Visual Representation of Information as Communicative Practice

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Anyone who has clarified a thought or prompted a response during a conversation by drawing a picture has exploited the potential of image making to convey information. Images are increasingly ubiquitous in daily communication due to advances in visually enabled information and communication technologies (ICT), such as information visualization applications, image retrieval systems, and virtual collaborative work tools. Although images are often used in social contexts, information science research concerned with the visual representation of information typically focuses on the image artifact and system building. To learn more about image making as a form of social interaction and as a form of information practice, a qualitative study examined face-to-face conversations involving the creation of ad hoc visualizations (i.e., "napkin drawings"). Interactional sociolinguistic concepts of conversational involvement and coordination guided multimodal analysis of video-recorded interactions that included spontaneous drawing. Findings show patterns in communicative activities associated with the visual representation of information. Furthermore, the activity of mark making contributes to the maintenance of conversational involvement in ways that are not always evident in the drawn artifact. This research has implications for the design and evaluation of visually enabled virtual collaboration environments, visual information extraction and retrieval systems, and data visualization tools.

Introduction

Imagine that you are in a doctor's office with your father, who is being examined by a cardiologist after a mild heart attack. The doctor reviews the details of your father's current condition and gives you a report of recent tests and scans, highlighting some numbers that were higher or lower than she would have liked to see. She then poses the following question: What would you like to do next? In response to your blinking stares, the doctor pulls a piece of paper out of a drawer in the exam room. Printed on the sheet is a rudimentary line drawing of the human heart. With a few quick strokes, she clearly explains to both of you where your father's heart had been previously repaired, where the most recent heart attack had been triggered, and where there are still some troubling spots. She lays in a series of hatch marks to indicate where the next procedure might need to occur as she walks you through the steps she will take if surgery is necessary. Through that drawing, she represents your father's past, present, and future. She also provides you with a concrete image of the interventions that might need to be performed. All of this is accomplished with a few deftly drawn lines. As a result, you are able to coordinate expectations and you and your father decide to wait to see how his health progresses over the next 6 to 12 months. The drawn image will not become part of your father's permanent medical record. In fact, the doctor hands your father the drawing as he leaves the exam room and he promptly discards it.

The spontaneous act of drawing during face-to-face conversations is an informal information sharing practice that is ubiquitous, in both personal and professional contexts. Often corresponding to moments of heightened clarity, insight, or coordination, marks on a napkin or diagrams sketched on a white board are visual information artifacts that embody the exchange of meaning between individuals in distinct ways. To learn more about the practice of image making as a specialized form of information and communication behavior, a study examined face-to-face conversations involving the creation of ad hoc visualizations (Figure 1), also called *spontaneous visualizations* or *free-form representations* (Walny, Carpendale, Riche, Venolia, & Fawcett, 2011). Ad hoc visualizations are drawings created for a particular purpose within a specific context, without consideration for any possible wider application. These so-called napkin drawings are sometimes kept, sometimes abandoned and are notoriously cryptic for those not present when they were created.

A parallel can be drawn between the problem posed by these spontaneous visual representations and the challenge

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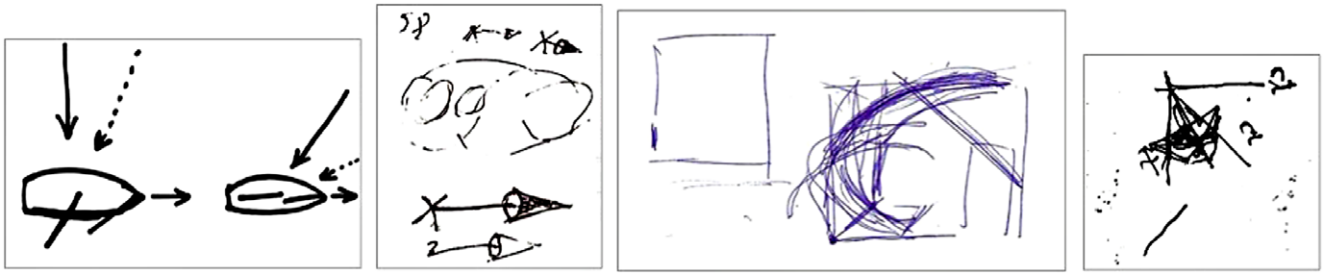

FIG. 1. Examples of drawings spontaneously created during conversation. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

of interpreting prehistoric marks discovered on a cave wall. Art historians can speculate about the meaning of an image but remain unable to determine with certainty what the cave drawing represents because the opportunity to observe its creation has passed (Guthrie, 2005). Similarly, when we neglect to attend to the context in which ad hoc visualizations (and other images) are created, we hamper our own abilities to account fully for the role these images play in our information and communication landscapes. We may be able to isolate figures or symbols, but, without taking into account the social interaction in which the activity of creation is embedded, we remain unable to identify with authority or credibility the role that the act of image making plays in communication. This is highly relevant to the design and evaluation of a range of visually enabled information and communication technologies (ICT), especially those meant to support collaborative work. In information science, visual information is typically represented and managed based on the affordances of the artifact, often neglecting to account for all that is communicated through the situated action of creating an image.

Image-Enabled Discourse

The study described here examines image-enabled communicative activities to learn more about the practice of image making as a specialized form of information behavior. Images are increasingly ubiquitous in daily communication, in large part due to advances in visually enabled ICT, such as information visualization applications, image retrieval systems, and virtual collaborative work tools such as digital whiteboards. However, image-making practices in collaborative contexts are not entirely dependent on technology. Anyone who has clarified a thought or prompted a response during a conversation by drawing a picture has exploited the potential of image making as an interactive tool for conveying information.

The term *image-enabled discourse* is introduced here to describe these conversational situations and includes (a) the motivation or need for the image, (b) the deployment of the image in a specific context, and (c) the reception of the image within an overarching communicative structure. These are aspects of visualization practice identified by Ware (2000) in his discussion of computer-generated representations of information. When we focus solely on the content of that image (either through automated analysis or through more qualitative interpretation), we run the risk of generating static analyses of graphic content in which the image is seen as a *fait accompli* rather than evidence of an interactive process of communication.

The process of examining image-enabled discourse, therefore, focuses on the context for creation of the image in collaborative contexts and de-emphasizes analysis of the image as an artifact. Underlying this discourse-focused position is the assumption that important and underevaluated elements of perceived meanings can be identified through analysis of the circumstances in which images are created and deployed as a means of social interaction and communication. This approach stands in contrast to a predominant thread of visual research in the information science field in which the image artifact is the primary focus (discussed further below).

