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The Matter of Space: Bodily Performances and the Emergence of Boundary Objects During Multidisciplinary Design Meetings

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Prior research has identified the importance of embodied action in establishing representational infrastructure during disruptions in interdisciplinary work. This study expands on such research by examining meetings of interdisciplinary museum design teams—including educators, designers, researchers, and museum professionals. In these meetings, the museum space (exhibition room) emerges as a boundary object as it is presented through diverse material artifacts including floor-plans and mock-ups. The authors’ analyses identify and describe bodily and discursive practices of place-making and place-imagining that the participants perform as they attempt to maintain continuity across these shifting material forms and occasions.

**INTRODUCTION**

“To experience, to undergo, is to be certain. To hear of someone else’s experience is to be uncertain.”

(Star & Bowker, 2007, p. 276)

One of the most striking features of Star’s work is the way, in her prose, personal narratives come to inform scholarly discourse, infusing the universality that is often associated with science with the intimacy of actual lived experiences. As two young scholars who came across Star’s work not long ago, we soon recognized its wide impact on many of the studies about design, technology, and education that were to inform our own research. However, it was not until we read her original publications that we came to appreciate the extraordinary depth of her work, where theoretical notions often were formulated in their connection to insightful narratives of everyday experiences. Reading Star we discovered texts full of stories and vital experiences of particular individuals, including her own, which she described in ways that made it possible for us to read them as common and familiar. We learned that apparently aseptic scientific practices such as coding in qualitative research could be conceptualized as involving not only
formal abstraction, but also the researchers’ affect and attachment with particular lived objects of research (Star, 2007). It was thus that we came to find in Star’s work not just a repository of useful analytical concepts for the study of human activity, but also a passion for understanding the tensions between the sometimes unclassifiable and idiosyncratic lived experiences of individual subjects, on one hand, and the more or less formal social infrastructures that sustain them, on the other.

Moved by a similar passion, in this article we examine how lived-in experiences become important organizing resources in cooperative design work in and through bodily work. As the opening quote suggests, there exists a tension—an ontological gap (Roth, 2005)—between the certainty of experiencing and undergoing, on one hand, and the uncertainty involved in hearing about someone’s else experience, on the other. In cooperative work, this tension is one between “the formal and the empirical, the local and the situated, and attempts to represent information across localities” (Bowker & Star, 1999, p. 291). According to the pragmatist and cultural-historical framework that informs much of Star’s work (Bowker & Star, 2000; Star, 1998), technological infrastructure—including material representations and classification systems—is a means by which the tension is overcome. Yet, in often focusing on the objects and artifacts that make up such infrastructures, we tend to overlook a first materiality that is fundamental to their constitution: that of the living bodies that both perform and undergo continuities across materials and occasions.

We begin the article by discussing the notion of boundary objects (Star, 1989; Star & Griesemer, 1989) and emphasize their material/organizational structure in cooperative work. We then review literature that shifts attention from objects to the mutually constitutive relations that exist between objects and the bodily and material actions that bring them forth as relevant aspects in cooperative work. Our empirical settings consist of two research projects in which educational researchers, exhibition designers, software engineers, and museum curators cooperate in the design of technology-enhanced exhibitions in a science museum and in an art museum. In both settings, the museum space (exhibition room) emerges as a boundary object as it is made present through talk and gestures, as well as through other material resources, including floor plans and mock-ups. Through ethnographic and interaction analyses, we describe the bodily and discursive work that the participants perform to make these different means of presentation emerge as a coherent set of resources for cooperation. In particular, we focus on practices of place making and place imagining, which, rather than relying on formal categorization, are performative in nature and draw from lived-in bodily experiences to orient and support cooperation. These analyses provide the empirical ground for a discussion on the importance of the living body as a constitutive aspect of the emergence of boundary objects in cooperative design work.

BOUNDARY OBJECTS AND THE MATERIAL ORGANIZATION OF COOPERATIVE WORK

Boundary Objects and Material/Organizational Structure

The notion of boundary object addresses the question of how participants belonging to different social worlds achieve cooperation despite their different views, methods, and systems of
classification. In their seminal study, Star and Griesemer (1989) take as a point of departure the characterization of scientific cooperation as involving interessement practices (e.g., Callon, 1985)—practices through which the participants from one background translate the concerns of the others “to fit their own programmatic goals” (Star & Griesemer, 1989, p. 389). Star and Greisemer expand on this work to elaborate a more ecological model where, rather than a problem of interessement, “the problem of all the actors in a network . . . is to (temporarily) reduce their local uncertainty without risking a loss of cooperation from allies” (p. 391). From this perspective, interprofessional teams’ achievement of a coherent set of translations becomes a practical matter of mutual orientation that depends on “the extent to which entrepreneurial efforts from multiple worlds can coexist” (p. 390), and not on making one group’s view an obligatory passage point for all. In their account of the historical development of a natural history research museum, Star and Greisemer described boundary objects as those concrete or abstract objects—including “specimens, field notes, museums and maps of particular territories” (p. 408)—which “have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation” (p. 393). Together with (or in the form of) classification systems, technologies, and representations, boundary objects become part of infrastructures, which emerge from and sustain the developing cooperative practices (Star & Ruhleder, 1996).

Through the years, boundary objects have been extensively invoked to account for the way material artifacts become relevant organizational resources in cooperative work. In this study, our interest on boundary objects lies in the relation between what Star (2010) considered an underrepresented dimension, namely, their “material/organizational structure” (p. 602), and bodily engagement. In our view, presenting the words material and organizational bounded by a slash mark, as Star does, is appropriate because it makes possible to refer to both aspects in their unity, rather than as two different things only to be united by analytical work. This unity exists in and as performed action; the materiality of any object “derives from action, not from a sense of prefabricated stuff or ‘thing’-ness” (p. 603). Thus, the material and the organizational are irreducibly related because “the materiality of anything . . . is drawn from the consequences of its situation” (Bowker & Star, 2000, p. 152). Recent literature investigates how different types of objects acquire different functions as they move from nonroutine to more routinized and formalized organizations (e.g., Lee, 2007; Pennington, 2010). However, articulations of how concrete and moment-by-moment actions and situations bring about particular material/organizational properties are less often elaborated.

