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Co-participation among school children around a computer-based exhibit

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Abstract
This paper investigates the different forms of social interaction that emerge between young science centre visitors (aged 9–14 years) around a specific computer-based exhibit, which, like most computer-based exhibits, prioritizes an individual user. Based on video recordings, the paper shows that these young visitors, unlike adults, engage in various forms of co-participation around the exhibit. The empirical analysis compares different degrees of participation among the participants, ranging from minimal to full participation. The analysis shows that the affordances of a computer-based exhibit do not impose themselves upon visitors' actions at that exhibit. While the exhibit has a preferred use – a 'prescribed interaction', which prioritizes an individual user – the schoolchildren in the study mould what may seem like natural functions of the exhibit.

Keywords
children, computer-based exhibits, co-participation, interactivity, museums, science centres

Previous research on museums and science centres suggests that computer-based exhibits often hinder or limit co-participation (Heath and vom Lehn, 2010). Computer-based exhibits are primarily designed for single users to undertake a series of actions in response to pre-specified questions or puzzles posed by the system. The individual focus of such designs undermines both the ability to interact and value of interactions among co-participant around such exhibits. In addition, co-participants often have limited access to the information presented on the screen (by virtue of the size of the screen and the position of the user) and cannot necessarily see the actions in which the primary user engages

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(Flagg, 1993). Thus, companions become *partial witnesses* to the actions of the primary user (Heath and vom Lehn, 2002).

Thus far, research on social interaction and computer-based exhibits has focused on adult behavior and on adult–child interaction. However, studies in settings others than museums have shown that computers can facilitate social interaction, particularly between groups of children. For example, research refutes that computer game-playing is necessarily an antisocial activity. While the actual playing of such games is sometimes an individual, isolated pursuit, it is also often collaborative, and the focus of a great deal of talk and interaction (Jessen, 1999; Livingstone and Bovill, 1999).

Children and young adults make up an important visitor group in museums and science centres, and in the recent past there has been a significant increase in visits by schoolchildren (Bellamy and Oppenheim, 2009). While schoolchildren rarely visit museums of their own accord, little is known about how they interact with each other around the objects in the exhibitions. This paper explores the ways in which schoolchildren aged 9–14 years participate with each other and interact around a computer-based exhibition on the brain at the science centre Experimentarium in Denmark. The exhibition consists of 31 exhibits featuring different brain challenges. The present paper focuses on one particular exhibit, which, like many other computer-based exhibits, is designed for a principal user who interacts on an individual basis with the system to achieve a particular goal. The paper is particularly concerned with the different forms of social interaction that emerge at the exhibit. Before presenting the approach and the empirical findings of this study, however, I will discuss a few background issues concerning computer-based exhibits, social interaction, and participation in museum settings.

Digital technologies in museum settings

A small but growing body of literature focuses on digital technologies in museums (Drotner and Laursen, 2011; Parry, 2010; Tallon and Walker, 2008). Much of this literature advocates the use of digital technologies in museum settings, arguing that such technologies can contribute to unique and rewarding experiences among visitors. There is also a widespread belief that computer-based exhibits, by virtue of being ‘hands on’, offer a more effective pedagogical tool than traditional forms of exhibition (McLean, 1993). To museum staff, digital technologies are seen as fun, but also as allowing visitors to be ‘active’ and to exercise choice (Macdonald, 2002). Curators in Macdonald’s study felt that they were empowering the visitor and thus being more democratic in their museological practice. Computer-based exhibits are also seen by curators in the museum world as being part of a contemporary ‘language of the mass media’ that museums must speak if they are to be able to communicate with young adults (Witcomb, 2008). It is a widely accepted assumption in the museum field that visitors, particularly children, want and must have computer-interactive exhibits (Adams et al., 2004). However, some studies suggest that computer-based exhibits are ineffective in producing the learning outcomes for which they were designed. For example, Caulton, in a review of educational research in the area, states the following: ‘the evidence that they have actually learned anything, or indeed have not actually had their previously held misconceptions reinforced, remains unproven … the evidence to date is patchy and largely anecdotal' (Caulton, 1998: 2).

Participation and social interaction around technology in museum settings

The concept of participation in relation to the design of participatory spaces is widely discussed in museum studies. Like the exhibits themselves, such studies largely focus on the individual user and how she or he interacts with content, and on how the content helps connect the user with other people. For example, Nina Simon outlines five stages of interface, from 'Individual consumes content' to 'Individual[s] engage with each other socially'. Stage five makes the entire institution 'feel like a social place, full of potentially interesting, challenging, enriching encounters with other people' (Simon, 2010: 27). These studies of museum visitors focus on the individual as a unit of analysis and largely characterize their experience as a series of individual encounters with particular objects (Hooper-Greenhill, 2006). Only recently have researchers begun to consider how visitors interact with one another around exhibits and to recognize that social interaction and participation are critical to how we experience museums and galleries. These studies recognize that people take each other into account and build actions together, and that such interaction forms an unavoidable part of their experience. For such studies, participation does not take the form of static categories but is organized through dynamic, interactively organized practices; consequently, being social involves embodied interaction and subtle coordination rooted in the specific temporal and spatial arrangements of the practical situation (see, for example, Alač et al., 2011; Goodwin and Goodwin, 2004; Roth, 2005). Heath and vom Lehn (2002) found, for example, that the presence and conduct of others can have a great impact on what visitors see and do in a museum, and on the opportunities that arise for exploration, investigation and learning. While participants explore the museum, they are continually aware of and sensitive to each other's actions in the same space. In other studies, Heath and his colleagues also show that the actions of companions and strangers can have critical influence on what visitors look at, for how long, and in what way, when they gather around an exhibit and mutually constitute the sense and relevance of what they see (Heath and vom Lehn, 2004; vom Lehn et al., 2001).