For this study, drawing during face-to-face conversations is positioned as a specific type of information-driven communicative behavior, distinct from doodling or artistic practice. This interactive phenomenon is inherently dynamic and interactive; each participant may have unique and evolving goals throughout the course of the exchange, so the creation of ad hoc visualizations may serve different purposes as the conversation progresses. This article focuses on the following two specific research questions: (a) What communicative activities are taking place when people draw during face-to-face conversations? (b) Which affordances of drawing are most salient for image-enabled discourse strategies?

Related Literature

With the rapid development of interactive tools and technology, the ability to create and share images has increased exponentially, radically expanding what Elkins refers to as the domain of images (1999) to include data visualizations, infographics, digital video and photography, virtual, and computer-generated graphics. This transition has integrated our experiences of visuality, technology, and information. The range of forms that visual information takes reflects

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how expansive image-enabled practices have become. A brief review of image-oriented research in information science and related fields gives a sense of the diversity of approaches taken to problems related to working with visual information in communicative contexts.

A majority of information science research focusing on images can be characterized as having (a) a primary focus on the artifact in order to identify keywords and standardized descriptors, essentially converting the image to a text-based schema (Datta, Joshi, Li, & Wang, 2008), or (b) a primary focus on system building as in the case of much information visualization and image retrieval systems research, where issues related to user behavior are often explored in relation to system evaluation (Ellis & Dix, 2006). Close examination of image-enabled information behaviors is not typically the primary goal of image research in information science, although there are some recent exceptions (e.g., Beaudoin & Brady, 2011; Makri & Warwick, 2010; McCay-Peet & Toms, 2009; Yoon & Chung, 2011).

Ellis and Dix (2006) conducted an analysis of user studies of visualization systems to understand better why user-based evaluations of these systems were "so difficult." Recognizing the persistent limitations of user studies in this area, they recommended a more explorative approach to evaluating these systems. Shneiderman and Plaisant's (2006) in-depth, long-term case studies could be seen as an example of this type of approach. Heer, Viégas, and Wattenberg (2009) developed a tool for asynchronous collaborative information visualization, envisioning visualizations not only as analytic tools but as social spaces. Their user study of the system, therefore, included social data analysis. Huang, Eades, and Hong (2008) have also attempted to apply more robust user studies to reconsider traditional approaches to evaluation of information visualization systems.

Outside the field of information science and distinct from the study of images as artistic expression, humanities-based research has focused on visual communication that revolves around the following three themes: (a) image typologies, which involve the classification of images into distinct categories, such as charts, graphs, diagrams, and so on. (Arnheim, 1969; Elkins, 1999; Ware, 2000); (b) the study of visual grammar, which attempts to identify structural rules or patterns of use in visual communication (see, e.g. Bertin, 1983; Goodman, 1968; and Tufte, 1983, 1990, 1997); and (c) discussions of visual culture, which typically rely on semiotics to explain the intersection of various social/cultural systems through visual artifacts (Dikovitskaya, 2005; Kress & van Leeuwen, 1996; Rose, 2007). Scholarship across these three themes generally focuses on the communicative impact and content of image artifacts in specific cultural contexts. The process of image making is typically addressed in the domains of art and design, understandably focusing on artistic expression and often using language that is difficult to extend to social science domains.

Science and technology studies (STS) research looking at inscriptions in scientific practice, including images, writing, and calculations, is among the most relevant to the development of an image-enabled discourse methodology. In deconstructing the representational devices used by scientists, such as maps, electrical diagrams, chemical formulas, and models (Tibbetts, 1990), STS scholars show that, in fact, the scientific image is not a static object but part of a dynamic discourse. These researchers have devoted particular attention to the roles that graphic representations play in social and procedural activities in laboratory settings. As Lynch (1988, p. 202) states, visual displays are more than illustration; they are "essential to how scientific objects and orderly relationships are revealed and made analyzable."

Latour (1990) argues that visual representations are privileged over other modes of evidence because images have a distinct ability to retain an internal "truth" while travelling across time and space, resulting in a heightened ability to persuade a greater number of people of the veracity of one's findings. To challenge and ultimately accept scientific discovery, the social activity of sharing is essential. Latour (1990) asserts that scientific inscriptions "are not interesting per se but only because they increase either the mobility or the immutability" (p. 31) of evidence, allowing the dispersal of findings and facilitating debate.

Amann and Knorr-Cetina further support a connection between visual representations and scientific practice by articulating that "the notion of evidence is built upon the difference between what one can see and what one may think, or have heard, or believe" (Amann & Knorr-Cetina, 1988, p. 134). They examined image-analyzing talk in laboratories (i.e., discussions about the quality and content of visual data as they are being recorded), showing that interactions around visual evidence play an important role in stabilizing the representation of findings. Their observations of laboratory shop talk revealed challenges and conflicts among team members regarding the meaning and accuracy of scientific images. According to Amann and Knorr-Cetina, these disagreements are an important part of scientific inquiry. Because images can often be interpreted in multiple ways, they are important catalysts for these types of challenges and ultimately contribute to more robust science. The work of Ochs, Gonzales, and Jacoby (1996) supports this observation. They examined the talk, gesture, and graphic representation practices of physicists and concluded that a combination of grammatical markers and graphic representation helps scientists to maintain stable points of reference and therefore achieve mutual understanding and consensus.

Expanding beyond the domain of the scientific laboratory, Goodwin (1994) found similar results in his work comparing talk, gesture, and graphic representation of archaeologists in the field with litigators in a courtroom, highlighting the role of visual modes of communication in the development of what he calls *professional vision*, or an emergent sensitivity to categories of phenomena relevant to a given work practice. Goodwin went even further to say that, although professional practices such as those of scientists and litigators provide clear examples of the ways in

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which visible objects are implicated in the construction of a discursive community, these practices are "pervasive features of human and social cognitive life" (p. 630). Streeck and Kallmeyer agree: "Inscriptions are certainly as important in the business world as they are in science labs" (2001, p. 467), as evidenced by their close analysis of a conversation between two German entrepreneurs that involved drawing and writing.

The study described in this article shows that the principles of inscription identified in these investigations of scientific and professional practices can also be observed in more generalized communicative contexts. This study of drawing practices complements both information systems and artifact-centered image-oriented research as well as visual culture scholarship by contributing a detailed look at image making to expand current approaches to looking at the information-driven aspects of visual representations. Building a more comprehensive understanding of the role that visualization plays in communication means not just looking at the image artifact. Understanding image-enabled interactions requires study of the motivations for deployment of images in dialogic communicative strategies as well as how the reception of these images affects communicative outcomes. A framework for conceptualizing image-enabled discourse is described next.