Bodily Action and Cooperative Work

There is research about cooperative work in general, and about boundary objects in particular, emphasizing the role of bodily action in the emergence of working infrastructure. Some research has emphasized how bodily aspects contribute to the achievement of cooperation despite consensus because the body affords forms of knowing and communicating that do not rely on prior formal understandings. Henderson (1991, 1998), examining how visual representations and prototypes function as boundary objects during (engineering) design work, discusses how the latter elicit and capture—conscript—the different participants’ tacit knowledge. Drawing from Polanyi (1958), Henderson (1991) uses the notion of tacit knowledge broadly “to signify
knowledge that is not verbalized” (p. 451). From this view, assumptions about shared formal knowledge are not required. Rather, participants pertaining to different social worlds can relate to the same representations and tools because these index to different “stocks of tacit knowledge” (p. 451). Taking as point of departure notions of distributed cognition (Hutchins, 1995), Hall, Stevens, and Torralba (2002) examined how participants in interdisciplinary projects made salient particular aspects of an emerging *representational infrastructure* through animation performances, that is, performances involving the coordination of verbal and gestural actions over and about the material representations. Through animation performances, participants belonging to specific disciplines made visible aspects of different disciplinary practices (e.g., geology). This allowed them to assemble, evaluate, and disrupt the representational states of the collective and distributed cognitive system.

Other research has focused on how bodily engagement and the material objects that come to be known during cooperation exist in a relation of mutual constitution. Such studies suggest that there exists a reflexive relationship between embodied interaction and the emergence of particular material artifacts as these become relevant to activity (e.g., Roth, 2009; Zemel, Koschmann, LeBaron, & Feltovich, 2008). Zemel et al. (2008), for example, analyze the deictic practices through which a fistula—as a boundary object that provides for the relevance and organization of the cooperative work during a surgery—is referred to as a *missing object* in the here and now of situated action. These studies provide evidence that actions and objects exist in dialectical relation, mutually presupposing and bringing forth each other during joint coordination of talk and bodily action.

Further evidence of the interrelation that exists between objects and the material actions that bring them forth comes from research attending to how workspaces are involved in the organization of cooperation. Accordingly, settings must be seen as developing along with the activities that turn them into particular inhabited *places*. Thus, Suchman (1998) characterizes work settings not as given, but as cooperative achievements of the participants. Investigating the practices in an airport operations room, she concludes that “through their interactions with each other and with their environment, members of the operations room create the space for their joint individual activities at the same time that those activities are structured by the spaces in which they occur” (p. 57). Noble, DiMattia, Nemirovsky, and Barros (2006) make the case that, in investigating how tools are appropriated and mastered through practice, we should also pay attention to how lived spaces change as tool use transform our relationship with the world. Streeck (2013) illustrates this process as a transformation from “space into place” through the developing and changing social configurations and activities in a public town plaza.

### BODILY PERFORMANCES AND THE EMERGENCE OF BOUNDARY OBJECTS: TWO CASE STUDIES FROM INTERDISCIPLINARY DESIGN WORK IN THE ART AND THE SCIENCE MUSEUMS

The literature just reviewed suggests that there are relations of mutual constitution between objects, bodily actions, and work settings. In this study, we investigate such mutually constitutive relations in the context of cooperative design work in museum settings. In the remainder of this article, we draw on ethnographic and interaction analysis methods (Jordan & Henderson, 1995) to examine bodily and discursive practices through which museum spaces—as made present
through gestures, prototypes, and visualizations—come to function as boundary objects in two different design projects involving a science and an art museum. In Zemel et al.’s (2008) study just described, a fistula is made present as a missing object during surgery through bodily practices, thereby becoming an organizing aspect of the social transaction despite (and precisely because of) its absence. Similarly, in the cases that we analyze in this study, exhibition rooms that do not yet have the specific form and function that they will have at the end of the design process become an important organizational resource in and through bodily work. As we show throughout the analyses, this work makes salient the participants’ relation to material spaces in two interrelated ways. On one hand, the participants’ transactional work can be characterized as one of place making, through which the workspace changes and becomes a particular inhabited place within which the participants find resources to achieve shared ways of orienting their work. On the other hand, their transactional work is one of place imagining, as it does not orient toward the immediate material setting, but toward imagined ways in which the museum spaces become inhabited places. We begin by describing the settings and the role of the museum room as both an object of design and a boundary object in two interdisciplinary design projects. We then analyze the participants’ bodily and discursive practices and methods in and through which the museum space (exhibition room) emerges and evolves as both an object of design and as a boundary object.

THE MUSEUM SPACE AS BOUNDARY OBJECT

We draw our analyses from two design projects conducted in Norway during the 2010–2014 period, one involving an art museum and another involving a science museum. Although different in the knowledge domains, the two projects have in common the arrangement of multidisciplinary design teams consisting of participants from different social worlds, including museum staff (directors, curators, and museum educators), architects, educational researchers, and technology and interaction designers. The projects also share the general goal of developing technology-enhanced solutions for the design and redesign of museum exhibitions, as both were funded by two independent research and development grants from a program aimed at enhancing “interaction, innovation and value creation in the ICT-based network community” (Research Council of Norway).