Some of these studies have revealed that computer-based exhibits often hinder or limit co-participation and collaboration critical to learning and engagement (Heath and vom Lehn, 2010). Computer-based exhibits tend to reflect a particular model of human interaction that is not primarily concerned with interaction between people. The *prescribed interaction* with the system is designed to elicit a series of single actions from the user in response to the system (Heath et al., 2005). As a consequence, it can prove difficult to share, exchange and discuss the information provided by computer-based exhibits. Companions and other visitors must wait their turns and become *partial witnesses* to the actions of the primary user (Heath et al., 2005). If collaboration occurs, it is limited to one person helping others to follow the instructions prescribed by the system. In cases where others tried to collaborate, the researchers found numerous examples of the principal user 'becoming irritated and in some cases trying to push their eager co-participant away' (Heath and vom Lehn, 2010: 270). Even with installations that facilitate co-participation by allowing participants to have equivalent access to the resources and to the task in question, Heath and vom Lehn (2008: 82) found that the 'game is played simultaneously, but not collaboratively; its production is accomplished individually with little cooperation or co-participation between the players themselves'.

Children and social interaction around technology in museum settings

Some of the studies that treat museum visits as social rather than as a purely individual experiences, focus on children, specifically adult–child interaction. This research includes significant studies of family conversations in museums (Borun, 1995; Falk and Dierking, 1994; McManus, 1994). For example, Linda Blud (1990) studied how different types of museum exhibits create different amounts and kinds of social interaction. A fully interactive exhibit stimulated much more interaction between parents and children than the combined amount of interaction around a pushbutton exhibit and a static exhibit. In addition, the nature of the interaction differed at the three exhibits. The interactive exhibit motivated much more debate and argument, and discussions were primarily exhibit-related, while at the other two exhibits there was a more didactic exchange of information, and more conversation was unrelated to the exhibit.

Hemmings et al. (2001) produced another relevant study of children interacting around technology in a museum setting. Their primary concerns are educational processes and teacher intervention. They identify different strategies of intervention used by the teacher when groups of schoolchildren gather around an interactive exhibit. Each strategy implicates different approaches to the nature of the group. One strategy is non-interventional, in that the adult never intervenes and the group self-organizes in way that all are able to participate in the activity; for example, everybody takes a turn. Other strategies of intervention have other implications, and the constitution of the group can be extremely fluid. Several groups may form and disband during the intervention.

There is very little other research on group interaction around technology in a museum setting between children without adults, and yet spending time with friends has been found to be one of the key motivations for visitors (Pekarik et al., 1999). Social interaction is now widely recognized as being crucial for learning science (Roth, 1998), and, specifically, for learning science at museums (Allen, 2002; Falk and Dierking, 1994).

Materials and methods

The methodological framework for this study combines micro-ethnography and interaction analysis (Jordan and Henderson, 1995). The data for this study were gathered at a computer-based exhibition on the brain at the science centre Experimentarium in Denmark. The Experimentarium is the oldest and largest science centre in Denmark, and attracts approximately 350,000 visitors annually, including approximately 100,000 schoolchildren.[1] The brain exhibition consists of 31 exhibits featuring different challenges for visitors.

We collected stationary video recordings at six different exhibits and handheld recordings at, and in between, the exhibits, for a total of approximately 20 hours.[2] However, for the purpose of this study, I deal only with 3 hours of recording from one weekday morning at a particular exhibit, called Muscles to the Brain. The visitors are all schoolchildren (mainly aged 9–14 years). During the recordings, visitors are coming and going all the time, leaving the exhibit unused for no more than a few minutes. In total, 75 visitors use the exhibit or are gathered around it during the recordings. On only two occasions is a single user alone at the exhibit. At other times, two or more visitors are using the exhibit and/or are gathered around it.

Video recordings allow researchers to capture precise recordings of participants' interactions with exhibits and other people in the situation (Jordan and Henderson, 1995). The amount of detail that can be captured in video recordings makes them a powerful resource. However, like other methods, video analysis provides a version of events and cannot be accorded an ultimate objective status. Video recordings selectively delete or foreground aspects of the original setting, brought about by technical arrangements and theoretical interests (Hall, 2000). Regarding the data for the present study, we physically separated the camera from the action by mounting it to a tripod some distance from the exhibit, while also positioning it within the 'proxemic' shape of the group gathering around the exhibit (Hall, 2007). Once set up, we left the camera to record the action, only returning occasionally to check on the recording and the placement of the camera. While the stationary camera provided a nice wide view of the visitors' interaction with each other and the exhibit, it only captured blurred views of the touch screen of the exhibit. In order to supplement the recordings and enable the analysis of which screens were displayed and which buttons were pushed, I collected screen shots and the curators' storyboard of the exhibit's computer activity.