Theoretical Framework

A discourse-oriented perspective on image creation allows connections to be drawn between visual communication practices such as spontaneous drawing and sociolinguistic theories of interaction through language use. A theoretical framing of image-enabled discourse is presented to make these connections explicit and to inform the design of the study. The foundation for this framework is built on the notion of communicative practice as defined by linguistic anthropologist Hanks, which is presented first. This is followed by an introduction of specific principles from interactional sociolinguistics that allow the general concept of communicative practice to be operationalized through data collection and analysis.

Image-Enabled Communicative Practice

Hanks (1996) describes communicative practice in terms of the semistructured, semiformal intersection between three aspects of language use: form, ideology, and activity. *Form* acknowledges that language is a system with predictable elements and structural regularities such as grammar. *Ideology* is the collection of cultural norms, positions, expectations, and consequences brought to the interpretation of the utterance. *Activity* is the improvised and interactive nature of communication. For example, you are walking down the hallway at work and encounter a colleague with whom you collaborate on a regular basis but who is also your superior. You exchange pleasantries, each asking about the other's family. Then you switch gears to address some miscommunications that may have taken place in a series of emails exchanged earlier in the day. Finally, you part ways, saying, "OK, see you at the meeting on Friday." According to Hanks, from a linguistic perspective, that exchange can be analyzed in terms of the form of the language: grammar, syntax, turn-taking. The use of language can also be understood in terms of the ideology that is reflected in words: You are familiar with your colleague (asking about family) but also are subject to the hierarchical relations associated with being part of an organization (deferring to your boss in the face of conflict). In addition, that very same exchange can be examined for cues about the communicative activities taking place through the use of language (greeting in the beginning, repair work when you discussed the misunderstanding, and projection of an ongoing relationship when you committed to seeing each other in the future). Regularities across these three dimensions of form, ideology, and activity define communicative practices. They are analytically distinct while being deeply integrated in practice. We interact through the use of language as a result of the combination and entanglement of these three dimensions of communication.

Image-enabled communicative practice (i.e., image-enabled discourse) can also be described along these three dimensions. *Form* corresponds to the structural content of an image as studied by researchers working in the areas of visual grammar and typologies, image retrieval, and data visualization. *Ideology* relates to the roles that images play in cultural contexts, which is the focus of research in the area of visual studies. However, currently there is limited empirical research on a generalized understanding of image-enabled communicative *activities*. This refers to the interactive and dynamic role images can play in the exchange of meaning. This study addresses the gap by examining in detail image-enabled communicative practices and the role that they play in social interactions. Doing so allows an explicit connection to be made between Hanks' robust notion of communicative practice and visually enabled interactions in both face-to-face and technology-mediated contexts.

Interactional Sociolinguistics

Hanks's work articulates the importance of communicative activities, and interactional sociolinguistics provides support for understanding different types of activities and the roles that they play in establishing and maintaining conversational involvement and coordination. Interactional sociolinguistics addresses the ways in which meaning is generated through the interactive use of language (Gumperz, 1982). Gumperz has shown that specific strategies related to not only *what* we say but *how* we say it provide important contextualization cues that are used to interpret meaning. These strategies allow us to do things (i.e., perform communicative activities) through the use of language.

For example, *code switching* is a discourse strategy that has specific parallels with spontaneous drawing practices.

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Code switching refers to instances in which multilingual conversants switch from a dominant language to an alternate one (or to a sublanguage such as slang) in the midst of a conversation based on a variety of cultural or communicative motivations (Gumperz, 1982). In a bilingual family, when a mother uses one language to scold or punish a child and another is used to express affection, she is code switching. When a teenager shifts to slang during a classroom discussion she is signaling to her peers that she is purposely creating distance from more formal social interactions of school. She is code switching.

One of the most important aspects of these switches, as analyzed by Gumperz, is that the change of language (or code) is seen to be communicative, in and of itself. He notes that these switches are rarely performed because a speaker does not have the appropriate vocabulary in the initial language but are typically done for strategic reasons. Code switching as a communicative activity is intended to signal contextual cues, meaning, and social roles. The child has only to hear that a parent is speaking in the "discipline" language to know she is being reprimanded.

Drawing during a conversation can be viewed as a communicative activity closely related to code switching, with the potential to signal contextual cues related to intended meaning in the same way as the linguistic shifts previously described. Drawing, gesture, body positioning, and verbal communication are all modes of communication that play a role in the image-enabled communicative practices examined in this study. The concept of code switching (or mode switching in this case) draws attention to the communicative impact of shifts, overlaps, and redundancies among modes of expression.

In addition to code switching, there are other complementary theoretical constructs from the field of interactional sociolinguistic that can contribute to a theoretic foundation for an investigation of image-enabled discourse. Notions of framing (Goffman, 1974; Tannen, 1993), footing (Goffman, 1979), and stance (Jaffe, 2009) are commonly used to describe types of discourse strategies used to influence social interaction and conversational involvement.

The term *framing* is used across a number of different disciplines. In interactional sociolinguistics, it refers to the process of identifying and applying an appropriate set of expectations to a given communicative episode (Tannen, 1993), in essence enabling a shared point of reference to be established. *Footing* is used to "describe how, at the same time that participants frame events, they negotiate the interpersonal relationships, or 'alignments,' that constitute those events" (Tannen & Wallat, 1993, p. 60). Goffman (1979) explains that a footing shift can signal a change in the participation framework of a conversation such as when a new person enters a discussion. Shifts in footing can also indicate changes in production formats, such as when one person quotes (or speaks in the voice of) another. *Stance* refers to "taking up a position with respect to the form or the content of one's utterance" (Jaffe, 2009, p. 3). Studies focusing on stance generally take into account a range of cultural and social factors that influence the manner in which an individual positions and represents himself in the world. These three aspects of discourse management are particularly embodied performances of sociolinguistic interaction (i.e., "taking a stance on something," "staying within a frame of reference," "being on sure footing"). The analysis shows that drawing, too, is an embodied form of social interaction, closely associated with similar communicative activities.

Sociolinguistic theories of interaction can be extended into the realm of image-enabled communication through the work of multimodal discourse analysts, such as Levine and Scollon (2004), Norris and Jones (2005), Scollon (1998), Norris (2004), and Goodwin (2000, 2003, 2007). In the study reported here, drawing and mark making are operationalized as a special type of nonverbal marker, similar to gestural forms of expression, and are also capable of indicating specific communicative strategies. This framework allows a systematic approach to analysis of both verbal and nonverbal markers that reveals the interconnectedness of modes of communication such as spoken words, bodily gestures, and drawing practices.

