"I don't understand it either, but it is cool" – Visitor Interactions with a Multi-Touch Table in a Museum

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Abstract

Most tabletop research presents findings from lab-based user studies, focusing on specific interaction techniques. This means we still know little about how these new interfaces perform in real life settings and how users appropriate them. This paper presents findings from a field study of an existing interactive table in a museum of natural history. Visitors were found to employ a wide variety of gestures for interacting; different interface elements invited different types of gesture. The analysis highlights challenges and design conflicts in the design of tabletop interfaces for public settings, such as latency times and side-effects of 'frame-less' content, which had some users struggling to learn how to interact. While the majority of visitors engaged at least briefly with the table, which enabled browsing question-answer text about animal species, talk amongst visitors dealt mainly with how to interact and evoked few comments, indicating shallow engagement with content.

1. Introduction

Most tabletop research to date presents lab-based user studies that investigate specific interaction techniques. Relatively few publications [12, 15] discuss field studies or user tests conducted outside of the lab. Such field studies can provide us with richer insights into the factors that influence interaction, in particular the role of the use context.

Interactive tabletops are making their way into public spaces, such as museums [8] and retail stores. This provides a unique opportunity to investigate user interaction in-situ (cf. [9, 18]). In these settings users are free to interact or not. They are confronted with the system without any introduction as to its purpose and function, let alone on how to use it. The system has to survive on its own, in an environment full of competing objects of attention. Another useful quality of public spaces is the diversity of users, of different ages, educational backgrounds, experiences with and attitudes towards technology.

Tabletops lend themselves to being used as a museum interactive: they provide space and give access to multiple visitors, invite to "gather round the table", and allow for playful interaction while keeping technology in the background [8]. But it is not necessarily the installations with the most interactivity (or the most content) that make good and engaging exhibits [1, 9, 18]. The question is thus, what type of application is best suited for the museum context, and how interactive tabletops can integrate into it.

This paper presents findings from a field study of an interactive table in a museum of natural history. The 'Tree of Life' table was developed and designed by the well-known German media design company ART+COM as part of the make-over and renovation of the Berlin Museum für Naturkunde, which re-opened after two years of closure in July 2007. The study used this setup as an opportunity to investigate how people understand and engage with an interactive table without having been primed or instructed how to use it and to its functionality and contents, and to assess its fit within the museum context.

2. The Study

2.1. Location: Museum für Naturkunde Berlin

The Berlin Museum of Natural History [12] is one of the largest museums of natural history worldwide. It was severely damaged in World War II. With a bid for public money it became possible to renovate and redesign four of the major exhibition halls. The museum has been hugely popular since re-opening in 2007, drawing 250.000 visitors within the first 12 weeks. Visitors are mostly families with children and adults with an interest in nature and geology.

The renovated wings feature several interactive installations [2], most prominently the Jurascopes, medially augmented telescopes that bring to life the

dinosaur skeleton, and the 'Tree of Life' table. Moreover there are numerous 'dynamic legends', information panels for exhibits with texts and diagrams, where visitors can choose images, films and animations on related themes running on integrated screens.

2.2 The 'Tree of Life' Table

The 'Tree of Life' table is located in a hall dedicated to evolution, which is lit primarily from illuminated see-through showcases forming aisles. The table is located towards the end of the hall. It is 75cm high and has a 1.15 x 2.15 m projection surface with a 15cm border all around. It is top-projected and employs a capacitive sensor technology, patented by ART+COM, which can make surfaces of any size multi-touch interactive. With this particular technology, as a side-effect, the system sometimes reacts to users' bodies at a short distance from the surface (a body of fluid close to the surface can already create an electric field)

The application can be categorized as information browsing. Visitors can choose from questions that pop up and relate to species, such as 'Are marsupial young born inside the pouch?' or 'Are there male and female earth worms?' When someone touches a question, an answer appears consisting of text and photos. The table size allows for four distinct areas with one question each, two on each long side. This reduces potential interference (noted in [14]), as interactions only affect one question area. All elements (pictures, text, icons) seem to float on a white surface, fading in and moving subtly into place when they appear (figure 1).

Figure 1. Setup of table and typical scene.

