Scaling Practices of Spatial Analysis and Modeling

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Symposium Description

In this symposium we present recent research on spatial analysis and modeling as these forms of spatial thinking are practiced in the professions, and in interactions between professionals and public stakeholders. Our objective is to provide descriptive and comparative analysis of learning in this new socio-technical domain. Authors of a recent survey of research on learning and use of spatial thinking (NRC, 2006) argue that a wide variety of advances in science and technology made over the past century would have been unlikely or even impossible without innovations in ways of representing, analyzing, and thinking about spatial structure. Despite steady progress in basic cognitive research on how spatial thinking develops and is learned (Newcombe & Huttenlocher, 2000), there are many open questions about how people learn to think spatially across different domains (Liben, 2003), and equally, how forms of spatial analysis might contribute to what is taught in K-12 schools (Edelson, Gordin & Pea, 1999; Enyedy & Mukhopadhyay, 2007). Moreover, while there is some speculation about how new technologies might change spatial thinking (e.g., Uttal, 2000), there has been little research in this area.

Comparative case studies of doing and learning spatial analysis and modeling in professional work settings can provide new insights into how people learn spatial thinking, outside the psychological laboratory and in settings where spatial technologies and work practices are rapidly changing. In three case study papers, we ask on how professionals change scale and modality, strategically, while at work in different practices: physical anthropology, urban planning, and emergency medical communications. In each case, we ask how changes in scale and modality both extend the body over time and space, and bring disparate aspects of the world into the body as proximal, modality-specific experiences (Barsalou, 2008; Gallese & Lakoff, 2007). In each case, we consider problems of coordination (how are different scales and modalities layered together in practice), of learning (how are newcomers inducted into practice), and of innovation (how are new technical practices developed and incorporated into existing work practice).

Comparative case studies reported in this symposium use a common set of methods that focus on learning as changes in interaction, biography, and group history (Scribner, 1985). In each case, we engage in three study phases. In the first phase, we identify a project work group and collect ethnographic data, including semi-structured biographical interviews with central participants. In the second phase, we capture detailed video recordings of naturally occurring work sessions, and we index these by topics and events for further study. Selected episodes are transcribed for detailed interaction analysis. In the third phase, we conduct video-elicited interviews with central participants, asking for their (separate) understandings of episodes we have selected as critical in our analysis of their work and learning. Video recordings and video-elicited interviews provide material for our analysis of learning as changes in interaction, while biographical interviews and participant observation provide material for our analysis of learning as movement along professional trajectories.

Our analysis of professional practice follows from our recognition that abstractions such as 'scale' are made meaningful as situated constructs:

> 'scale' is rendered most meaningful in its development as an empirical generalization—a concept made real by building up an understanding of complex and dynamic relationships and processes in context.
>
> (Howitt, 2003, p. 151)

Moreover, our comparative analysis across cases allows our approach to develop and test theoretical constructs of scale-in-practice. Of particular focus in this symposium are the relationships of scale to the modalities of the body. In his examination of undergraduate physics students, Nespor (1994) considers how students, as physicists in training, "move out of everyday bodily space-time and into the textual space-time of the discipline" (p. 78). A progression from scales and modalities of the body to scales and modalities of representation is also generally supported in Actor Network accounts of scientific work (e.g., Latour's (1988) account of the circulation of textual "immutable mobiles").

However, across the present cases of professional practice we pursue a contrasting argument that asserts the significance of scales and modalities of the body across three forms of genesis of professional practice. In the microgenesis of routine professional practice, experienced or more 'full' (Lave & Wenger,

1991) members of practice engage in scale coordination and assembly that involve specific disciplinary relations of embodied scales/modalities with representational scales/modalities. In other terms, our spatio-temporal analysis makes evident how 'full' members of professional practices are "variably scaled" (Nespor, 2004) within particular practices of the body and coordinated practices of representation. In the ontogenesis of new members to practice, newcomers become "rescaled" through practice, by bringing particularly scaled histories to present practice and by learning new practices of scale coordination and assembly. Innovations to practice—the sociogenesis of new ways of working—also involve new relations among scales and modalities of the body and of representations. Resources and models from other disciplines or practices—differently scaled and with different modal relations—are often the engines of such transformation. Thus, our account across these diverse cases is not an argument concerning the replacement or loss of the body in representational practice; rather, we argue that the particular relations between embodied scales and modalities and representational scales and modalities, and the variable and extensibility of the "professional body" in these relations, provides an important and understudied account of professional practice.