Materials and Methods

Data Collection

A protocol was designed to record systematically spontaneous drawing practices in collaborative contexts in a naturalistic, observable environment. Participants engaged in conversation with a previously unknown peer in an informal, meeting-room setting, with an array of typical office supplies available. The participants were specifically not told that drawing was the focus of the study to preserve the spontaneity of drawing practices. Instead, during recruitment and briefing, they were told that the study was about informal information sharing among peers. A series of conversation prompts was provided to each pair of participants to spark discussion and generate a data set of video-recorded conversations.

The protocol was administered to eight pairs of participants (16 volunteers recruited from undergraduate and graduate student populations at a large university), with three pairs in a pilot study and five pairs taking part in the main study. Pairing was determined by availability and to ensure that participants did not previously know each other. In the main study, the participants were split evenly between males and females. Three of the pairs were male/female, one was female/female, and one was male/male. Three of the participants in the main study were not native English speakers, each of whom happened to be paired with a native English-speaking partner.

Instigating conversation. A set of standardized conversation prompts in the form of questions to be answered by the participants initiated and focused interactions. The rationale for this approach was an assumption, supported by anecdotal evidence and pilot testing, that drawing during face-to-face

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conversation is not a rare event. If enough conversations are recorded, at least some will involve spontaneous drawing practices. Furthermore, this design made it possible to analyze two conversations about a similar topic, in a similar situation, in which one involved drawing and another did not. Burgoon et al. (2001, 2002) employed a similar approach in their work looking at the dynamics of deception in dialogic communication.

The intent of using conversation prompts in this investigation of drawing behaviors was not to create a controlled experiment but instead to devise a situation for making observations in an unobtrusive and consistent manner while creating an authentic experience for participants. In this case, participants were college students; therefore, an authentic experience was one that took place in a school setting but was informal enough that the participants would feel comfortable engaging with each other in a natural way. The aim was to create a situation similar to the first meeting of a pair of students randomly assigned to work together on a group project. Interactions such as these that require individuals to establish functionally similar frames of reference for communication around an unfamiliar or assigned problem can also be found in professional settings.

Conversation prompts. The conversation starters were designed to provide favorable circumstances for the creation of drawings while not being overly prescriptive. Conversation prompts were created using data from a preliminary study that involved gathering narratives from approximately 50 individuals about conversations in which they had participated when drawing had taken place. These candidate questions were reviewed by several trained social science researchers to determine appropriateness for use in this context. The ideal question was one that (a) was answerable within a 10- to 20-minute conversation, (b) did not require specialized knowledge beyond what a typical college student in the United States would be exposed to, and (c) was not overly deterministic about requiring the use of drawing to respond. As a result of this face validation process, a set of 20 conversation prompts was selected for use in the study. Examples of these prompts include the following:

- What is the most stable way to build a set of shelves?
- How do clouds form?
- How far is it from the earth to the sun in relation to the whole solar system?
- Why are the organs in the human body located where they are?

Participants were explicitly informed that a correct response was not necessary, but that they should do their best to come up with an answer with which both participants were comfortable. Pilot testing evaluated the ability of participants to respond to the prompts while engaging in naturalistic interactions with a peer participant. Evidence of this was seen in conversational involvement, coordination, humor and laughing, and ability to respond to the conversation prompt question without undue difficulty.

Analysis

Video recordings of prompted conversations provided empirical data for analysis. Initial review of recordings for quality and richness confirmed that the data corpus size was adequate for the qualitative, inductive approach to analysis typical of discourse-oriented studies (Johnstone, 2000). Each of the five pairs in the main study responded to three prompts. Video data were logged based on conversation prompt, yielding 15 conversations clips (three per pair), each approximately 5 to 15 minutes in length. Drawing spontaneously occurred in seven of the 15 conversations. For each of the five pairs, at least one participant drew at some point during their interactions.

All 15 conversations were transcribed, allowing comparisons to be made between interactions involving drawing and those that did not. For discourse-based studies, transcription can be an essential and recurring procedure in the analytic process (Ochs, 1979). The video transcription and analysis processes were informed by Charmaz's approach to grounded theory (1983), which advocates a two-phased inductive procedure that allows researchers to identify emergent themes qualitatively within a data set (*initial coding*), and then apply structured codes derived from these themes (*focused coding*) to create rich, systematic descriptions. Heath et al. (2010) describe a very similar approach to the analysis of video data, including a third phase,
analytic search, which occurs throughout the systematic review and description of the data and involves gathering candidate instances of particular phenomenon, actions, or processes of interest.

With this grounded approach to coding data, an analytic framework emerged that highlighted connections between verbal and nonverbal markers of social interaction through discursive strategies such as framing, footing, and stance-taking (Goffman, 1974; Gumperz, 1982; Jaffe, 2009; Tannen & Wallat, 1993). To capture details about verbal and nonverbal communication behaviors systematically, iterative transcription and analysis followed a multistaged process (Table 1). Preliminary data preparation focused on verbal utterances and involved creating a base verbatim transcript for each conversation. Initial coding included adding annotations of nonverbal behaviors related to multimodal communication events (Table 2) such as passages in which

TABLE 1. Analytic process.

Preliminary data preparation	Verbatim transcripts
Initial coding	Narrative transcripts (video log) Collection of emergent themes
Focused coding	Transcripts annotated for: • Drawing behaviors • Framing behaviors (topic, agreement, boundaries, stance, and vector)
Analytic search	Identification of affordances

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TABLE 2. Annotation scheme for communication behaviors related to coordination and conversational involvement.

Behavior	Dimensions
Gestures	Hand, shoulders, head Degree of articulation (high to low) Frequency/repetition (habitual to rare) Mirroring, echoing Touching Tilt, nod/shake
Overlap	Overlapping speech Simultaneous speech and gesture/movement
Gaze	Position and orientation of head/face Direction
Drawing behaviors	Picking up implement Picking up or orienting paper Drawing Hovering implement over surface of paper Putting down implement Using implement to direction attention
Body position	Distance Orientation Trunk, arms/hands, head/face Mirroring and echoing

TABLE 3. Common discourse elements across all 15 conversations.

Common discourse element	Explanation
Statement of the **topic**, or domain, of the exchange	This most commonly took the form of one of the participants reading the question aloud.
Agreement to engage by both participants	In most conversations this took an explicit form, with each person stating in some way, at some point, "Yes, I can engage with you on this topic."
Delineation of the **boundaries** of the conversation	This involved the negotiation of what was needed or necessary in order to answer the question.
Establishing stance	This occurred when a person entered into active engagement in the conversation, either through statements like "I know . . ." or "I think . . . ."
Introduction of a **vector**, or trajectory, for the conversation	For some conversations, the direction of the conversation was set in the very beginning, in others the trajectory was adjusted and altered throughout the discussion.

speech, body orientation, and drawing practices were tightly coupled (as well as "nonevents," such as long periods of silence; Harrigan, 2005; Manusov & Patterson, 2006).