Ethical concerns are an important general issue for video recording in public settings. For the purpose of the study, notices were placed at all of the entrances to the exhibition as well as near the recording cameras, to inform visitors of the recording and to provide them with the opportunity to refuse to be recorded. No visitors did in fact refuse to participate. Further, we contacted school classes that were known to be planning a visit the science centre on the recording days to inform them about the research project and provide the teachers with the opportunity to refuse to participate. The teachers were also provided with copies of a letter with information about the project, intended for the children to bring home and discuss with their parents. During the recording time, a few visitors made comments about the cameras or commented to the camera, but no visitor refused to participate.

The recorded data provided the foundation for the analysis. Initially, all materials and logging events and activities were reviewed, using intermediate representations such as indexing and macro level coding (Barron and Engle, 2007). I began the analysis by transcribing and investigating particular fragments of data. While co-participation between the participants was common at all the recorded exhibits, my analysis focused on the Muscles to the Brain exhibit. I chose this exhibit because it was clearly designed for an individual user (see below). Consequently, the co-participation and collaboration at the exhibit were all the more remarkable. I transcribed the 3 hours of video recordings at the exhibit, and coded the transcript according to number of participants active at the time and how they co-participated. I noted bodily conduct in the transcripts and included it in the coding. From this coding, different degrees of co-participation emerged in different sections, from minimal to partial to full participation.

The exhibit Muscles to the Brain

Muscles to the Brain is a typical hands-on interactive exhibit. According to Witcomb (2008), such exhibits at museums and science centres share the following characteristics:

1. The presence of some technological medium;
2. A physical exhibit, which is added to the main display;
3. A device, which the visitor can operate, involving physical activity.

The underlying scientific methodology is the idea of the experiment, where the visitor touches a surface and something then happens: for every action, there is a reaction. By design, knowledge is gained experientially rather than didactically, as users take an active role in the construction of their own knowledge, thus challenging the traditional curator-centred model in which museum visitors are very much like guests invited to witness a dialogue between experts (Bayne et al., 2009; Bicknell and Farmelo, 1993; Falk and Dierking, 2000; Hooper-Greenhill, 2003).

Like the conventional computer exhibits discussed earlier, Muscles to the Brain is in many ways designed for an individual user. The exhibit consists of a single exercise bike, placed on a slightly elevated podium (Figure 1). A touch screen computer is placed above the handlebars, facing the person on the bike (Figure 2). Sensors on the handles measure the user’s pulse. Thus, the physical affordances of the bike and the display and input

Figure 1. The interactive exhibit Muscles to the Brain.

Figure 2. The exhibit's touch screen, with memory match game instruction page displayed.

technology discourage others beside the single user from having access to the system's operation.

Furthermore, the sequence of actions is designed to allow an individual visitor to progress towards a particular understanding to the effect that exercise influences the brain. First, the visitor is asked to solve a simple memory game. Second, the visitor must exercise on the bike for 90 seconds. Finally, the visitor is asked to solve a different memory game. Based on the two memory game outcomes, the visitor's result is given in the form of two numbers (pre-cycling result and post-cycling result) plus a personal message, for example: *You became better the second time you played the game. It was expected. During your physical exercise you increased the level of oxygen in your blood, which not only supported the physical work, but also benefitted your brain activity, especially after you completed the physical work. A long-term effect with a better environment for development of synapses (connections) in the brain is also demonstrated.* In this way, the progressive three-part sequence is designed to shape an individual user's interaction with the system and to achieve a particular goal.

There are instances in the data that support the expectation that others accompanying a visitor are excluded from participating, and passively wait for their turn while watching what the participant is doing. Consider the following example. The extract starts with two boys – Boy1 and Boy2 – arriving at the exhibit:

(Extract 1)[3]

((B1 mounts the bike))
B2: I'll try after you
((B1 checks in, answers questions, and starts to solve memory game))
B2: are you not going to cycle
((B1 finishes memory game))
B1: yes
((B1 positions himself on the bike))
B1: hold this ((hands B2 his lunch))

B2: fo:od
((B1 cycles, B2 moves closer to the bike, stops at B1's left side))
B2: for how long time are you doing that
B1: I don't know
B2: an hour
B1: no
B2: a minute
((B1 stops cycling, starts solving post-memory game))
B2: how many times do you think
B1: two times
B2: is the goal to get better
B1: yes
((B1 finishes memory game, reads result at the screen))
B1: thirty-four and then-
((B2 moves to B1's right side, mounts the podium, B1 dismounts the bike to the left))
B2: all right now it is your turn

From the moment when B1 mounts the bike and B2 says *I'll try after you* (line 316), there is a clear division of labour, which continues throughout the segment. B1 is doing the whole three-step process of the exhibit, and while he is doing his work, B2 is watching and waiting his turn. B1 engages with the exhibit and concentrates on his task, leaving no openings for B2 to co-participate. He treats B2's questions as secondary to the task at hand, and his answers to B2 are short; he initiates no further interaction with B2 (lines 321, 328, 330, 334, 336). B2's secondary position is consolidated as B1 asks him to hold his lunch (line 323), excluding him further from participating in the work at the exhibit. B2 further complies with his secondary position, as he poses questions about the tasks and goal of the exhibit (line 327), thus treating B1 as more knowledgeable, with primary access to the exhibit. B2 may even try to hasten his turn, but overall, both boys mark B1 as temporary owner of the exhibit and of the activity, and B2 as witness and retainer.