Shifting Between Person, Structure and Settlement Scales in Anthropological Field Work

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In this paper we report from a study of a group of physical anthropologists, focusing on joint activity by the group's faculty leader (Tom) and one of his advanced graduate students (Wanda) as they worked to "ground truth" a model of colonial succession by walking through a settlement they were excavating in the highlands of Peru. In this and other work activities of this scientific group, researchers deliberately moved between different spatial scales and representational modalities, in support of analysis, modeling, and research management. Newcomers to the group tended to work on individual dwellings (structures) within the colonial settlement, restricting their contributions to excavation and digital stratigraphy of particular features. Over time, their work expanded in scale to include work across structures, and with full group membership, to model changes in related structures over time. As part of a modeling innovation, underway during our case study, new ways of showing cultural behavior at the settlement scale provided group members with new, embodied resources for making explanatory inferences about colonial succession.

Tom's research investigated changes in the built environment of an Incan settlement in 16th Century Peru as an instrument of Franciscan colonization. For Tom, a major disciplinary objective was to model relations between phenomena at structure-scale and settlement-scale for a group of people who lived centuries ago during a transition between Incan and Franciscan rule. His group studied the settlement for four years, excavating structures in the summer and organizing and analyzing data during the academic year. In typical work, students focused on one or two particular structures, digging, collecting, and documenting while in the field, and creating digital stratigraphic representations back at the university. At a national conference where the group presented, students reporting on their structure excavations, while Tom used their findings for his analysis at the level of the whole settlement.

In the most recent field season, the group returned to Peru for a variety of tasks, one of which was to "ground truth" paths between structures in the settlement. Their earlier maps of the settlement, derived from aerial photographs and field surveys, were not precise enough to support a modeling innovation under development by Tom as the lead investigator. Using methods borrowed from network analysis, Tom modeled movement through the settlement into a central plaza, keeping track of what residents of each structure could observe as their neighbors passed along least-effort paths to the plaza. This measure of "observational power" was calculated for each structure (household) in the settlement, and could be compared before and after architectural changes undertaken by the Franciscans. Not only were new buildings constructed and old buildings renovated under Spanish colonization, but a new plaza was also built. Tom conjectured that changes in the built environment had drastic effects on the daily lives of residents, changing their social status and relations of power within the settlement. However, to establish

this new kind of modeling within the discipline, Tom had to insure that his maps correctly represented the location and orientation of each structure's doorway and paths between structures and the central plaza.

Tom and Wanda visited each structure and walked these paths in an effort to "ground truth" the settlement model. For one of the structures they visited, building that Tom and Wanda noticed that the original door, shown in their existing settlement model, had been blocked by a terrace for another building, and converted to a window. Tom reasoned that the terraced building must have been built later, blocking the original door, so a new doorway would have been built after architectural changes accompanying Franciscan rule. Wanda, standing at the remodeled door/window, immediately picked up on Tom's train of thought:

Wanda: So, I mean this would be a good one to look at changes from,=
Tom: [right
Wanda: [like earlier use, versus later [use
Tom: [yeah, yeah. Yeah=we could model this [as a
           doorway,
Wanda: [Model this one, and the [other one.
Tom: [and that one. Yeah. Yeah there's a doorway here.
Wanda: Uh huh. A::and, [that o::one,
Tom: [this is, one side and then this is the other side here.

Wanda related modeling the doorway and path for this particular building to the larger goal of the analysis, comparing the everyday experience of residents of the settlement before and after Franciscan colonial rule. As he listened to Wanda, Tom got increasingly excited, and evaluated (positively) her move into modeling at settlement scale ("yeah, yeah. Yeah"). They began to finish each other's sentences in overlapping talk, describing how to model earlier versus later use. The two then attempted to walk the path to the colonial plaza. After several starts and stops and consultations with a settlement map Tom was carrying on his laptop, Wanda exclaimed, out of breath, "When they rerouted it, in the colonial part? They like, you know, it was a pain in the ass for those people!"