Most important for this study, as the upcoming analyses show, in both projects the museum spaces (exhibition rooms) emerge both as objects of design and as boundary objects in and through the different means—mock-ups, gestures, representations—that makes them present during design work. Here we follow Binder et al. (2011), who differentiate between (a) object of design; (b) the design object or thing that the design work delivers as outcome; and (c) the object’s constituents, which consist of the different artifacts and representations that are generated and used through the design process. By disentangling the notion of object of design from that of the thing that is handed over at the end of the design process, we can characterize the designers’ relation with their object of design—here, exhibition rooms—without assuming that the final outcomes serve as the model for their actual performances during the design process. Rather, design work involves a “peculiar process in which the focus is on a thing that does not yet exist” (Binder et al., 2011, p. 51). It is through working with the diverse material constituents
that emerge during the design work that both the object of design, which results from and orients the cooperation work, and the design’s final outcome take shape and become structural aspects of activity. In the cases analyzed here, the museum space functions both as an object of design and as a boundary object, much like Boujut and Blanco’s (2003) intermediary objects, which “act as boundary objects . . . [and] as mediators translating and representing the future product” (pp. 210–211).

The settings consist of a series of meetings and workshops during which the participants present and negotiate design ideas and action points that, most often, each group has developed locally. With regard to boundary objects as moving back-and-forth between having ill-structured character in common usage, but a tailored and well-structured one worked locally within groups (Star, 2010), these meetings and workshops lay in the middle, constituting opportunities for the interdisciplinary team to expand their shared object of design and to develop new forms of membership (Bowker & Star, 2000). The design meetings and workshops were video and/or audio recorded. Pictures, artifacts, and documents, as well as field notes taken during the meetings and workshops, complete the database. Drawing on interaction analysis techniques (Jordan & Henderson, 1995), we shifted between individual and joint data sessions where we contrasted each other’s descriptions of the observed social transactions against the actual materials. During these sessions, particular sequences became salient in which the organizational character of the museum space as a boundary object became visible as place-making and place-imagining practices during interdisciplinary work. Before we present the analyses of such sequences, we describe the two research settings.

The Case of the Science Museum

The science museum project involved the design of a new exhibition about the topic “energy for the future,” a topic that was also a module in the science curriculum in Norwegian upper secondary schools. Motivated by this thematic overlapping, the Norwegian Museum of Science and Technology, the University of Oslo, an architecture firm, and a company producing visual effects joined in a research and development project aimed at bridging science learning across the school and the museum through technology-enhanced solutions for the school and for the museum settings. The analyses presented here focus on the museum setting.

The role of the museum space as an organizing resource in this project was first documented in a prior study (Jornet & Jahreie, 2013). In that study, and building on activity theory (Engeström, 1987), we examined how instances in which a room of the science museum was made present by different means became occasions for negotiating what previously had developed as conflicting views or tensions regarding the purposes of the cooperative enterprise. These tensions related to differing historical relations that the different participants, belonging to different social worlds, had with regard to the roles of the school and the science museum as educational settings. The tensions existed in the form of conflicts and disagreements in practical design matters such as to what extend scientific disciplinary aspects of the knowledge domain “energy for the future” should be presented in the museum setting, or how much emphasis should be put in supporting reflection and the understanding of scientific issues, versus supporting entertainment while favoring the more socio-political aspects of it. Opportunities for overcoming these
tensions emerged, however, as prototypes and sketches of the museum space and related artifacts where introduced. Just as studies on cooperative design work report, these prototypes and sketches facilitated the emergence of boundary crossing situations in which the participants begun to “negotiate and combine ingredients from different contexts to achieve hybrid situations” (Engeström, Engeström, & Kärkkäinen, 1995, p. 319). Most important, as the upcoming analyses show, it became analytically possible to trace historical links between the participants’ noticing of structural aspects of the museum space—as physically present or represented through floor plans and sketches—on one hand, and transformations in the material and conceptual organization of the cooperative work, on the other.

The Case of the Art Museum

The design work in the art museum case involved multiple related and overlapping trajectories and teams, where the organization of the workspace and the ways in which the museum space was made present through talk and gestures also became interrelated. One trajectory involved the “re-hang” (redesign) of the permanent collection of art led by the new head curator of the National Gallery. The second involved the design and (less permanent) installation of an interactive project room in a corner of the National Gallery for a period of about 2 months. The rehang involved choices about the arrangement, sequencing, and selection of artwork from the museums collection. This process was a major undertaking for the museum and involved the design of new interpretive materials and aesthetic choices about spatial features such as the color of walls and suggested pathways for visitors through the museum. This trajectory was largely performed internally by museum staff, but overlapped with the multidisciplinary team in the project room design.

Aspects of the design of this project room have been presented previously in Pierroux and Ludvigsen (2013), and Steier (2014). The project room was conceived as an interactive space used to engage young people with the work and life of Edvard Munch and to explore new uses of interpretive media and technologies for all visitors. This room was to be situated around the corner from a popular room in the gallery containing the most famous works of Munch, and this interactive project room was viewed as a compliment to that gallery space. After several initial meetings, a design workshop was planned in which the chief museum curator of education walked up to a whiteboard to present an alternative model for conceptualizing the project room. This model was based on previous work from a high school outreach program and consisted of four pedagogical or “interpretive themes” (Pierroux & Ludvigsen, 2013). These four themes included My Self, My Friends, My Place, and My Media and were intended to characterize and explore different aspects of an artist’s life and work. The design team then quickly took up these ideas. At a follow-up workshop, this curator was asked to present these themes in more detail by incorporating relevant works and texts by Munch as they might be organized around these themes. Over the course of the next several weeks, these themes became a way to structure the project room both conceptually and physically as they were mapped onto four distinct stations with their own activities and technologies. For example, the My Self theme developed into an activity in which visitors would re-create and photograph themselves posing as Munch in his self-portraits. In this way, an original conceptualization evolved and materialized as a particular design product throughout the project as it was mediated by the museum space.
The two cases just described suggest that there is a mutually constitutive relation between the material features that were brought through the production and discussion in, over, and about the different presentations of the museums’ rooms, and the opening of new possibilities for advancing the cooperative work toward a definite materialization of the design object. This mutual relationship features in both projects, although perhaps in opposite directions: Whereas in the art museum case a way of conceptualizing the object of design seems to lead to particular spatial configurations, in the science museum case ways of organizing and conceptualizing the design work became mediated by existing features of the museum room. In both cases, however, the mappings between material resources, organization of work, and conceptualization achievements involved concrete work during social transactions.

