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Editorial

Introduction: interactive graphical communication

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In an influential paper titled "External cognition: how do graphical representations work?", Scaife and Rogers (1996) noted, amongst other things, three biases in work on graphical representations: that it has been primarily concerned with external representations which are not actively modified by the user (i.e. limited interactivity), it has ignored the role of social and communicative context (e.g. collaborative sketching), and it has not made progress toward a framework that might allow the designer to produce and evaluate new forms of graphical representation. They pointed out that "little is known about the cognitive value of any graphical representations, be they good old-fashioned (e.g. diagrams) or more advanced (e.g. animations, multimedia, virtual reality)". They argued for a theoretical approach that considers the role played by external representations in relation to internal mental ones: "we need to ask what is the nature of the relationship between graphical representations and internal representations, and to consider how graphical representations are used when learning, solving problems and making inferences".

Interest in expanding research on graphical representations into these areas prompted the Workshop on Interactive Graphical Communication at Queen Mary University of London in August 2000 and, developing out of that discussion this special issue. The papers collected here do not, jointly or individually, provide the kind of processing account that Scaife and Rogers argued was necessary for effective design. However, these papers do present empirical and theoretical progress in addressing several of the limitations they identified. They also present concepts and principles that provide a basis for engaging with the design of systems to support interactive graphical communication.

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This special issue is multi-disciplinary, as any meaningful exploration of interactive graphical communication ought to be. The contributions draw directly on computer science, psychology, linguistics, and clinical aphasiology and touch on a variety of other disciplines. One consequence of this is that each contribution adopts its own perspective on the theme of interactive graphical communication. Although this enriches the discussion, it also places a burden on the editorial to provide some orientation to the different perspectives employed across this special issue.

The use of the term 'graphical' shows a basic consensus in the present papers. A broad range of graphical representations are considered, ranging from informal sketches to engineering diagrams and organizational charts. Their common characteristic is that the use of space on the page (or screen) is treated as integral to the syntax and semantics of the graphics as representations. The simplest examples of this are the use of space on the page to represent physical space in the world, e.g. mechanical diagrams. More abstract mappings between space on the page and logical or conceptual spaces are found in examples like data flow diagrams. Space on the page is also used to represent non-denotational aspects of graphics such as the sequence of drawing actions or the organization of contributions by multiple authors to a drawing.

The present papers also show some consensus in their concern with a general sense of 'interactive' to include 'dynamic'. As noted, existing research on graphical representations has primarily focused on the characteristics of static representations e.g. conventional graphs, pictures accompanying text and textbook engineering diagrams. By contrast, the papers in this volume are all concerned, in one way or another, with the dynamics of graphical interaction—crudely put, with what happens when graphical representations or parts of them change over time. The two papers that are most clearly concerned with dynamics at this generic level are by Tversky, Morrison and Betrancourt, and by Furuyama. Tversky *et al.* provide a critical review of the effectiveness of animated graphical displays as means of conveying information about complex systems. Furuyama examines how the rhythmic dynamics of speech and gesture, another spatially organized modality, may provide a basis for their co-coordinated use in interaction.

Against the background of these shared concerns the papers diverge substantially. A clear distinction is in the type of interactivity that is the focus of interest and two broad themes can be distinguished. The first is a notion of cognitive interaction, which relates to the responsiveness of a system to the user's cognitive processes, especially comprehension. This view focuses on user–system interactions mediated by multimodal representations. The representations of interest include the visual—static graphical representations such as diagrams and dynamic graphical representations such as animations—as well as the verbal. The focus is less on how a user physically interacts with a system, but rather on how the interactive and dynamic representations presented by the system in response to user-initiated actions aid the users cognitive processes. Interactivity (the user being able to act on representations) and dynamism (the representation changing over time) are seen as separate, though sometimes confounded, dimensions of analysis. For example, an animation that supports only start and stop operations is low in interactivity in this sense even though it may be highly dynamic. The papers by Narayanan and Hegarty and Tversky *et al.* are primarily concerned with interaction in this first sense.

The second sense of 'interactive' relates to use in communicative interactions between individuals. Scaife and Rogers (1996) noted that collaborative drawing and associated phenomena such as the development of *ad hoc* graphical conventions have received little attention in the literature on graphical representations. In this case the interest is not in individual cognitive processes but in the characteristics of graphics as a medium of communicative exchange: to put it in Furuyama's terms, in the *inter* rather than *intra* individual processes. Examples are the use of sketches as part of design discussions or the use of drawing as an auxiliary mode of communication in routine interactions. The papers by Healey, Swoboda, Umata and Katagiri, and by Sacchett are primarily concerned with interaction in this second sense and, less centrally, so are the papers by Giordano and Furuyama.

A sense of the collective contribution of the present papers can be glossed in terms of two observations. One contribution is that the utility of interactive and animated graphics as representations of information, including process information, is yet to be demonstrated (Narayanan and Hegarty, Tversky *et al.*). The logic of negative results dictates that this is necessarily a provisional claim. There is a strong intuition that interactive graphics should be useful for conveying certain kinds of information. However, the work presented in these two papers indicates that this intuition is yet to find compelling empirical support. As the papers suggest, this is an important cautionary tale for the designers of complex multimodal information displays.

A second joint contribution is that the utility of graphics in communicative interaction derives as much from their properties as a medium of exchange as from their 'de-notational' or cognitive advantages as representations of particular domains (Healey *et al.*, Sacchett). To use a distinction employed by Sacchett, the potential of interactive graphical communication in this sense derives as much from its contribution to the interactional coherence of an exchange as its contribution to the transactional coherence of the message exchanged. This may also prove to be an important issue for design. Sacchett argues that accuracy and completeness of a graphic are less important than the skills required for conducting graphical exchanges and collaborating with recipients. Similarly, Healey *et al.* propose that specific graphically mediated mechanisms of interaction may be critical to the coordinated use of graphical representations. Giordano additionally notes that the role of graphics as domain representations and as a medium of communication may often be in conflict. This tension is reflected in conflicts between formality and flexibility of graphical representations within the design process.

In addition to the cautions mentioned above, the papers provide some positive guidance for design. The cognitively oriented approaches explore the efficacy of interactive graphical representations in terms of how these might aid cognitive processes that construct appropriate mappings to their associated mental representations. The papers by Narayanan and Hegarty and Tversky *et al.* propose principles that can inform the design of effective computer-to-human communication through interactive multimedia, and the role of animation in such communication. The communicatively oriented approaches focus on constraints relating to the publicly available aspects of graphical representations. For example the extent to which all parties to an exchange are able to contribute and modify the elements of the graphical exchange (Sacchett, Healey *et al.*). Both the cognitive and communicatively oriented

approaches emphasize the importance of integration of different modalities and that people show a strong tendency to integrate signals or actions in different modalities into a single psychological or communicative unit (Furuyama).

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