clock hour (or perhaps the path of the hour hand moving through one 12-hour cycle; the speech is ambiguous), while the talk that occurs with the re-enactment explicitly names the source and goal. The third gesture (counting) follows immediately from this position, with the speaker counting aloud, "one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve," while tapping each of the numerals in clockwise order around the clock face. Here the gesture enacts a counting motion as in Figure 5, although in Figure 6 the count is by ones rather than fives and the speaker names the numerals as they are tapped, highlighting sequence rather than quantity. This series of three gestural forms exhibits image-schematic and geometric structure (cf. Mittelberg, 2010) from three distinct cognitive models: the geometric form of the circle, the SOURCE-PATH-GOAL structure of clock-hand motion, and the SOURCE-PATH-GOAL structure of a counting path. If we compare this with the example shown in Figure 4, we see that gestures can exhibit geometric or image-schematic structure from distinct cognitive models in succession or in unison, when cognitive models have been jointly activated or combined in the speaker's conceptualization.

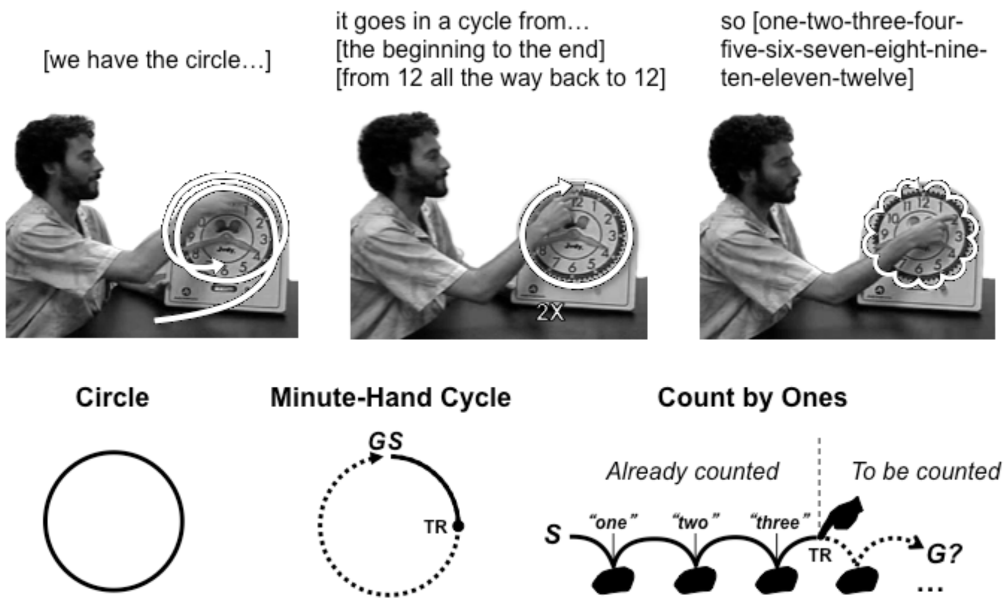


Figure 6. Sequence of gestures depicting circle shape, minute-hand cycle, and counting path [bracketed speech co-occurs with gesture]

Figure 7 shows a different example of image-schematic structure from distinct models being combined in gesture. Here, rather than a single gesture exhibiting structure from two models simultaneously as in Figure 4 or a series of gestures exhibiting structure from successive models as in Figure 6, a change in the form of an ongoing gesture marks a shift in focus from one cognitive model to another. The gesture stroke is initiated as a counting action, counting tick marks that represent minutes ("one, two, three…"), but as the count reaches "ten" the form changes from bouncing and tapping each tick mark to moving steadily around the dial, stopping at the *12*. This change coincides with a transition in speech from counting aloud ("… eight, nine, ten") to profiling the continuation of the process to its endpoint ("and it would go all the way, and you think you would end up at sixty?"). The first part of the gesture exhibits the image-schematic structure of a counting path: the trajector starts at the *12* and jumps from tick mark to tick mark clockwise around the dial. The second part of the gesture exhibits the image-schematic structure of a minute-hand cycle, moving steadily around the dial to the *12*, while the teacher's speech construes this gesture as indicating the continuation of the counting process along this path. The shift in mid-gesture marks the correspondence between the counting path and the familiar minute-hand path: both have the same SOURCE-PATH-GOAL structure (from the *12* around the clock face to the *12*), though they have different manners of motion, bouncing intermittently vs. moving steadily. This conceptual correspondence makes it clear why the counting action must start at the *12* and proceed clockwise: only by doing so can it produce a correct time reading. In this example, as in Williams

(2008a), gesture links counterparts from different conceptual inputs and joins them to structure in the world.