In this section, we examine bodily and discursive methods that the participants perform to achieve coherence and continuity across occasions and shifting modes of presentation of the museum space as a boundary object. As anticipated earlier, our analyses focus on performances of place making and place imagining. These are different from other deictic and referential practices in that, whereas the latter assume the existence of an object that is being pointed at and referred to, the former are object forming: They involve a form of distributed imagination in that they orient the participants toward material affordances that do not yet exist. First, (a) we characterize the work involved in bringing the museum space to bear as an organizational resource as being of multimodal and topological—as opposed to typological—nature. We then contrast (b) work that relies on the presence of material representations—that is, a floor plan of the museum space—with (c) work that relies on the body as a means to make the museum space present. In a final section, (d) we illustrate how bodily practices of place making lead to both (i) the development of durable artifacts and representations and (ii) the development of attentional orientations and dispositions that last across the design trajectory. At the same time as we describe these diverse methods, we account for how bodily and performative aspects of social transaction relate to the boundary object’s interpretive flexibility, as well as to its moving toward more standardized forms of cooperation (Bowker & Star, 1999; Star, 2010).

Multimodal and Topological Nature of the Museum Space as a Boundary Object

We begin our analyses by focusing on a fundamental feature of the material/organizational aspects of the museum space as a boundary object: its presence as a multimodal resource. Multimodality is often retrieved in the analyses of embodied interaction to highlight the fact that social transactions are not based on one single modality of communication (e.g., verbal), but draw on diverse semiotic resources (Streeck, Goodwin, & LeBaron, 2011). Face-to-face communication involves the simultaneous deployment of different semiotic resources, forming a multilayered phenomenon where no single layer is coherent by itself, but forms part of a coherent whole (Hutchins & Palen, 1997). By being drawn in conversation, diverse materials come to form integral part of communicational projects, thereby becoming relevant and intelligible for the organization of subsequent action. Thus, multimodality emphasizes the fact that communication rests upon materials, rather than upon abstract and intangible features: it rests upon the existence
of discontinuities or *lines of resistance* that we encounter and make relevant as we engage with an otherwise undifferentiated material continuum (Eco, 1999). Upon use, and within given communities of practice, these discontinuities come to mark discrete categorical boundaries, achieving a *typological* function, working “as tokens of some type category” (Lemke, 1999, p. 174). But in the continuity that characterizes lived-in bodily engagement, materials are also drawn into intelligible action through *topological* modalities of semiosis (Lemke, 1999): modes where continuous variation, rather than discrete symbols, achieves signifying function.

In our database, we identified several instances in which multimodal and topological aspects came to the fore when the museum space was made relevant in the design work. These instances (a) often were motivated by *breakdowns* and repairs during conversation and (b) often led to new conceptualizations of the design object. Here, we present one such instance to exemplify and emphasize the thorough materiality of the social transactional phenomena involved in the cooperative design work. The episode was recorded early during the art museum design trajectory, where a technology-enhanced room to supplement an already existing exhibition on original works by Edvard Munch is to be developed. The episode was not video recorded, only audio recorded. Being interested in studying the bodily aspects of cooperative work, we were initially concerned that this material would not serve our purposes as it lacked a visual record. However, to our surprise, and precisely in a passage in which the museum space becomes both thematized and drawn on as an organizational resource, the material nature of the recorded transactions became stubbornly present as gradations in the audio material that indicated a participant’s movement through the meeting space.

**Excerpt 1**

01 R2: not combining them completely, but they do have a, from a space perspective- if you’re having the space represent the connection between the themes that those are closely aligned.

02 R1: so you’re using the wall without taking the floor space for one of the activities

03 R2: right, that too.

04 C1: I think you lose something by doing that, but on the other hand the space is limited.

05 R1: [m::]

C2: [m::]

06 R2: I don’t mean they have to be in the same space but on the same wall, using the same wall. but they could be very much two different activities.

07 C1: [m::]

C2: [m::]

08 R1: it could be like = what’s his name? douglas gordon’s work. where you have munch’s friends on one wall, himself on the other and they could have dialogue across the room. <using someone else’s voice> <you talking to me? you talking to me?> do you know that work?

09 R2: you know, another possibility is if you walk in.((sound of dragging chair)) maybe we are not at this level anymore. ((R2’s voice sound fades away as footsteps can be heard))
you walk into the room and the first thing you see is the, you know. because you have some of these in the museum now I think.

10 R1: floating screen, floating wall.

11 R2: yeah, you walk in, and this is myself or munch’s identity, and you register or have your picture taken, get your bracelet here. everything else in the rest of the room. I don’t know if the room is appropriate for putting up a wall in the middle.