While the case above is not unique, the majority of the participants in the recording more commonly engage in various forms of co-participation with each other and with the exhibit. Next, I will present an analysis of some instances that provide particularly clear examples of some of the different forms of co-participation I found in the dataset. The analysis that follows reflects different degrees of participation among the participants. I begin with examples of what could be called minimal co-participation, and then present instances of partial co-participation. Finally I present an instance of full participation: six girls using the exhibit in collaboration.

Minimal co-participation

In this example, the interaction between the participants involves minimal co-participation. One principal user does the main work of interacting with the exhibit, while at the same time the activity becomes a focus of mutual attention and negotiation. Two girls have arrived at the exhibit, and we join the action just after Girl1 has placed herself on the bike and received her welcome message on the screen. Girl2 stands next to her, on her left side:

(Extract 2)

469	G1:	will you take the test ((reads aloud))
470	G2:	yes
471	G1:	yes ((presses 'yes' button))
472		((screen switches to game instruction page))
473		((G1 presses picture of start button))
474	G2:	no (.) press there ((points to 'start' button))
475	G1:	start ((presses 'start' button, screen switches))
476	G2:	how ((reads aloud, points to answer buttons))
477		[much time do you-
478	G1:	[how many hours per week do you exercise ((reads aloud))
479	G2:	fifteen
480	G1:	thirteen ((presses 'thirteen' button, presses 'next'))
481		((G1 presses 'next' again, screen switches to memory
482		game))
483	G1:	wo:w it's a game ((begins playing))
484		((both laugh))

The extract begins when G1 reads aloud the question on the screen (line 469). The question is already visible for G2, but in reading it aloud, G1 officially shares the question with her companion and makes it their common topic. In her response, G2 provides a candidate answer (*yes*, line 470). Next, G1 presses the 'yes' button while saying *yes* (line 470). Again, she is formally making her action and her answer accessible to her companion. The extract provides three more examples of G1 reading aloud (lines 475, 478, 480: *start, how many hours per week do you exercise, thirteen*). The extract ends with G1's *wo:w it's a game*, in which she exhibits a new understanding of the exercise (line 483).

By reading aloud and displaying her understanding, G1 shares her experience with G2. Also, while G1 does not actively invite G2 to participate, she does not exclude her from participating either. And, indeed, G2 participates: She provides candidate answers (*yes, fifteen*, in lines 470, 479), corrections and instructions (*no (.) press there*, line 474), she points, and she laughs with G1. Thus, the two girls are making a shared experience in which G2 is not only an inactive witness. However, the girls still seem to orient to G1 as the primary user of the exhibit. While G2 points to buttons, only G1 actively presses buttons. Also, while G2 provides candidate answers, G1 formally announces and executes answers. At one point, G1 even rejects G2's candidate answer (*thirteen*, line 480). In any case, the asymmetry seems to be unproblematic to the two girls, and the segment ends with the two of them laughing together (line 484).

The above extract provides an example of a common way that the schoolchildren in this study minimally co-participate around the computer-based exhibit. While the division of labour is clear, with one principal user doing the main work of interacting with the system, the participants negotiate responses to the system of the exhibit, and establish and display the activity as a joint focus of attention.

Partial co-participation

In this section, I present examples in which the interaction between the participants can be characterized as partial co-participation. In these examples, there is a clear division of labour, but the interaction makes it difficult for us to identify the principal user of the exhibit. A boy arrives, then a girl:

(Extract 3)

((Boy arrives, mounts bike, checks in, enters his age))
((Girl arrives))
G: what are you doing
B: it's asking how many hours per week I exercise
G: seriously
B: yes
G: zero ((presses 'zero' button, screen switches to game
instruction page))
B: o:r you're so cheeky ((laughing))
G: but you do
B: no I don't I exercise at least twelve hours per week
((laughing))
((G presses 'home' button, nothing happens))
G: it's probably this one ((presses 'back' button, screen
switches back to question))
B: six ((presses 'six' button))
((B presses 'next' button, screen switches to memory game,
B starts solving game))

Figure 3. Line 70: B on the bike, G presses 'zero' button.

Figure 4. Line 74: B says *I exercise at least twelve hours per week* (laughing).

In this example, G not only provides a candidate answer to the system's question, she also registers the answer by pressing the corresponding button. In turn, B evaluates and rejects her response (*o:r you're so cheeky*, line 72) and provides his own response (*I exercise at least twelve hours per week*, line 74). G accepts his rejection (*presses 'back' button*, line 77), and B carries out his answer (*presses 'six' button*, line 79).