During focused coding, common discourse structures related to establishing and maintaining a frame of reference were identified and marked in the transcripts. During this phase of analysis, the concepts from interactional sociolinguistics discussed in the previous section, in particular framing and stance, played an important role in structuring annotations related to communicative activities. These concepts led to the development of an emergent coding scheme that described patterns of interactions along the five dimensions shown in Table 3.

In practice, identifying common discourse structures facilitated comparisons across conversations that involved drawing and those that did not. Focused coding also included demarcation of specific drawing activities, identified as discrete discursive episodes. Episodes are passages of discourse that are coherent and reflect thematic unity based on the purpose of the speaker (Nakatani, Grosz, Ahn, & Hirschberg, 1995; van Dijk, 1981). Episodes can be nested or overlapping but always have a coherent self-referential structure. In the seven conversations in which drawing took place, there were two to six distinct episodes in each, yielding 26 discrete drawing episodes for analysis.

Analytic search focused exclusively on those 26 drawing episodes and was used to collect information about the ways in which affordances of drawing were evident in the communicative behaviors of participants. Affordances were identified and collected throughout the analytic search process. These affordances are discussed further in the next section.

TABLE 4. Communicative activities associated with visualization based on direct observation.

Activities	Frequency
Clarifying. Addressing a gap or missing information by providing additional information or details	6
Inventorying. Consolidating, gathering, listing all that is known; pooling known information; creating a scaffold for laying out known and unknown elements	5
Showing. Literally and visually representing a tangible object (i.e., easier to show it than to say it)	5
Integrating. Merging existing ideas	3
Connecting. Explicitly and tangibly showing conceptual relationships; showing connections that have been synthesized; not literal, physical connections	3
Translating/transforming. Changing the form or format of a message, often for the purpose of verification	3
Hijacking. Seizing control of conversation; an attempt to determine independently the focus of the discussion	1
Total	26

Results

Image-Enabled Communicative Activities

Analysis of directly observed conversations confirmed that the use of drawing during face-to-face conversations occurs for a variety of reasons and at different stages of the communicative process. A set of image-enabled communicative activities, summarized in Table 4, describes the range of communicative activities accomplished though the act of drawing. In Table 4, frequency indicates how often the activity appeared across the 26 episodes of drawing collected

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FIG. 2. **a,b:** Participants using gestures to discuss the location of heart (left) and lungs (right) in the human torso. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

during the study. This list is not exhaustive of all possible communicative activities associated with drawing but represents a subset of the diverse ways in which mark making can be deployed for communicative purposes. The presence of these activities in the conversations analyzed in this study, along with the work on inscriptions in scientific practice previously mentioned, argues for deeper, more systematic investigation of the role that the creation of visual representations of information plays in our communication practices.

The image-enabled practices described in Table 4 reflect joint communication activities embodied through the process of mark making. This list includes only those activities associated with the making of the mark and does not reflect analysis of communicative behaviors associated with any of the ways that, once created, the drawing might have been deployed within the conversation. This was a purposeful analytic choice to maintain the focus of the study on the activity of image making. In spite of this focus, the artifact did come into play when examining the affordances of image making practices, as discussed below.

Evidence of these activities confirms that the deployment of image making during face-to-face conversations occurs for a variety of reasons and at different stages of the communicative process. Each of these activities is described here in more detail. (*Note:* In the following examples, all names have been changed to protect the privacy of participants. Photographs and video stills are used for research publication purposes with the explicit permission of study participants.)

Clarifying. Participants used mark making to clarify their ideas by providing new, supplemental, or additional information in a visual form. Clarifying, as used here, refers to providing additional information in order to make use of an emerging concept or representation. This was the most frequently observed drawing activity in the conversations analyzed in this study. Drawing was used to address gaps in knowledge as participants worked together to frame a response to question prompts. In the cases in which drawing is used in the process of clarifying, the mode of visual representation is used to provide new or additional information.

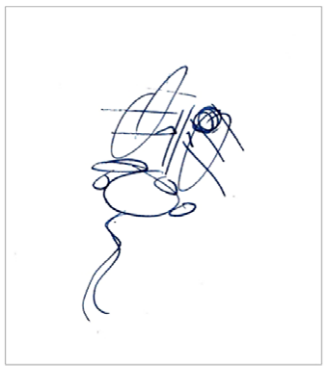

FIG. 3. Drawing of the organs in the human torso. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

As Norris (2004, p. 51) explains, a mode of communication is a system of representation, and multiple modes can be deployed during interactive episodes. When one pair was talking about why the organs in the human body were located where they are, they began by gesturing to their own bodies when referring to specific organs. They mirrored each other as they pointed to their own torsos as they discussed the position of the heart within the chest cavity (Figure 2a,b). However, when it came to the specific location of other internal organs such as the lungs, intestines, and pancreas, drawing was used first to establish the commonly understood elements (actually an instance of inventorying; see below) and then transitioning to clarifying the location of the other organs in relation to those waypoints (Figure 3).

Inventorying. Inventorying refers to the practice of drawing to consolidate, gather, or list what is known about a topic. Inventorying typically occurred in discussions of the human organs (Figure 3) and the solar system (Figure 4). As mentioned above, Figure 3 was created during an episode of clarifying and added to during a separate instance of

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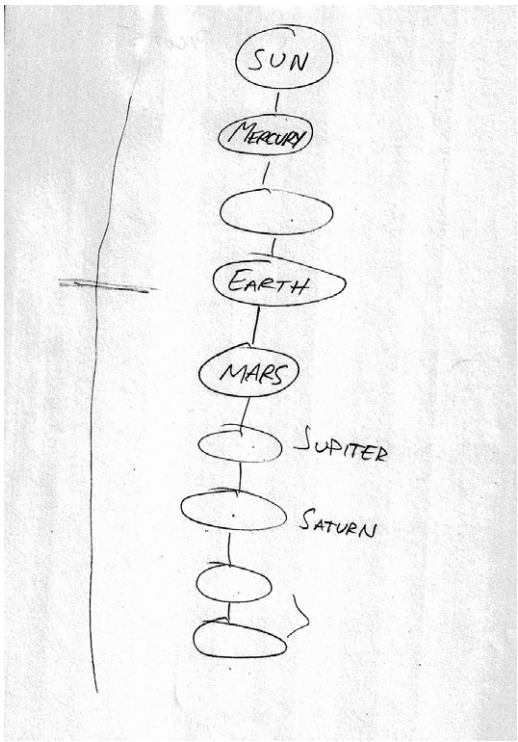

FIG. 4. Drawing of the solar system.

inventorying. This is a clear example of the ways that focusing on the completed image artifact alone can obscure the nuances of the communicative activities unfolding as result of visualization practices. Clarifying and inventorying are related, though distinct, activities, although this is not necessarily evident in the artifact.