As to the microgenesis of routine professional practice, this episode highlights the problem of coordinating representations of architectural structure and cultural behavior at different scales. While guided by a planimetric view of the settlement on his tough book computer, Tom and Wanda still struggled to find structures, paths, and architectural features at a (much needed) scale of walking between structures. On finding unexpected architectural features as impediments to their own mobility (a blocked door, paths interrupted by a terrace), Tom and Wanda rapidly expanded their analytical scale to that of the whole settlement (relationships between buildings) over a time period of colonial succession. The existing, flawed representation (in Tom's laptop) was coordinated with on the ground experience to repair the model and to imagine a new line of analysis.

As to the ontogenesis of members of the practice, Wanda's reasoning here operated at a scale larger than the individual structures she had excavated during previous field seasons. As the summer progressed, Wanda was well on her way to becoming a full participant in the discipline, exhibiting facility with shifting scales to reason about relations between structure and settlement scales. Also during the summer season, she found a new settlement in the highlands, which had not yet been excavated, and began to create settlement-scale maps that would support a dissertation project during subsequent summer fieldwork.

As to the sociogenesis of new ways of working, in this episode we see Tom and Wanda struggling to provide accurate architectonic data for a new, network modeling technique. Whereas earlier field work and analysis was devoted to finding architectural changes to individual structures, the "observational power" network analysis demanded that Tom strengthen his modeling of architectural features of individual structures (doorways) as well as the paths connecting these structures to the central plaza as part of the settlement's daily life under two administrative orders (Incan, Franciscan). Tom and Wanda used their bodies at walking, human scale, They walked among structures at the site, locating themselves in relation to other structures and within the map representation in the laptop, repeatedly shifting between structure and settlement scales to imagine changes in daily life for past-time residents. As both of their bodies stumbled through uneven and steep terrain and their breathing became labored, Wanda made a significant observation about a result Franciscan renovation, that it resulted in "a pain in the ass" for people who lived in parts of the settlement that lost more direct access to the plaza.

Changing the Structure of Planning Participation by Moving Across Scales

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This paper discusses how urban planners seek out and borrow innovative ways of coordinating scales from other planning departments across the nation to more successfully induct public participants into the planning process. Planners routinely imagine possible changes for communities and urban areas, but in an age of participatory planning, need public backing to leverage support from other governmental agencies involved in implementing change. Incorporating local residents and business owners into the planning process necessitates a new kind of scale coordination so that participants can eventually "see" their community as a planner. While maps at the planimetric scale are commonly used in public meetings and provide a visual of a large area that is not within reach of the body, some planners promote "charettes," or workshops, where residents and other stakeholders experience their community at a walking-scale, accompanied by a planner. Becoming intrinsic to the space under consideration is talked about by planners as having considerable advantages over extrinsically dominating the area as one does when viewing a map. This innovative technique of regaining the body at a walking-scale, and coordinating it with a representational scale in community workshops, is an effort to simultaneously instruct and construct a participating public in the "professional vision" (Goodwin, 1994) of urban planners.

The data for this paper is taken from a professional workgroup meeting occurring in a governmental planning department located in a medium-sized, mid-South city (Gotham). The purpose of the meeting is to discuss innovative ways in which other cities' planning departments have facilitated public participation in "community update" or "visioning" workshops. Currently in Gotham, these workshops have residents, business owners, and other stakeholders seated around a table-sized map that represents the community under review. Facilitated by a planner, each group of participants is urged to imagine possible changes for the community, and to point out aspects that should remain the same. Participants are encouraged to draw or write on the map with a permanent marker to make desires for their community visible for the duration of the meeting. Unfortunately, public participants spend a considerable amount of time in these visioning workshops trying to understand the model before them, asking about colors, symbols, and the locations of places that bear personal import.

While relying on maps and scaled representations of an area is commonplace in the practice of planners, these models tend to breakdown for newcomers and create more hurdles than supports for design. In response, five Gotham planners in a workgroup meeting were discussing ways to guide residents and business owners *into* the model, in the hope that conceptualizing space and imagining possibilities for that space might be easier. One innovation from a West Coast planning department was arranging a visioning workshop (or "charette") so as to feel more like running a shopping errand— entering a store, running into familiar faces, and having a chat. In this scenario, the planning workshop would take place in a local storefront, rather than in a church basement, and involve planners, business owners, and residents more informally discussing ideas for community change. A map of the community was close-by for referencing. Once a few ideas came to the fore, a planner would escort the participants into the street space for a stroll, also called a "site tour." The Gotham planner who first mentioned this idea, Tanya, states, "I always thought it would be interesting to take people out to the environment we're trying to change." It is during this site tour that planners could highlight for public participants the community characteristics of which they take notice, and vice versa. Another Gotham planner described the walking-scale charette as a way to "really be out there."