In executing an answer to the system's question, G overrides the two-way turn taking system provided by the interface, through which the text on the screen and the individual user interact. The boy has started an interaction with the interface, but the girl takes over and answers on his behalf. Interestingly, B does not question G's action, only the content of her response. The override is temporary: the interaction between G and the system gets deleted, and the interaction continues between B and the system. However, momentarily, G and B enact the different parts the exhibit was designed to elicit from the intended individual user, and B's role as primary user is suspended.

In another example of partial co-participation, a girl takes a lead:

(Extract 4)

118		((Girl arrives, mounts the podium, presses 'start'))
119		((Boy1 and Boy2 arrive))
120	B1:	I'm good at cycling
121	G:	come with your ring
122		((G checks in with B1's ring))
123	G:	how old are you ((reads aloud))
124	B2:	eight
125	B1:	nine
126	G:	okay ((presses button 'nine'))
127	G:	how many hours per week do you exercise ((reads aloud))
128	B1:	nine hours

129	B2:	nine hours?
130	G:	that's one and a half hour per day
131		((G presses nine, screen switches to memory game))
132	G:	get up
133		((B1 mounts podium, G descends from podium and starts
134		lowering the saddle))

Figure 5. Line 120: G and B1 on each side of the bike's saddle. B2 behind them. B1 says *I'm good at cycling.*

In this extract, G arrives shortly before two boys. She begins the interaction with the system (*presses 'start'*, line 118), but she does not mount the bike. B1 arrives and overtly announces his qualities as a biker (line 120), and G treats this as a request to do the exercise – which she grants (*come with your ring*, line 121). In the following, G takes B1 through the system's series of questions and she executes his answers (lines 122–131). The segment ends when G instructs B2 to get on the bike (line 132).

G takes on a very active role in the interaction with the exhibit's system. She initiates the interaction, and pursues and executes it. B is passive in his interaction with the system, but he delivers his visitor identity when G requests it (his ring), and he also provides G with answers to the system. Both orient to B as the biker (*B1: I'm good at cycling, G: come with your ring*, lines 120–121; *B1 mounts podium, G descends from podium and starts lowering the saddle*, lines 133–134). In that way, there is a clear division of labour in the sequence. However, the division is not between an interacting user on the one side and a witness or helper on the other side. Instead, G and B both orient to B as the biker and G as the instructor and button presser. Consequently, they collaboratively enact different parts of the model user – the individual for whom the exhibit is designed.

In these examples, the participants not only establish the activity with a joint focus of attention. In their social interaction, they also seem to claim shared ownership of the activity and to distribute rights about who does what when acting at and around the exhibit. Consequently, the interaction does not clearly single out a principal user.

Full co-participation

In this example, the interaction between the participants can be characterized as full co-participation. The activity at the exhibit not only becomes a focus of joint attention and negotiation; the model user seems completely erased. Unlike the previous example, the different parts of the activity are not divided between the participants; instead, the participants all claim equal ownership to the individual parts of the activity. We join the action just after Girl1 has started cycling, and G2, G3 and G3 gather around her:

(Extract 5)

19		((G1 finishes memory game))
20		((G1 starts to cycle; G2 and G4 are on her left side))
21	G1:	it's good for the brain ((cycles))
22	Ps:	(5.3)
23	G2:	it is fun
24	G1:	no it's hard
25	Ps:	(0.7)
26	G3:	can I help you
27	G1:	yeah
28	Ps:	(3.3) ((G1 continues the cycling))
29	G3:	we might as well share ( )
30	Ps:	(1.5) ((G1 steps down from bike))
31	G4:	and after that it's my turn ((G3 mounts bike and starts
32		cycling, G2 takes her place, at right side of the bike))
33	Ps:	(0.5)
34	G4:	and after that it's my turn ((G4 moves to right side of
35		the bike, places herself a bit behind G2))
36	G1:	yeah
37	G3:	o:h it's so hard ((stands up on bike))
38	Ps:	(10.0) ((G3 cycles, standing))
39		((G2 mounts bike, places herself on the saddle behind G3,
40		G3 continues cycling))
41	G2:	okay?
42	G3:	yeah
43	Ps:	(5.5)
44	G2:	do- do I [never get to try
45	G4:	[can I also can I-
46		((G3 starts descending the bike))
47	G4:	can I try [after Lina
48	G2:	[move move for god's sake ((G3 moves away, G2 49
		starts cycling))
50		((G5 arrives))
51	G5:	I'm in too ((moves to the right side of the bike))
52		((G6 arrives))
53	G6:	what's it about
54	G2:	cycling really fast

Figure 6. Lines 20–29: G1 cycles, and G2, G3 and G4 watch her.

Figure 7. Lines 30–33: G3 mounts bike and starts cycling, G2 takes her place at the right side of the bike.

Figure 8. Lines 34–36: G4 moves to right side of the bike, places herself a bit behind G2, G1 moves to the left side of the bike.

Figure 9. Line 39: G2 mounts bike, places herself on the saddle behind G3, G3 continues cycling.

Figure 10. Lines 46–48: G3 descends from the bike and moves to the left side of the bike.