Mark making allowed participants to create a visible, tangible scaffold for laying out what was known and to identify where specific gaps in collective knowledge or experience remained. When drawing is used to inventory, the conceptual or physical components of a system are laid out on the page (or whiteboard) so that both participants can see and discuss them. Inventorying was often deployed as a means to establish common ground for continued conversational involvement (Clark, 1996). Drawing as a means to lay out what is known about a topic provides the ability to create a tangible, visible representation of a shared frame of reference, allowing the participants to establish conversational involvement and coordination.

Showing. In situations in which there was a need to display literal, visual information (often about a physical form), drawing was used to show rather than verbally describe what something looked like. Although the completed drawing could come into play subsequently during the conversation, the activity of showing, as it is used here, refers to the initial creation of the image that is a visual depiction of an actual object. When participants used drawing as a means to show something, they often accompanied their action with statements like, "Here, let me see if I can draw it." This activity was most clearly seen in instances in which one participant was showing another how parts fit together, such as in a conversation about building a stable set of shelves or another interaction that made reference to the mechanism of a dumbwaiter (Figure 5). In addition to referring to a realistic rendering of an actual object, showing implies an interactive dimension and directedness to the activity of visual representation. Showing also conveys a sense of revealing as a drawing unfolds.

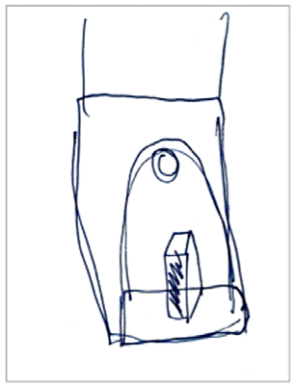

FIG. 5. Drawing used to describe a dumbwaiter. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Integrating. In many ways, integrating is the most collaborative drawing activity observed in the conversations. It was often deployed when neither participant had a complete idea or adequate domain of knowledge to respond to the question. Drawing enabled information to be pooled and, importantly, transformed into something new from the various parts and pieces contributed by individuals. These integrating behaviors require the ability to (a) establish common points of reference, (b) aggregate input from multiple sources, and (c) build isomorphic bridges between knowledge domains. Drawing allowed these things to be accomplished by providing a means for externally representing individual knowledge in order to combine it into a representation of collective understanding.

Connecting. As discussed above, in some cases when drawing was deployed in conversations, an image was created to show tangible, physical relationships, such as the joints in a bookshelf or the location of organs within the body. There were other cases, however, in which the relationships being depicted through drawing were not literal or concrete. In these situations, visual representations were used as a means of connecting conceptual relationships. Mark making was used to give form to the synthesis of information occurring as the conversation progresses. The activity of drawing (e.g., the lines drawn between abstract shapes and forms) mirrors the creation of connections between abstract ideas generated by the conversation.

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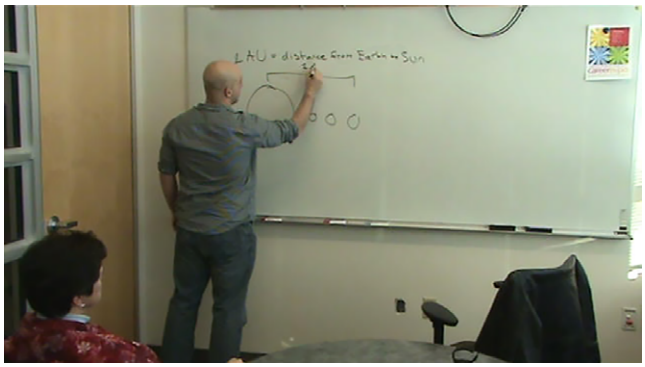

FIG. 6. Visual representation of one astronomical unit. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

In responding to the question about the relative distance from the earth to the sun, Gavin first inventoried what he and his partner, Walter, knew by drawing an abstracted diagram of the solar system (shown in Figure 4). At the conclusion of their conversation, he summarized their final response by adding the vertical line that runs down the length of the left side of the drawing, making a hash mark about half way down the page. As he drew the line and marked the midway point, he stated, "It's about that long." In doing this, he connected an abstract idea about the order of the planets (he has diagrammed them as if they are neatly queued up in a straight line, equidistant from each other, all roughly the same size) with a radically simplified idea about the distance between the planets in relation to the sun (again, equidistant and very close to each other). The actual physical reality to which Gavin is referring is so far removed from the image he has drawn that this cannot be an instance of showing. Because his diagram has been abstracted to such a high degree, the action of drawing the line is more closely related to the activity of connecting concepts in the same way that one might draw a Venn diagram or tree graph.

Translating/transforming. Generally speaking, verbal communication was the primary mode of interaction between individuals in the study; however, there were instances when a verbal expression was "repeated" in a visual format through drawing. Translating through drawing requires the ability to transform a representation accurately from one language or mode to another. For example, one pair felt that the concept of an astronomical unit (AU) was somehow related to answering the question about the distance from the earth to the sun in relation to the whole solar system (Figure 6). Mary was not sure what the definition of an AU was, but Henry thought that it was the distance from the earth to the sun. After he shared this information with her verbally, he wrote it on the white board in words; then, saying "And then we can probably draw a diagram," Henry drew a rudimentary diagram of the solar system, adding a bracket and label "One AU" to indicate the distance from the earth to the sun. The repeated act of recording the concept of an AU both verbally and visually helped this pair to establish a stable frame of reference for the rest of their conversation.

Hijacking. Hijacking refers to a situation in which a participant unilaterally seizes control of the conversation by using drawing to reorient the focus of the conversation. When Denise and Mike were talking about how to build the most stable set of shelves, Mike went on a tangent about an unrelated topic. Denise patiently listened to Mike for a few minutes; however, she eventually hijacked the conversation and brought it back on topic. She did this by moving her pencil toward the paper on the table in front of her, signaling a physical shift of orientation for both of them. Then she began to draw, enacting a shift of mode. As her drawing took form she said, "I think, you could either, you know, have the, the three boards, you know, do that little shelving frame." The combination of her physical movement, her words, and her drawing introduced a new topic of conversation (reframing the conversation), successfully rescuing the conversation from Mike's tangent. Denise's words and her actions combined to signal that she was independently attempting to set the topic and direction of the conversation, a marker of hijacking behavior in this context.