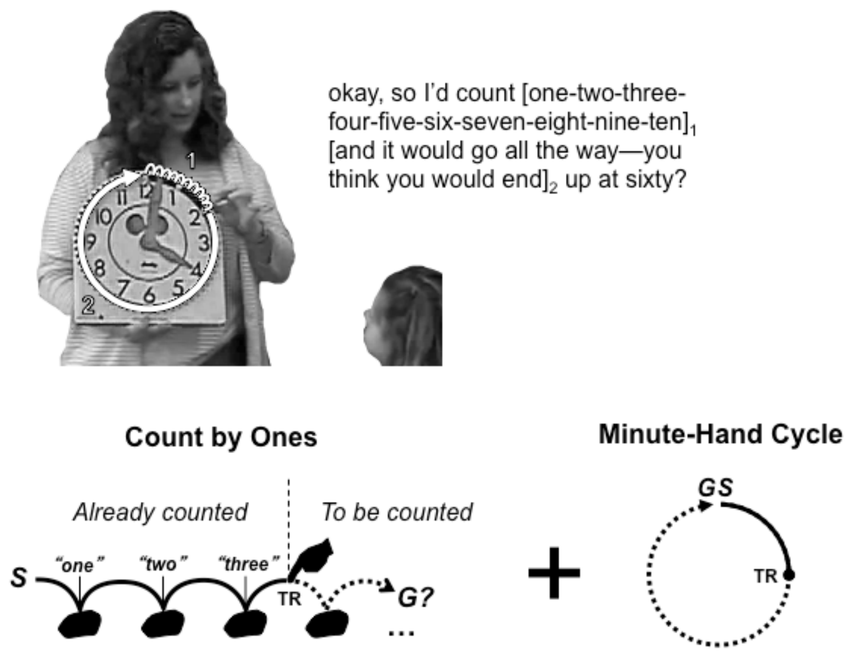


Figure 7. Concatenated gestures depicting counting path and minute-hand cycle [bracketed speech co-occurs with gesture]

5. Discussion

The examples described above show how embodied interaction with the world can be an essential component of cognition and how this is reflected in communication and performed in instruction. In counting, actions of the hands coordinate the functional systems that compute quantity by linking number tags with objects. In communication, hand movements enact aspects of the speaker's conceptualization, including image-schematic structure in the cognitive models that frame the speaker's discourse. In instruction, conceptual elements may be deliberately depicted to guide the listener's conceptualization: the hands and speech work in concert to activate cognitive models, to link them with structure in the world (or virtual structure conjured in the air), and to enact the coordinations that produce solutions to questions like "What time is it?" These gesture-speech performances are essential to perpetuating cognitive practices like counting and time-telling across generations—indeed, it is difficult to see how speech alone could keep these practices alive in our culture, nor how it could communicate the innovations that elaborate these practices over time (Williams, 2012).

Other researchers in the cognitive linguistic tradition have described the performance-like quality of instructional gestures and how they depict cognitive models. Núñez (2007) presents the example of a mathematics lecture in which the instructor uses gesture to enact a mathematical function in the air while he walks across the room to depict the process continuing to infinity. Núñez argues that while mathematicians define a function formally as a mapping from one set to another (x_i to y_i), which is a static model with LINK image-schematic structure, the lecturer's gestures during instruction characterize a function as the movement of a point along a path, which is a different and dynamic model centered on a path schema as described here. In a similar vein, Mittelberg (2010) analyzes the gestures produced by linguistics professors lecturing on syntax. The professors use their hands to represent linguistic constituents as horizontal virtual objects and move their hands to trace out giant tree-structure diagrams in the air. Mittelberg argues that the instructors' gestures are based on both geometric and image-schematic structure. The examples from Núñez and Mittelberg support the view that many instructional gestures are deliberate performances. In both cases, the speaker's gesture space is enlarged (scaled up) to make the depictive gestures clearly visible to the audience, an indication of their addressee-design. It is also apparent that the structure of what is being depicted in the air—the mathematical functions and tree-structure diagrams—derives from the material representations that mathematicians and linguists construct and interact with in the course of their professional work. In these examples, the gestures draw or trace imagined diagrams in the air while they enact aspects of the cognitive models that underlie those conventional representations, including their image-schematic structure. In my example of the teacher counting on the clock face in Figure 5, the gesture does not depict a conventional material representation; rather it displays the SOURCE-PATH structure of the counting path, evoking this conceptual component by enacting the canonical form of counting motion familiar to the children, who have acquired the cognitive model for counting as a cultural practice. This enactment is part of the teacher's process of linking the counting model with other conceptual and material aspects of time-telling to produce a "counting on the clock" model (detailed in Williams, 2008a). Like the examples of graphing mathematical functions or diagramming the syntax of sentences, counting on the clock demonstrates how cognitive models, language, and gesture are intimately connected with and dependent upon the symbolic cognitive artifacts employed in specific cultural practices, a point emphasized by Sinha (2014, pp. 65-70). I believe that these relations are especially evident in gestures produced during instruction, a key mechanism of enculturation.