Figure 11. Lines 50–52: G5 and G6 arrives: *what's is about?*

Initially, G1 cycles, and G2, G3 and G4 watch her (line 20). With a question, G2 positions herself as a mere witness with partial access to the experience (*is it fun*, line 23). However, G1's response (*no, it's hard*, line 24), elicits an offer from G3 that breaks from her previously passive position (*can I help you*, line 26). After a few seconds, access is granted (*G1 steps down from bike*, line 30). Next, a shift in the girls' positions takes place. While G3 starts cycling, G2 and G4 place themselves next in line: G2 places herself at the right side of the bike where G3 had waited a moment earlier, and G4 goes right behind her (line 31–35). G3 then follows G2, cycles, and the segment ends with G4, G5 and G6 standing next in line. Thus, the girls distribute the activity of riding the bike and they mutually assign the space around the bike different qualities: a waiting area with a line at the right side of the bike and a watching area at the left side of the bike.

When G1 steps down from the bike, and the other girls line up, the activity gets transformed from the work of a principal user to a distributed activity among the girls. The girls take turns at the bike and collaborate to ensure that everybody gets her turn. Also, they work together to make the shifts fast and efficient. While G3 cycles in a standing position, G2 mounts the bike and places G3 on the saddle behind her (lines 39–40). G4 stands on her right side, ready to take over. Time seems to be an issue (*do I never get to try*, line 44; *move move for god's sake*, line 48), and they all get to do the work at the exhibit.

The girls override the goal of both the individual score and the progression, which is built into the exhibit (the three-part structure, with pre- and post-memory game results). Instead, they make up their own game within the game. The original game constrains as well as enables their new game, which resembles a relay race (shifting turns, run as fast as you can, then get away as fast as you can).

In examples like this, there is no principal user, nor are different parts of the activity divided among the participants. Instead, the participants negotiate and distribute equal rights and ownership to the individual parts of the activity. Newcomers continually get enrolled and there are no bystanders, as everybody gets their turn. Instead of one principal user doing the work, they are all immersed in play of jointly energized focus.

Discussion

My analysis has shown some of the different forms of social interaction that emerge between schoolchildren around an interactive exhibit. While the majority of the participants engage in various forms for co-participation, I have focused on particularly clear examples of three kinds of co-participation: minimal co-participation, partial co-participation and full participation. The three kinds should not be thought of as discrete categories, but more as a continuum from no, or minimal, co-participation to full participation. Moreover, the degree of co-participation can change from one moment to the next, on a turn-by-turn basis. As shown in extract 3, a boy starts the interaction with the exhibit, then a girl intervenes in a sequence that could be characterized as partial co-participation. This sequence ends when the girl withdraws and the boy continues the game on his own. In this way, the degree of co-participation can change, sometimes from one moment to the next, as the participants interact.

In many museum studies, visitor participation is seen as an individual practice and the highest stage of interface makes the entire institution 'feel like a social place' (Simon 2010: 27). The present study is more in line with studies that demonstrate that social interaction forms a pivotal and a virtually unavoidable part of people's experience at museums. All those who happen to be within *perceptual range of the event* (Goffman, 1981) will have some sort of participation status relative to it. At the same time, this study recognizes that different computer-based exhibits engender very different forms of interaction, facilitate different actions, and provide different opportunities for exploration and social interaction. This study focuses on one particular computer-based exhibit – a typical one designed for an individual user.

The schoolchildren in this study commonly use the computer-based exhibit in ways contrary to their intended use. They override the goal of the individual score and they collaboratively enact different parts of the sequence designed for an individual user. Research suggests that visitors will find, and often prefer, unintended ways to engage with an interactive exhibit (Gammon, 1999). However, the fact that the children in this paper's examples use the exhibit against its intended use does not necessarily mean that they do not become interested in, aware of, or even knowledgeable about, the scientific content of the exhibit–that exercise is 'good for the brain'. Indeed, there is a burgeoning body of research in the social and cognitive sciences that demonstrates the importance of social interaction for learning and the ways in which knowledge and skills are gained in and through interaction between people in practical situations (Lave, 1988; Rogoff, 2006; Rogoff et al., 2001; Roth, 1998; Wenger, 2003). In addition, in museum research, there is a growing recognition that social interaction can enhance visitors' understandings (Borun et al., 1996; Falk and Dierking, 1994). Moreover, in several of the data extracts, the children interact with the exhibit and with each other in what can be described as a playful manner. Previous research also has indicated that play is an important component of successful museum visits. Even though is difficult to measure what children learn from play, it does not mean that learning fails to occur (Gyllenhaal and Perry, 1998). In sum, while we cannot determine from this study what the children at the exhibit have learned; at the same time we cannot exclude the possibility that learning occurs in relation to the exhibit.

Conclusion

The findings in this study build upon and support previous research that stresses the importance of visitors' social interaction in museums. While participants explore the museum, they are continually aware of and sensitive to each other's actions in the same space, actions of both their companions and other people who happen to be there at the same time. The present study shows that the schoolchildren visiting the science centre commonly engage in various forms of co-participation around exhibits, ranging from minimal to full participation. Only rarely did companions to the young visitors remain passive. These findings are contrary to research on adults, which shows that companions commonly take the position of passive witnesses, although in some cases, adult family members do participate, but only after having already done the whole activity at the exhibit themselves (Heath and vom Lehn, 2008). In the present study, the young companions engage and interact with each other and with the exhibit during the progressive three-part structure of the activity.