Prior to the episode, the possibility of organizing the exhibition room according to four themes has been introduced during previous meetings. In the audio, we hear an educational researcher (R1) pointing out that another educational researcher (R2) has had the idea to combine two of these themes. However, R2 objects specifying that the idea is not “combining them completely,” but that the themes “My Friends” and “My Self” have a connection that can be represented “from a space perspective” (turn 01). R1 then offers a reformulation, “so you are using the wall without taking the floor space” (turn 02). R2 accepts, but indicates that that is not all (turn 03). C1, a museum curator then provides an evaluative statement, emphasizing both pros and cons to R1’s suggestion. Nevertheless, R2 initiates a second repair clarifying what he does not mean (turn 06): the two themes do not need to be “in the same space but on the same wall.” R1 then draws an analogy with an artist’s work, which the whole group laughs about. Yet R2 initiates a new turn, presenting another possible way of arranging the space in connection to the two mentioned themes. It is at this point that a difference apart from that brought about by the participants’ talk becomes perceptible in the data: The sound of a chair being dragged precedes the fading and subsequent ascent of R2’s sound of voice (turns 13–15). It becomes clear to us that R2 is moving as he talks.

Instances such as this one, in which a participant addresses repairs in conversation (Schegloff, 2007) by standing up and walking around, animating or performing aspects of the meeting’s space in order to make present particular visions about an imagined museum room, are pervasive in our data. The multimodal and topological nature of the coordination work becomes evident as we, as researchers, perceive specific material discontinuities—in this case the shifting volume of R2’s voice as he moves—that provide intelligibility to the episode. Importantly, these very same resources are the ones that the participants in the workshops and meetings draw on to achieve cooperation. It is by attending to how these multimodal and topological aspects become intelligible resources for cooperation in interdisciplinary design work that this study addresses the material/organizational force of boundary objects.

Bodily and Discursive Work in the Presence of Material Representations of the Boundary Object: Interpretive Flexibility and Place Imagining

Because objects, actions, and settings mutually constitute each other, how individual actions become a coordination resource varies depending on the material circumstances in which they occur. Here, we first explore the role of bodily performances in making materials relevant and intelligible for the cooperative work by examining bodily and discursive performances that occur in the presence of visual representations. Visual representations such as models, sketches, and plans are central features in cooperative design work, where they work as boundary objects by virtue of the interpretive flexibility they afford. In such situations, opportunities to articulate the
participants’ diverse views upon given objects emerge (Henderson, 1998). In the two cases analyzed here, however, the participants do not only appear to articulate their knowledge, making visible to others part of the work that they had conducted locally, but also push themselves beyond what they—whether tacitly or explicitly—already know by using these representational materials as occasions to imagine not-yet-existing places.

In the following excerpt, taken from the science museum project, we describe bodily and interactive methods for making relevant the museum space as a boundary object as the architects present a sketch of the floor plan for the exhibition room. The setting is a meeting room and involves a presenter standing beside projected slides of architectural illustrations. We enter the episode as a curator from the science museum questions the architect on the reasoning behind a feature of the floor plan, which the curator categorizes as consisting of “small cages.” The question leads to a repair in which the architect objects to this way of categorizing, and a reformulation of the question follows. Through the sequence, there emerge diverse ways of interpreting the floor plan.

**Excerpt 2**

01 A1: it’s not that bad really. I mean these four (pointing as in Figures 1a and 1b) are not cages. they are spaces with- with a ceiling; (gesturing as in Figure 2a) because that gives you much more possibility to work. (gesturing as in Figure 2b)

02 C3: so you have just one entrance to an exhibit, you have three walls. isn’t that correct?

03 A1: no. not these four. (gesturing as in Figure 2c) these are all open.

04 C3: ok. so you only have two walls here.

05 A1: you have this one and that one which is corner more than walls.

06 C3: but just tell me why do you want this.

07 A1: we don’t have walls enough in this space. and this gives a framing to it. (gesturing as in Figure 2d)

08 R3: but you get some immersive feelings in these spaces.

09 A1: and of course we want to have a focus around each theme which is usually- like when you have like seventy themes in a jammed room. you have, this is this. it’s related to this one but it’s not the same as this one. (gesturing over the floor plan)

10 C3: I think that point about kind of making immersive. it’s a possibility of making immersive experiences. and if you see in the science center, you see people walk around. they do something in one exhibit. but there are so many cool things to do, that they just start to run. and then they try to separate into different areas, and there was much more noise and running before we did that. there is still noise and running but . . . just separating things into different themes makes it easier. and now you go down to single exhibits it will be very interesting to see how that would work because I think you can increase the focus on exhibits and use the walls and make different immersive experiences.

Through this episode, the interpretive flexibility that the visual representation of the museum space affords becomes evident. Views of the walled features as either caged or immersive reveal emerging tensions between understandings of what the experience of being in this (imagined) place may be like. The walls serve either as boundaries or as surfaces to be projected upon.
Toward the end of the episode, the curator describes very specific possibilities for the behavioral affordances of this place as discouraging running between exhibits in order to encourage visitors to calmly focus on particular exhibit features. It is interesting how the different interpretations are produced through verbal and bodily means around the floor plan as part of larger practices of sense making.

First, the interpretive flexibility is realized as the participants produce statements about the walls and their function in supporting different kinds of engagement in the museum. At stake are different ways of categorizing aspects of the represented space. One curator suggests that there are “small cages,” whereas the architect objects, instead categorizing them as “spaces with ceiling.” The material presence of the floor plan provides the indexical ground upon which the participants verbally articulate different forms of moving around the yet-to-exist museum space. Thus, the architect’s objection is substantiated by indexing and iconic gestures, which demonstrate just how aspects of the floor plan are not closed, and how other aspects are “corners more than walls” (turn 01, Figures 1a–2c). These spaces, then, can be pointed at alternatively and be described as a means to divide the room in terms of different but connected themes (Figure 3). In this regard, the floor plan functions as resource for a sort of interessement practice, where one way of structuring the museum space is argued over another by animating (Hall et al., 2002) and making salient specific persistent features of it, that is, black lines on the illustration slide that can be pointed at and be demonstratively shown.