Artifact and Activity

One of the ways in which the process of image making is distinct from many other modes of communication is that it produces both situated activity (as described above) and discrete artifact, each having distinct and sometimes contradictory attributes or affordances (Snyder, 2012, 2013; Streeck & Kallmeyer, 2001). However, image artifact and image-making activity are not separated in practice. Existing in a state of entanglement, these different aspects of drawing can be exploited within a single conversation or interaction, sometimes virtually at the same time; however, when viewed in terms of enabling characteristics, the two are analytically distinct. As Streeck and Kallmeyer (2001, p. 480) point out, in some cases "the drawing of the line is a motor sign conveying a specific sense, [while] the mark resulting from the act embodies the same meaning, but it does so over time." In other instances, the motor action alone carries the meaning, with the resulting sign having "no immediate relevance." Because of this, analysis of image-enabled discourse requires a means to make distinctions between the action and the trace, to determine how each is contributing to communication.

Contrasting affordances of image-enabled communicative artifacts and activities observed in the data are listed in Table 5. Analysis showed that a communicative impact of these images lies in the activity of making the mark in addition to the artifact itself. As can be seen in the examples above, there is much about the act of making a mark and the role that this activity plays in communication that is not reflected in the image artifact itself. Furthermore, the salient attributes of drawing as an activity (sequential,

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TABLE 5. Affordances of drawing.

Activity	Artifact
Sequential	Unordered
Intermittent	Persistent
Mutable	Stable
Embedded	Discrete
Performative	Static
Unconventional	Iconic

performative, embedded in the greater conversation structure) are at times sharply contrasted to features of the drawing artifact (unordered, persistent, discrete) being exploited at the same time or in close proximity. This dual, and in some cases contradictory, nature of drawing as simultaneously artifact and activity explains one of the reasons why the meaning of visual representations of information can sometimes be so challenging to capture and represent. It also speaks to what is distinct about image-enabled discourse.

Goodwin (1994, p. 611) articulates one aspect of this difference in terms of materiality: "Instead of mirroring spoken language," inscriptions use "the distinctive characteristics of the material world to organize phenomena in ways that spoken language cannot—for example, by collecting records of a range of disparate events into a single visible surface." Rose and Tolia-Kelly (2012) discuss visual materiality in terms of what we choose to make visible, how we make things visible, and the implications of these choices. The ephemeral motor sign and the tangible trace are both potential conversation resources that exploit principles of visual materiality using different means, making this mode of communication multidimensional in ways that gesture and spoken language are not. It is this complexity of materiality that distinguishes image-enabled discourse from other modes of communication.

FIG. 7. Denise drawing her idea for a stable shelf. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

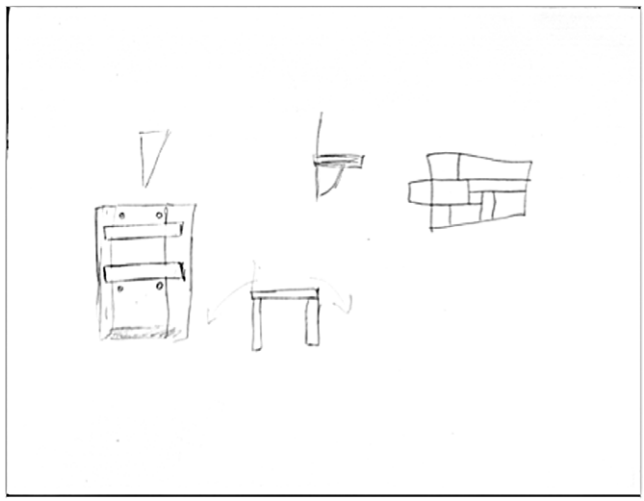

FIG. 8. Drawing of a stable shelf.

An Example of Contrasting Affordances

Returning to Mike and Denise's conversation, a closer look at their interactions can further illustrate the ways in which contrasting affordances of drawing activity and drawn artifact appeared in conversations. This pair responded to the question "What is the most stable way to build a set of shelves?" Early in their conversation, Mike suggested that pyramids are particularly strong and proposed that a bookshelf in this shape might be especially stable. He gazed out the window as he verbally speculated at length about the triangular books that would need to be created to go on such a shelf. As described above, after several minutes, Denise brought the focus of the conversation back to the topic of stable shelving (rather than odd-shaped books) by beginning to draw a picture of a shelf that she thought would be strong. Mike's monologue trailed off as Denise's drawing took shape and his attention settled on the image she was creating (Figure 7).

She drew for a few minutes, talking through her idea for a stable shelf as she added features to her picture in the same order that she would follow if she were actually to construct the shelf, emulating the process of physically constructing the form. Here we can clearly see that she was exploiting the *sequential* nature of activity of drawing. In fact, her words alone are relatively indecipherable without the accompanying sequential and visual unfolding of her drawing: "I think, you could either, you know have the, the boards, you know do that shelving frame." Even if you look at the drawing after the fact (Figure 8), it is not entirely clear to what her verbal statements are referring.

Mike replied with a series of affirming vocalizations and clarifying questions as she drew, indicating that he was both involved and participating in the conversation. He understood what she was doing. In this way, the sequential affordance of drawing allowed Denise to emulate the activity of

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FIG. 9. Transition between Denise and Mike performing the activity of drawing. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

building a shelf, enabling Mike to become engaged in her thought process. This results in conversational involvement and coordination.

At the same time the unfolding activity of visual representation played an important role in Mike and Denise's discourse structure, the drawn artifact also left an *unordered* and *persistent* record of their conversation. Eventually, Mike joined in the conversation more actively by taking the pencil from her, at her invitation (Figure 9) and made a drawing beside hers to show his idea for the shelves, reflecting the intermittent quality of drawing activity within the overall conversation framework. Drawing can start and stop throughout a conversation without necessarily breaking the primary frame of reference. The persistent external representation of the conversation (Clark, 1996) in the form of the drawing gave Mike access to various stages of Denise's train of thought (not just the last thing she said) when he was ready to contribute. The state of being unordered and the condition of being sequential, as well as persistence and intermittence, are contrasting affordances that come into play in distinct ways in this conversation, discussed below.