As to the microgenesis of routine professional practice, this episode demonstrates how incorporating a walk along a community's business corridor into the usual design review can coordinate embodied scale (the pace of walking, what can be seen) with much larger representational scales. Taking a walk down a familiar street with a planner might allow community stakeholders to insert their own experiences into the planner-created, representational view of that space. While coordination of embodied (intrinsic) views with planimetric (extrinsic) views comes naturally to planners, public participants in the planning process often struggle with this coordination. From the perspective of professional planners, providing public participants with a chance to experience proposed developments at a walking scale may

help to convey planners' proposals. And because urban planning increasingly requires public input and support, providing these forms of coordination is increasingly important. In response, the planning department in our case was searching for techniques of scale coordination to invite new forms of public participation in urban planning.

In terms of the ontogenesis for members of the practice, Tanya's site tour idea (borrowed from another planning department) was quickly taken up by the other four planners. In interview she reported making "good" proposals for neighborhood developments, only to face staunch opposition from community residents who gave little evidence of understanding the proposal. Tanya's search for how other departments managed this problem identified a strategy that promised, at a personal level, to give Tanya a new way of working. She described her desire to transport members of a neighborhood association to another part of town where they could walk through and around a novel kind of development, as opposed to experiencing only pictures and maps. "Sometimes [residents] really have to see it to get the idea," she reported.

Regarding sociogenesis, or changes in the collective practice of planning, planners in Gotham already realized that the daily, embodied experience of residents living in a particular place, on a particular street, next to a particular house, was not well represented in the maps and models that they designed. As a proposed innovation in their practice, borrowed during a systematic search of other cities' visioning techniques, the storefront charrette promised to offer public participants a new way to experience the contrast between existing and proposed urban space. By partnering with local businesses to host street level activities in which planners and members of the public move between neighborhood scale maps and walking tours, these planners began to organize for a different way of constructing/instructing public input and political support for departmental initiatives. This new form of charrette extended to public participants many of the same changes in scale that planners typically rely on in their own work—shifts between an extrinsic perspective in plan views and an intrinsic perspective while walking through neighborhoods to imagine changes in the built environment.

Modality and Scale at AirMed

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In this paper, we report on findings from a study of the uses of multiple resources available for conducting time-sensitive and complex spatial navigational work in a technology-intensive environment. The site of our study is the flight communications center (FlightCom) at a large hospital (Hampton Hospital). We call the flight program at this hospital AirMed. FlightCom personnel coordinate the operations of four AirMed helicopters, one fixed-wing aircraft, and neonatal ground ambulances, creating what Suchman (1997) called a center of coordination. These modes of medical transportation service an area within 900 miles of the hospital.

Staffed around-the-clock by up to four communicators, FlightCom gives us an opportunity to study how spatial analysis relies on established routines, models, and technical infrastructure while also being conducted on the fly. Spatial problems at FlightCom, which must be approached in a time-sensitive manner, include making precise determinations about where to send a helicopter using a range of resources (e.g., geographic information system (GIS) databases and on-the-ground information from medical crews, which is often unreliable), using multiple modalities to coordinate communications among several helicopters sharing the same airspace, and coordinating communications among medical personnel at various locations and across time and distance.

Cases of spatial analysis and modeling typically emerge at FlightCom when calls come in from area emergency dispatchers requesting that a patient be transported as quickly as possible from one location (e.g., the scene of an accident, a referring hospital) to another location (e.g., Hampton Hospital, another local hospital). Flight communicators regularly solve the spatial problems presented to them within each case by coordinating available resources to ensure that the helicopter flies safely to the scene, locates a landing zone, and returns with the patient. At FlightCom, the three forms of genesis of professional practice that form the foundation of our symposium are evident in the scale coordinations and assembly of experienced flight communicators, the way that newcomers' practices are rescaled across their work histories, and innovations to the practices of flight

communication involving new practices of the body and representation.