However, the participants in the meeting not only categorize but also elaborate narrative and performative accounts of forms of possible engagement in the museum. The floor plan not only becomes an indexical ground but also motivates that the participants begin to imagine different forms of engagement once structural aspects of the representation have been stabilized. Ways of “feeling” in the yet-to-exist space are not indexed to specific material aspects of the floor plan, but become elaborated through iconic gestures that augment the material representation, such as those that the architect performs in turn 07 (Figure 2d). In doing so, the museum space is not just specified and demarcated within a given typology, but is described as involving a set of affordances for action through a narrative account of a particular story. As the following analyses show, throughout the design trajectories, these narrative forms are produced not only verbally but also bodily, providing unique resources for the participants to make sense of their shared object of design despite different categorical understandings of it.
Making the Space Present Through Bodily Performance

An important feature in the cooperative work during the interdisciplinary meeting and workshops in the two projects is the prominent role of bodily performances. These become particularly salient when visual representations of the museum spaces are no longer present. To achieve their organizing function in the cooperative work, however, the museum spaces are made present through discursive and bodily performances. In this section, we illustrate this in two episodes, one from each project.

Performing an interpretation of the object of design. The first episode involves an interview between two educational researchers and a head curator inside the Munch Room at Norway’s National Gallery of Art Architecture and Design. The interview occurred in the early months of the art museum design trajectory. The curator has been asked to guide the researchers
through the gallery and to present the room and artwork in a way that he would present art to young people. We enter the episode about halfway through the 25-min interview, having seen the curator provide detailed presentations of several important paintings in the room. One educational researcher (R1) is asking questions while the second researcher (R2) is filming.

**Excerpt 3**

01 R1: and is there something in this sequencing that you would change, (.) for any particular reason? or is it- ((waves hands toward a series of paintings stopping briefly at each as though counting a sequence, as in Figures 3a–3c))

02 C4: I can’t say that. then I first have to take down everything.

03 R1: yeah;

04 C4: and then I have to decide; <using different voicing<do I want to have, for example, the scream in the middle because it’s the most famous? or do I want to have the biggest in the middle?> m:::. i haven’t decided.

05 R1: you haven’t decided.

06 C4: but the thing that I told earlier today; as far as this is concerned. is that- see. this is small compared to the other; ((approaching to R1 and pointing, as in Figures 4a–5c) ((turns from camera,inaudible)) So it takes a little bit. (.) this rooms artwork characters. so you- um:- I think if we take some works out, we can even,

[(.] make it a more stronger, (.) the one room.

07 R1: [((gestures as in Figure 5b))

m::::.

Immediately prior to the sequence, the curator has been articulating similarities and differences that exist between the different paintings hanging on the walls as an example of how they...
are typically introduced to visitors. R1 asks whether the sequencing of the paintings along the wall and if this arrangement is something that the curator would adjust in the “rehang” process, and accompanies her question with a counting gesture (turn 01). The curator states that first he needs to “take down everything” (turn 02). Then he offers two alternative organizational criteria (turns 03–04). Munch’s iconic The Scream could be placed at the center to provide emphasis, but the works could also be positioned according to physical size. The director then turns away from the camera to point across the room to an additional painting. As he turns away, his voice becomes inaudible for the camera, but we see him lean in with his body and head toward R1 (turn 06). This leaning, in conjunction with his deictic gesture, can be seen as facilitating a shared visual field with the researcher. The director goes on to explain that by removing some of the paintings from this room, the “one room” as a unit of experience becomes “stronger.” As the director explains this relationship he depicts with is right hand a grasping gesture as though holding a single unit. The researcher mimics this gesture using both hands to depict this unified conception of the room.

During this sequence, there is work that the participants perform to make the future exhibition room, as their object of design, the topic of talk. Because the participants are situated in a place that currently stands as the permanent collection, visualizing the future iteration of the exhibition requires some distancing from the current setting. This distancing, however, does not involve an abstraction; rather, it is performed bodily. The body orientations that the participants perform in concert with each other facilitate a shared visual field that constitutes the beginnings of a shared perspective towards the design object. Of importance, this being-there-together is not articulated verbally or by means of given categories, but becomes a lived-in aspect of their cooperative work, a lived-through form of interpreting the object.

Performing places and generalization. Instances in which body performances become a means of presenting the museum space provide opportunities for articulating idiosyncratic, lived-in forms of experience that then serve as developmental stimulus for the whole group to achieve new understandings of their object of design. However, just as a word is “absolutely impossible for one person, but . . . becomes a reality for two” (Vygotsky, 1986, p. 255), bodily performances also acquire a general character by virtue of being drawn into the intersubjective space of intelligible conversation. In the following sequence, we present an instance from a workshop in the science museum trajectory in which performing being in the museum becomes a resource for generalizing ways of designing architectural features to facilitate the visitors’ reflection during their visit. The group is discussing one of the suggestions presented by the educational researchers to introduce an exhibit explaining “heat pumps,” a subject in the school curriculum. The museum curator raises the issue that “interactives or exhibits are something different than the educational
program,” thus thematizing one of the group’s tensions given the participants’ different backgrounds and interests. Even if the group designs very good interactives, the curator suggests, they will fail if the scientific topic is too difficult and visitors “don’t understand anything.”