Discussion

From information graphics to complex data visualizations, images are playing an increasingly important role in communication and collaboration, especially in cross-disciplinary contexts (Fox & Hendler, 2011; Mathison, 2009; Mitchell, 2011). Motivation for the creation of information-driven images is often social in nature. Mathison (2009) posits that widespread use of images in a range of contexts reflects assumptions we have about images and their ability to transcend communication barriers. We use images to communicate because we believe (or intuit) that information presented in a visual format allows communication gaps to be bridged and provides access to broader audiences.

Visual representation is an embodied process in which ideas, thoughts, and expressions are given physical form (Arnheim, 1969). The action of mark making instantly leaves a visible, tangible record of a communicative expression, unlike verbal utterances or gestures. This means that as drawing is deployed during a conversation, it can simultaneously function as a stable, persistent waypoint (characteristics of the physical artifact) and also serve as a mutable, dynamic discourse strategy (characteristics of the social activity of communicating). This study shows that drawing is deeply embedded within conversation structures, and at the same time the drawn object exists outside the communicative structure of a conversation.

The principal goal of this investigation was to reveal how a contextualized understanding of the circumstances surrounding the creation of image artifacts can inform our methods for engaging with visual information across a range of applications. This method resulted in findings that (a) show some of the ways in which the spontaneous act of drawing a picture contributes to the exchange of information between individuals and (b) highlight the affordances of drawing that allow it to be used in these ways. These findings establish an empirically based point of departure for both extending current research and introducing new directions for investigating the role that visualization plays in small group coordination and collaboration. The observations presented here paint a picture of the many aspects of visually enabled communication that are currently overlooked, taken for granted, or only partially interpreted as a result of the prevailing focus on the image artifact. Multimodal discourse analysis of 15 video-recorded conversations highlighted the interconnectedness of modes of communication and revealed that, although the form of specific instances of mark making varied, patterns of communicative practices involving image creation do exist.

The conversations examined for this study shared certain similarities (e.g., the topics that were discussed and the need for negotiation between strangers). They differed, however, in the strategies deployed by members of each pair in response to the prompt and in response to each other. In one of the conversation, mark making was deployed as a "plan B" when an initial attempt to come up with a response failed. In another conversation, drawing was used as a means to become more specific, focusing the conversation and delineating the boundaries for an acceptable response. In a third case, drawing was used to maneuver in a kind of playing field or sandbox, allowing one participant to spill out what he knew about a topic in a nonlinear way, identifying the gaps in his knowledge. His partner engaged by attempting to fill in those gaps, and both used the visualization to determine whether they had enough information to formulate a response.

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Current approaches to collaborative visualization (Isenberg et al., 2011) tend to focus on either the image generated (the chart, the map, the diagram) or the technology used to create the image (the algorithm, the interface, the digital paint brush). In contrast, this research draws attention to the act of image making as a collaborative, communicative activity. Because of this, the intended meanings or purpose of specific elements within a constructed visualization cannot always be easily derived solely from the image-based object. At times, the primary communicative impact of an ad hoc visualization lies in the *activity* of making a mark rather than in the *artifact* itself.

Even when image-making tools are no more sophisticated than pen and paper, creating images within the context of an ongoing conversation is a technology-mediated event. Since before the advent of digital media, the ability to create and share images spontaneously in order to clarify, explain, or enhance a conversation has been part of the human communication toolbox. Although the ease with which we can make and share images on the fly has greatly increased with technological advances, these tools are enhancing behaviors that in many ways were already embedded in our communication practices.

Rich descriptions of visually enabled conversation and social interactions can greatly inform and influence the design of multimodal ICT. For example,

- *Creation of visual information.* This study makes an explicit connection between the practice of image making and the creation of information in collaborative contexts. The rapid increase and widespread availability of sophisticated content-creation tools and user-generated material on the web are just one practical reason to devote more attention to this important phase of the information life cycle.
- *Representation of visual information.* Although affordances of the image artifact can contrast or even contradict properties of image-making activities, both can contribute to the perceived meanings of an image. Representations of images, such as those used in image retrieval and information visualization systems, can and should acknowledge the dual nature of constructed visualizations as both artifact and activity.
- *Image-enabled coordination.* This study shows that social coordination may appear different when visually enabled means are put into play (e.g., lack of eye contact does not signify lack of connection; signs of coordination such as echoing or unison might cross modal boundaries). The full range of communicative activities associated with the creation of visualizations (not only those related to "showing") has to be adequately supported by visually enabled ICT such as virtual collaboration tools and information visualization interfaces.

There is a longstanding practice of using human experience and understanding as a gold standard in information science research. Observing interactions like the ones examined in this study can serve as a valuable baseline for continual improvement of systems to support coordination and collaboration. The communicative practices examined for this study, though only minimally mediated by technological tools, can inform the ways in which visual practices are supported and visual objects are represented in complex information systems. Understanding the dynamics of visual communication as an information-driven behavior is especially important given the increasingly prevalent role of visualizations in collaborative and multidisciplinary contexts. This study provides a theoretical and empirical basis for future work in this area.

Conclusions

When we draw for the purpose of communicating with another during face-to-face conversations, we are doing more than producing a visual artifact. We are engaging in a type of image-enabled information behavior. For example, drawing enables us to coordinate with each other, to introduce alternative perspectives into a conversation, and even to temporarily to suspend the primary thread of a discussion to explore a tangential thought without disrupting the prevailing frame of reference for the exchange. By creating an image within the context of an ongoing dialogue, we use the activity of visual representation to perform key communicative tasks related to the construction and exchange of information. This study has shown that those tasks go beyond mere illustration to include interactive and interconnected discourse management strategies.

This research took a deeply qualitative approach, involving social interaction analysis of video data guided by principles of grounded theory. The design of the study provides a structure for detailed analysis of image-enabled discourse in a situated context and the ability to compare across communicative practices both within and across pairs of participants. This approach also carried certain limitations. Placing participants in a problem-solving context, even broadly defined, introduces a form of discursive bias. The generalized context of the setting and problems does not address issues related to domain-specific visualization practices such as those performed in design, medical informatics, and business analytics. The close analysis of conversations is labor intensive and by definition focused on microlevel interactions, restricting the number of cases that can be examined. Future work will seek to mitigate these limitations by applying research outcomes in practical situations such as developing heuristics for existing or planned systems, as well as extending the investigation of collaborative drawing and visualization practices to broader contexts and more diverse populations.

Through this study, the concept of image-enabled communicative activities has evolved from a theoretical proposition to an empirically supported construct. These findings provide a basis for further investigation of the creation of images as an ad hoc information behavior. This study has shown that, by creating an image within the context of an ongoing dialogue, the action of visual representation performs key communicative tasks related to the construction and exchange of information.

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