In comparison with the conversational gestures studied by Cienki (1998a, 1999), Ladewig (2011; 2014), and Tessendorf (2014), the instructional gestures in my study likewise manifest image-schematic structure in cognitive models while being content-focused and situated in the material surround. The gestures do not act on the discourse or reflect abstract topics like honesty or morality; instead, they depict objects, processes, and actions integral to situated cognitive activities like quantifying objects or telling time, and they couple with the focal objects employed in these activities (or, in the case of gestures in the air, with implied evocations of these focal objects). The gestures combine iconic and indexical qualities—the hand traces circles over the clock face, enacts a counting motion as it would actually be performed on the clock, or outlines the path of the minute hand through one clock hour—to link the conceptual and material worlds in ways that support culturally conventional practices for distributed cognition. Despite these differences in the nature and function of the gestures studied by Cienki, Ladewig, Tessendorf, and me, all of the gestures manifest image-schematic structure inherent in cognitive models—whether of the content or of the discourse itself—in ways that provide visual and kinesthetic experience for the speaker as well as visual and vicarious kinesthetic experience for the listener, an alignment that promotes common ground. In instruction, the gestural performances become the focus of shared attention, with speaker gaze toward the gesturing hands often modeling this focus for the listener as the hands depict or enact structure necessary for the listener's understanding. In these interactions, the gestures help listeners build cognitive models or learn to apply them in situation-specific ways.

The conceptual nature of the gestures described in these studies contrasts with the mimetic quality of young children's gestures studied by Zlatev (2005; 2014) and Andrén (2010) and discussed by Cienki (2013). Zlatev (2014) suggests that the expansion of gesture around 3 to 4 years of age described by McNeill (2005, pp. 183-184) marks the start of a transition toward greater abstractness in children's gesturing (p. 24). The emerging picture is one in which mimetic schemas are apparent in early gestures produced in first-person perspective or character viewpoint, where the face, hands, and body are engaged in enacting the intended meaning, while image schemas at the heart of more abstract cognitive models (such as those involved in time-telling) become more apparent in gestures as children build knowledge and apply it in discourse, notably where gestures are produced from a third-person perspective or observer viewpoint, depicting with the hands in the space in front of the body. Both types of gestures continue into adulthood, with mimetic schemas evident in pantomimic gestures and image schemas evident in referential gestures (whether concrete or abstract) as well as in pragmatic gestures that act on the discourse, and, as I have shown, in instructional gestures that link cognitive models with material structures in cultural practices like counting and time-telling. There are many details yet to be worked out in this account, including how to reconcile the hypothesized early emergence of preconceptual image schemas with the developmentally later appearance of image-schematic structure in children's gestures, which may be related to changes in children's cognitive capacities and their participation in more sophisticated forms of cultural activity, leading in turn to more abstract forms of knowledge (more complex cognitive models, with richer image-schematic structure and more metaphoric and metonymic mappings, etc.).

Finally, the article opened with references to psychological reviews of gestures' influence on thinking and speaking and its benefits to communication. Kita, Alibali, & Chu (2017) claim that gestures influence thinking by helping speakers activate, manipulate, and explore spatio-motoric information and package it into units for verbal expression. Hostetter (2011) concludes that gestures benefit communication when they depict motor actions and, to a lesser extent, spatial information, especially when the information in gesture complements rather than duplicates information in speech, and she argues that the benefits of gesture to communication are greater for children, who may have less developed capacities for verbal expression and/or less experience with the topic. While these functions and benefits of gesture are likely present in my examples, my emphasis on gesture-for-thinking has been on using gesture to coordinate the elements of a distributed problem-solving system, such as coordinating number tags with objects to determine quantity, rather than the effects of gestures on thought, visualization, or speech production. My emphasis on gesture-for-teaching has been on linking conceptual content with structure in the world (Williams, 2008a) and doing so in such a way as to deliberately guide the conceptualization of others (Williams, 2008b), rather than communicating spatial or motoric content. When people use gesture to coordinate distributed cognitive processes or to guide others in doing so, they enact image-schematic structure at the heart of cognitive models employed in thinking and communicating, and these enactments make those conceptual relations and dynamics available for listeners' apprehension and, in the case of teaching, deliberately so.

6. Conclusion

In summary, path schemas are evident in gestures for thinking, where the hands are used to represent, coordinate, and compute problem solutions, and in gestures for teaching, where the hands are used in concert with speech to guide a learner's conceptualization. SOURCE-PATH-GOAL image-schematic structures from multiple cognitive models may appear together in gesture or emerge in succession as speech shifts focus during gesture production. The image-schematic structure in gesture may be incidental, reflecting aspects of the speaker's conceptualization that are not critical to what is being communicated, or essential, requiring that the listener perceive the structure and integrate it into the meaning being constructed in order to achieve the proper understanding. The examples presented here provide evidence that image schemas at the heart of cognitive models motivate and partially structure gesture for cognitive and communicative purposes and that image-schematic structure in gesture contributes to intersubjective understanding. From a developmental perspective, image-schematic structure should become increasingly evident in gesture as children develop more complex cognitive models and apply them in their thinking and communicating. From a cognitive scientific perspective, exploring the relations between cognitive models and visible action should help illuminate gesture's role in coordinating distributed cognitive systems and guiding the conceptualization of other participants in the activity.

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