In previous research on visitors' interactions around computer-based exhibits in museum settings there are no studies of self-organized group interaction between schoolchildren when no adults are present. The findings in this study are, however, in line with studies of young adults and computers in settings others than museums. The young participants orient to one another and to what they are doing. They share their experiences with their companion (see extract 2), and smaller groups are continuously formed and changed around the exhibits (extracts 3, 4, 5). The findings in this study are also in line with data analysed by Hemmings et al. (2001). While that study is concerned with teacher intervention, it provides one instance of how members of a group organize themselves around an exhibit, with an adult teacher watching but not intervening. The fluid constitution of the group and the 'everybody takes a turn' principle found in that study are very similar to what happens in the present study's instance of full participation (extract 5).

This study shows that the affordances of a computer-based exhibit do not impose themselves upon visitors' actions around an exhibit. While the exhibit evidently has a pre-programmed script for the individual user, the schoolchildren in the study re-shape the exhibit's prescribed interactions. A computer-based exhibit does set limits on what it is possible to do with it (Hutchby, 2001); as the present study shows, there are a variety of ways to respond to the range of affordances for action and interaction that it offers.

This study was limited to a small participant group and a specific setting. Further research on this topic should provide a clearer idea of the extent to which it can be generalized to other groups and settings. Even within the limits of this study, there are indications of gender-specific and age-group differences. Further studies could investigate such differences in a systematic way. Finally, there is a need to explore social interaction around different kinds of computer-based exhibits, such as exhibits designed for multiple users.

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Notes

1. See the Experimentarium website, available at: http://www.experimentarium.dk/frontpage/about-experimentarium/ (accessed 8 June 2012).
2. I collected the data together with a colleague, Nana Benjaminsen, who left the university shortly after and never got to work with the data.
3. Transcription symbols and conventions are adopted from the notation system developed by Gail Jefferson (Atkinson and Heritage, 1984: ix–xvi).

References

Adams M, Luke J and Moussouri T (2004) Interactivity: Moving beyond terminology. *Curator: The Museum Journal* 47(2): 155–170.

Alač M, Movellan J and Tanaka F (2011) When a robot is social: Spatial arrangements and multimodal semiotic engagement in the practice of social robotics. *Social Studies of Science* 41(6): 893–926.

Allen S (2002) Looking for learning in visitor talk: A methodological exploration. In: Leinhardt G, Crowley K and Knutson K (eds) *Learning Conversations in Museums*. Mahwah, NJ: Lawrence Erlbaum, 259–303.

Atkinson JM and Heritage J (eds) (1984) *Structures of Social Action: Studies in Conversation Analysis*. Cambridge: Cambridge University Press.

Barron BJ and Engle RA (2007) Analyzing data derived from video records. In: Derry SJ (ed.) *Guidelines for Video Research in Education: Recommendations from an Expert Panel*. Chicago, Data Research and Development Center, University of Chicago, 20–28. Available at: http://drdc.uchicago.edu/what/video-research.html (accessed 19 June 2012).

Bayne S, Ross J and Williamson Z (2009) Objects, subjects, bits and bytes: Learning from the digital collections of the National Museums. *Museum and Society* 7(2): 110–124.

Bellamy K and Oppenheim C (eds) (2009) *Learning to Live: Museums, Young People and Education*. London: Institute for Public Policy Research.

Bicknell S and Farmelo G (1993) *Museum Visitors Studies in the 1990s*. London: London Science Museum.

Blud LM (1990) Social interaction and learning among family groups visiting a museum. *Museum Management and Curatorship* 9(1): 43–51.

Borun M (1995) Family learning in museums: A bibliographic review. *Curator: The Museum Journal* 38(4): 262–270.

Borun M, Chambers M and Cleghorn A (1996) Families are learning in science museums. *Curator: The Museum Journal* 39(2): 123–138.

Caulton T (1998) *Hands-On Exhibitions: Managing Interactive Museums and Science Centres.* Florence, KY, USA: Routledge.

Drotner K and Laursen D (eds) (2011) Digital technologies and museum experiences [Special issue]. *MedieKultur. Journal of Media and Communication Research* 27(50). Available at: http://ojs.statsbiblioteket.dk/index.php/mediekultur/issue/view/509 (accessed 19 June 2012).

Falk JH and Dierking LH (1994) Family behavior and learning in informal science settings: A review of the research. *Science Education* 78(1): 57.

Falk JH and Dierking LD (2000) *Learning from Museums: Visitor Experiences and the Making of Meaning.* Walnut Creek: Alta Mira Press.

Flagg B (1993) Visitors in front of the small screen. In: Hannapel RJ (ed.) *What Research says about Learning in Science Museums* (vol. 2). Washington, DC: Association of Science Technology Centers, 21–24.

Gammon B (1999) Everything we currently know about making visitor-friendly mechanical interactive exhibits. *Informal Learning Review* 39. Available at: http://www.informallearning.com/archive/1999-1112-a.htm (accessed 16 July 2012).

Goffman E (1981) *Forms of Talk*. Oxford: Basil Blackwell.

Goodwin C and Goodwin M (2004) Participation. In: Duranti A (ed.) *A Companion to Linguistic Anthropology*. Oxford: Basil Blackwell, 222–244.