As to the microgenesis of routine professional practice, experienced flight communicators perform complex scale coordination and assembly work across each case they encounter, expertly varying practices of coordination and assembly across embodied and representational resources according to the demands of the case. In one case of "routine trouble," Dennis, one of the flight communicators, received a phone call informing him that an AirMed helicopter was needed at a regional hospital with known GPS coordinates. After Dennis relayed this information to one of the AirMed helicopter teams and they were in the air, the dispatcher called back to request that the helicopter land at the scene of the emergency, an ATV accident in a rural area. Based on street names supplied by the dispatcher, Dennis used an off-the-shelf location-finding software to locate the landing zone (LZ) and determine GPS coordinates, which were then relayed to the helicopter and punched into a computer-aided dispatch software tool that follows the helicopter in flight. Within a few minutes, the helicopter pilot reported back that they had been in communication via radio with the ambulance crew on the ground at the scene of the accident and received a different set of coordinates for the LZ. Dennis got on the phone again with dispatch, confirmed his coordinates by checking the cross-street information again and then asked the dispatcher, "Is any uh significant uh ground features or anything that I need to look for out there?" Receiving this information, Dennis reported back to the helicopter pilot, who was able to locate the scene of the accident.

In this episode, Dennis worked across multiple scales and modalities to assemble the landing zone—across, for example, multiple communication channels (i.e., phone and radio) and representational resources (i.e., off-the-shelf location finding software, GPS coordinates, specialty helicopter-following software) at various scales (e.g., street-level, level of ground features visible from a helicopter a thousand feet in the air, 900-mile radius of AirMed flight coverage). This work exemplifies scaling processes that extend the body and incorporate the world, showing the complexity of routine work of spatial analysis and modeling by experts in this professional setting.

As to the ontogenesis of new members to practice, the practices of newcomers are rescaled from their previous work histories to perform flight communication practices at FlightCom. Flight communicators are required to have at least two years of emergency medicine experience on the ground (e.g., as an EMT or a dispatcher for a local ambulance operation) prior to working for AirMed. Thus, over time as a flight communicator moves from on-the-ground medicine to an overhead view coordinating flights, practice is rescaled from on-the-ground scales to more expansive scales: navigational practices for finding sites of emergencies along local road networks in an ambulance shift to an overhead regional perspective of a 900-mile airspace and ground radius. This overhead perspective consists of an assembly of representational resources including paper and digital maps, communication resources for contacting helicopter pilots and nurses in flight as well as on-the-ground emergency dispatchers near the site of the emergency, and real-time tracking of helicopters in flight. Although flight communicators have at their disposal an array of representational resources, they continue to draw on their embodied knowledge gained from years on the ground as well as the embodied knowledge of other flight communicators in the room. For example, as flight communicators like Dennis work through episodes of routine trouble in assembling sometimes shifting landing zones, they often rely on embodied knowledge of local roadways, names, and routes gained from driving and riding in ambulances prior to coming to FlightCom. Over the course of work histories, flight communicators are cultivated as teams of professionals who can flexibly operate at multiple scales to complete their work. Embodied scales maintain their importance as a resource-to-be-called-upon in the complex practices of scaling at FlightCom.

As to the sociogenesis of new ways of working, we have observed innovations to the practice of flight communication involving new practices of the body and representation. At FlightCom, communicators not only track AirMed helicopters, but also those owned and operated by other companies that fly in and out of Hampton Hospital. These other helicopters are not equipped to be tracked in real time at FlightCom and so communicators have created innovative practices that aid in keeping all aircraft coming in and out of the hospital and in surrounding flight space safe. One of these innovations is the recent addition of a physical map zoomed in to the downtown Langdon area. The map is located under plexiglass on a table that sits between two communicators. On top of the plexiglass are small tokens that represent helicopters and can be moved as these helicopters move around Langdon. The communicators also use a grease pencil to mark the path of these helicopters as

their locations are reported by their pilots (e.g., from a neighboring hospital to the airport to fuel up). This embodied resource is coordinated with other innovations that utilize representational resources and operate at other scales (e.g., the "shadowing" of non-AirMed helicopters on flight-following software by approximating their arrival times and flight paths).

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