**Excerpt 4**

01 A1: that is what I am concerned about in this case,
02 C3: exactly, yeah.
03 A1: the solar cell, whatever. (. ) heat pump. (. ) to understand this you really- you just- is not enough to push the button. you have to start thinking. and if you have the perception or the expectation that you have to think. then you give more time.( . . . )
04 R3: but but but-
05 A1: because then you don’t give it two seconds. push the bottom. (gestures as if pushing button and raises head looking away) <voicing someone else’s voice< I don’t understand> you run off. ( . . . )
06 R3: but but but from your experience, and talking about experience and the connections with architectural design, spatial design um: (.) how do you create the sense of curiosity? for instance. how do you create the sense of this is something that I have to (d) slowly because is something that I have to (understand), (gesture beating on table), what do- what creates more of a rapid ((beating quicker on the table)) kind of activity?

(1.5)
07 A1: from eh- spatial point of view? (gazes to R3)
08 R3: ((nods)) I know for instance (gestures as in Figures 6a–c) sliding doors in in (. ) in the shopping malls. they go very slowly. (slows down gesturing)
09 A1: ((nods)) m:::
10 R3: because you are entering in there. the shop owners want you to slow down.
11 C3: interesting. (laughing)
12 R3: so it’s an architectural element [and you have to-
13 C3: [is the same thing with [[name of exhibition]](pointing down) when we get down there and see the exhibition = there are sliding doors. ((gestures as in Figures 7a–b)) so you enter the room and then the door opens and you go in and (. ) it closes and it gets totally dark, before the next door opens.

**FIGURE 6** Gesture sequence for Excerpt 4.
In the excerpt, the architect (A1) follows up on the museum curator’s (C3) note by expressing his concern that to “understand” the heat pump exhibit “you have to start thinking” (turn 01). He does not just express his concern verbally, but, through a sort of enacted depiction, he actually performs being in front of an exhibit and not getting enough time to understand (turn 03). One educational researcher (R3) then objects, offering a series of questions about how to create a “sense of curiosity” (turn 05). Initiating a conversational repair, the exhibition designer then asks, “from a spatial point of view?” to which R3 nods and offers a narration about “sliding doors in the shopping malls” (turn 07). He does so not just verbally, but also through a performance, positioning himself facing his hands, and separating them slowly as he utters “they go ve:::ry:: slowly” (turn 07). The curator expresses interest (turn 10) and initiates a new turn marking a similarity between the researchers’ narration and an exhibit that is open in the science museum, “down there” (turn 12). The curator then narrates entering that other exhibition room, where there are sliding doors too. Once again, he performs his narration, positioning himself behind his open hands, and separating them several times.

In the episode, two different experiences of being in two different places, a shopping mall and a science museum exhibition, are performed using almost identical gestures. The similarity of the two experiences is not just visible in the gesturing, but also marked verbally as being “the same thing.” Of importance, entering a space through sliding doors is performed to address a repair in conversation. Because repair sequences are efforts to deal with troubles of hearing and understanding, the performance constitutes as means for dealing with the achievement of intelligibility, in this case about how architectural design is related to creating particular experiences in those who inhabit spaces. Through the participants’ performances, an analogy is drawn between the two gestures and between the two narratives, thus constituting the beginning of a generalization. Perceptual and affective invariances that exist across the two situations are retained in the respective performances. For the analogy to make sense, these invariances are not elaborated in analytical terms. That they are “the same” is indexed by means of language. How they are the same, in contrast, involves a complex of talk and gesture where actually performing seems not just incidental but also central to the participants.
Mutual Constitution Between Bodily Orientations and Material Configurations of the Workspace

Boundary objects are “weakly structured in common use, and become strongly structured in individual-site use” (Star & Griesemer, 1989, p. 393). However, as flexible uses in interdisciplinary work become more standardized, boundary objects “begin to move and change into infrastructure” (Star, 2010, p. 605). Although infrastructures are often described in terms of artifacts and objects, in this article we attend to the way in which boundary objects, and the infrastructures that they mediate, exist in and as features of bodily engagement. In this section, we examine how bodily ways of making the museum space present become stable resources for cooperation in the form of attentional orientations and performative dispositions. We also illustrate how these dispositions evolve together with material transformations in the workspace.

We draw from the science museum case, where the spatial distribution of the exhibition room as an integrated set of multiple walled spaces (see excerpt 2) not only came to mediate the group’s conceptualizations and negotiations about their object of design, but ultimately made possible the emergence of a new division of labor. This involved dividing the design team in two groups, one focusing on the development of a single interactive exhibit that would be located within one of the space’s modules, and another group that would focus on designing and developing an iPad application that would prompt and support the visitor’s navigation throughout the whole exhibition. This, in turn, allowed the participants in each group to develop new material and conceptual resources for addressing emerging tensions that eventually will become stabilized in specific methods and tools.

We illustrate how this process involves the development of perceptual and attentional orientations through an episode discussing the design of the interactive exhibit, which addresses the topic of how heat pumps work. This topic was selected because it forms part of the school curriculum, but also because of older exhibition at the museum included a mechanical demonstration of a heat pump. However, this selection has been a problematic issue, with some of the educational researchers insisting on the adequacy of heat pumps because of the number of physical principles relevant for the curriculum, and some of the architects and museum curators arguing against having them in the exhibition for not having an evident socio-political relevance that is important for the overall theme of the new exhibition. In the new group, the architects no longer participate, and the museum curators and the educational researchers have new opportunities to focus on how the scientific content domain may form part of the exhibition.

During the meeting, the researchers have shown a video of school students visiting the older heat pump exhibit at the museum. The exhibit features a mechanical device that the visitors crank a handle to activate. Supported by the video material, the researchers make the case that visitors do not get to learn much about the scientific aspects of heat pumps by interacting with that exhibit. As part of the group’s work of bringing up ideas for improving the exhibit, a museum curator then presents a paper sketch proposing keeping the mechanical part of the exhibit, but incorporating an additional digital representation graphing pressure and temperature changes fundamental to heat pumps.