Gyllenhaal ED and Perry DL (1998) Doing something about the weather: Summative evaluation of Science Museum of Minnesota’s Atmospheric Explorations computer interactives. *Current Trends in Audience Research and Evaluation* (11): 25–35.

Hall R (2000) Video recording as theory. In: Lesh D and Kelley A (eds) *Handbook of Research Design in Mathematics and Science Education*. Mahwah, NJ: Erlbaum, 647–664.

Hall R (2007) Strategies for video recording: Fast, cheap, and (mostly) in control. In: Derry SJ (ed.) *Guidelines for Video Research in Education: Recommendations from an Expert Panel*,

Chicago, Data Research and Development Center, University of Chicago, 4–12. Available at: http://drdc.uchicago.edu/what/video-research.html (accessed 19 June 2012).
Heath C and vom Lehn D (2002) Misconstruing interaction. In: Hinton M (ed.) *Proceedings of Interactive Learning in Museums of Art and Design.* London: Victoria and Albert Museum. Available at: http://kcl.academia.edu/DirkvomLehn/Papers/114346/Misconstruing_Interaction (accessed 9 June 2012).
Heath C and vom Lehn D (2004) Configuring reception. *Theory, Culture & Society* 21(6): 43–65.
Heath C and vom Lehn D (2008) Configuring 'interactivity'. *Social Studies of Science* 38(1): 63–91.
Heath C and vom Lehn D (2010) Interactivity and collaboration: new forms of participation in museums, galleries and science centres. In: Parry R (ed.) *Museums in a Digital Age*. Milton Park, Abingdon, Oxon: Routledge, 266–280.
Heath C, vom Lehn D and Osborne J (2005) Interaction and interactives: Collaboration and participation with computer-based exhibits. *Public Understanding of Science* 14(1): 91–101.
Hemmings TA, Clarke KM, Francis D, Marr L and Randall D (2002) Situated knowlede and virtual education: Some real problems with the concept of learning and interactive technolgy. In: Mizen P, Hutchby I and Moran-Ellis J (eds) *Children, Technology, and Culture: The Impacts of Technologies in Children's Everyday Lives*. London: Falmer Press, 97–113.
Hooper-Greenhill E (2003) *The Educational Role of the Museum*. London: Routledge.
Hooper-Greenhill E (2006) Studying visitors. In: Macdonald S (ed.) *A Companion to Museum Studies*. Malden, MA: Blackwell Pub., 362–376.
Hutchby I (2001) Technologies, texts and affordances. *Sociology* 35(2): 441–456.
Jessen C (1999) *Children's Computer Culture: Three Essays on Children and Computers*. Odense: Odense Universitet. Center for Kulturstudier, Medier og Formidling.
Jordan B and Henderson A (1995) Interaction analysis: Foundations and practice. *Journal of the Learning Sciences* 4(1): 39–103.
Lave J (1988) *Cognition in Practice: Mind, Mathematics and Culture in Everyday Life.* Cambridge: Cambridge University Press.
Livingstone S and Bovill M (1999) *Young People New Media: Report of the Research Project: Children Young People and the Changing Media Environment*. Available at: http://eprints.lse.ac.uk/21177/ (accessed 19 June 2012).
Macdonald S (2002) *Behind the Scenes at the Science Museum*. Oxford, New York: Berg.
McLean K (1993) *Planning for People in Museum Exhibitions*. Washington, DC: Association of Science and Technology Centers.
McManus P (1994) Families in museums. In: Miks L and Zavala A (eds) *Towards the Museum of the Future*. London, Routledge: 81–118.
Parry R (2010) *Museums in a Digital Age*. Milton Park, Abingdon, Oxon: Routledge.
Pekarik AJ, Doering ZD, Karns, DA (1999) Exploring satisfying experiences in museums. *Curator: Museum Journal* 42(2): 152–173.
Rogoff B (2006) Cognition as a collaborative process. In: Damon W, Lerner RM, Kuhn D and Siegler RS (eds) *Handbook of Child Psychology, Cognition, Perception, and Language*. Hoboken, NJ: Wiley, 679–744.
Rogoff B, Turkanis CG, Bartlett L (2001) *Learning Together: Children and Adults in a School Community*. New York: Oxford University Press.
Roth WM (1998) *Designing Communities*. Dordrecht: Kluwer.
Roth WM (2005) *Talking Science: Language and Learning in Science Classrooms*. Lanham, MD: Rowman & Littlefield.
Simon N (2010) *The Participatory Museum*. Santa Cruz, CA: Museum 2.0.
Tallon L and Walker K (2008) *Digital Technologies and the Museum Experience: Handheld Guides and other Media.* Lanham, MD: AltaMira Press.

Vom Lehn D, Heath C and Hindmarsh J (2001) Exhibiting interaction: Conduct and collaboration in museums and galleries. *Symbolic Interaction* 24(2): 189–216.
Wenger E (2003) *Communities of Practice: Learning, Meaning, and Identity*. Cambridge: Cambridge University Press.
Witcomb A (2008) Interactivity: Thinking beyond. In: Macdonald S (ed.) *A Companion to Museum Studies*. Malden, MA: Blackwell, 353–361.

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