Tensions emerge as an educational researcher requests a more detailed explanation of how the curator’s idea illustrates the particular scientific principles. The curator elaborates on an answer, which is again responded to by a researcher who again problematizes its scientific soundness. It becomes evident that the participants do not have mastery of the same level of understanding.
of those physical principles, making it difficult to reach agreement on a shared idea. At this point, another educational researcher shifts the discussion as she asks to the curator while gesturing cranking (Figure 8), “but where is i:::t (.) the drawing? Where is the hands on thing in it? Or you have drop it?” The researcher rejects, and explains that what he shows “is the graph.” It then follows talk and gesturing describing how the idea looks. This includes not only positioning the actual drawing in an imagined space by holding the paper and pointing to the different features of the yet-to-exist exhibit (Figure 9), but also positioning the exhibit within one of the walled spaces. The participants stand up and move through the imagined space; they perform interaction with the exhibit through both performing a cranking gesture and gesturing to clarify where the imagined exhibit would stand within the walled space. The space they articulate demonstratively corresponds to the room’s distribution that has been discussed throughout the design trajectory, and that now returns as a way for the participants to achieve coherence. Thus, the episode shows how the organizing properties of the boundary object become increasingly an embodied means for interdisciplinary cooperation despite lack of consensus in substantial matters such as the scientific knowledge domain.

The episode also adds to a larger set of ethnographic materials that document how the emerging bodily and attentional dispositions brought about changes in the ways in which their object of design was made present. Perceptual and performative invariants were maintained throughout latter design and prototyping work, providing coherence to the entire trajectory. Gestural means of presenting the exhibit-in-place, such as the cranking gesture, became recurrent during
interdisciplinary discussion. These means turned into more stable material resources as prototypes of the heat pump exhibit were built in forms that afforded such perceptual and performative invariances (Figure 10). These further became new boundary objects that allowed the participants to join in increasingly refined discussion about how to achieve a final design outcome, whereas researchers and software engineers maintained the more specific discussions about how the scientific content was presented at the local level.

DISCUSSION AND CONCLUDING REMARKS: FROM INTERPRETIVE FLEXIBILITY TO JOINT BODILY ORIENTATIONS AND AFFECTIVITY

The purpose of this study was to examine ways in which bodily, lived-in experiences become part of interdisciplinary cooperative work. To do so, we turned attention away from the materiality of objects—artifacts, representations—as being contained within objects themselves, and focused on how the material/organizational aspects of boundary objects become functional in and through bodily and discursive performances. We examined the bodily and discursive work that participants in two interdisciplinary museum design projects performed to make a single boundary object—the museum space—materially and organizationally present. We showed how narratives and bodily performances of place making and place imagining became important resources to achieve coherence despite uncertainty during breakdowns in interdisciplinary talk in both the art and the science museum projects. We also described how the boundary object moved from having an emergent and situational character toward forming part of a more stable infrastructure for cooperation in and through bodily and attentional orientations that became recurrent throughout the design trajectory, and that facilitated new divisions of labor and tools. Thus, our analyses describe concrete ways in which objects, actions, and contexts exist in mutually constitutive relations with each other, fulfilling recent calls to move the discussion on materiality “away from the fixation with objects and images, and towards a better appreciation of the material flows and currents of sensory awareness within which both ideas and things reciprocally take shape” (Ingold, 2011, p. 10).
The evidence presented emphasizes the central role of the living body in bringing forth boundary objects’ material/organizational dimensions. Prior literature emphasizes how boundary objects facilitate cooperation by affording referential practices that coordinate attention. Thus, it has been acknowledged that “being able to point at and visually observe and touch” (Engeström et al., 1995, p. 329) boundary objects is an important part of joint problem solving in complex work. Our analyses show that, in cases where boundary objects are made present through various and shifting forms, they are not just looked at and touched, but lived-through and performed. The body thus becomes a primary site of coherence during activity by allowing certain material features or discontinuities that become perceptually and affectively salient to become also (and at the same time) relevant resources for coordinating action with others. Through bodily performances, the participants become sensitive to these discontinuities and to how they are functional within particular situations, thus engaging in intelligible relations despite their diverse views and access to information. In becoming bodily and affectively—rather than just intellectually—sensitive to these discontinuities, people becomes articulated (Latour, 2004). Being articulated, however, does not involve “accuracy of reference” (p. 210) with regard to the objects that populate work environments, but implies modes of knowledgeability that emerge from joint bodily engagement that the participants can perform and experience together. Thus, as shown in our analyses, the interpretive flexibility associated with boundary objects is achieved not only through reference and “negotiation of meaning,” as is often described in the literature, but also through particular stories that tell, rather than specify (Ingold, 2013). Through telling, Ingold (2013) argues, “in place of specification without guidance, the story offers guidance without specification” (p. 110).

The notion of joint bodily engagement as shared experience invites a return to the quotation that opens this article: “To experience, to undergo, is to be certain. To hear of someone else’s experience is to be uncertain” (Star & Bowker, 2007, p. 276). In our analyses, we describe instances in which tensions, misunderstandings, and uncertainties resulted from participants hearing about each other’s design proposals and understandings. To resolve these tensions and to arrive at certainty, participants would then invite one another into a shared experience of an imagined place. The imagined museum space thus materializes when a participant stands up to move and orient toward not-yet-present features, or mime the gesture of a possible action or tool, and in doing so achieves mutual intelligibility despite lack of consensus. Thus, there is not only an enactment of already existing (tacit or explicit) forms of knowing the museum rooms as finalized objects or products. Rather, joint bodily engagement provides intelligibility by bringing forth common and unitary lived-in situations within which participants from different social worlds become subjects together. Thus, through this study, the body emerges not just as a means to make tacit forms of domain-specific knowledge visible to others, but also as a fundamental moment in the bringing forth change and development during interdisciplinary design cooperation.

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