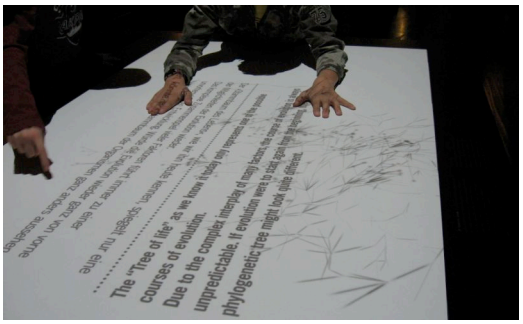

Figure 2. Renew phase when shoots evolve.

About every 7 minutes, the questions disappear for a general text on evolution around which a network of plant-like threads or shoots evolves, representing the evolution tree (figure 2). This is referred to as 'Renew phase'. After a while, the questions appear slowly, consisting of a picture in a circle (bubble) and a textual question. The icon of a hand next to bubbles provides a cue for users to touch them. On touching a bubble, it is replaced by two larger bubbles containing images and a close-up of the evolution tree, and a textual answer (figure 3 and 4). Usually text is too long to be shown fully in the available space (a window with transparent borders). Arrows for scrolling are located on its left. Touching and dragging it can also scroll text. Visitors can toggle between English and German by touching a smaller circle next to the text. After a while this bubble is replaced by an 'X' button that closes the current question-answer. To prevent visitors from accidentally closing an item, the 'X' button has a long latency time, and before actually closing, contracts and expands. The design takes into account that capacitive sensing is not accurate, as all interface elements are quite large.

As a second level of interaction, people can interact with the shoots that represent the tree of life. On touching the surface shoots grow from the touch, and, drift away, appearing to join the tree of life (figure 4). During the 'Renew phase' this seems to speed up the creation of the evolution tree. During the normal interaction, the shoots evolve out of touch occurring outside of bubbles and textual areas.

Information about the design brief could be gathered in interviews with ART+COM staff, but unfortunately the main designer of the application had left the company. The rationale of detailed design decisions thus cannot be reconstructed. An overarching design rationale was to allow for playful engagement with topics, different levels of access, and to keep children engaged (e.g. with the shoots) while adults can read. Exhibits should support family interaction, and provide space for parents to explain and mediate children's attention. The majority of interactives should have a serving function (the dynamic legends), and medial highlights should never become a main feature.

2.3 Study Approach and Data Collection

The study followed a rapid ethnography approach, drawing upon principles of ethnographic research and interaction analysis [3, 10], starting from open-ended observation and iteratively evolving issues for detailed analysis. Observations focused on the Jurascopes and the interactive table, but included other exhibits and halls to get a sense of how the new installations integrate into the museum. This furthermore allows for comparisons, the more traditional exhibits providing a 'benchmark' of typical activities and conversations that visitors engage in in this museum. This paper focuses only on findings regarding the interactive table.

The study coincided with school vacations around Berlin. Hence, the museum was very busy. Over the course of seven days, including a weekend, participant observations were conducted. Visitors were informed at the ticket desk about the study. The researcher walked around and for focused observations sat close to exhibits, taking notes of interactions and conversations that could be overheard. Sometimes, taking notes was not possible, e.g. when very close to visitors.

Overall, 38 pages of A5 handwritten notes were generated in open observation at the 'Tree of Life' table, corresponding to about three hours of logged observation. For 1:10 hour (sampled at five periods) it was listed whether visitors went to the table, interacted with it or observed others, read, or passed by. Supplementing the notebook, a photo documentary was collected, supporting recollection of events in the absence of video data, and enabling further analysis, e.g. of patterns of visitor positioning and postures, treating them as another type of documentary data.

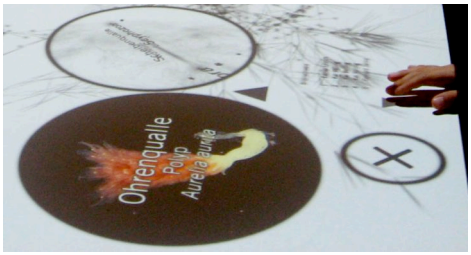

Figure 3. The parts to an answer (text at end)

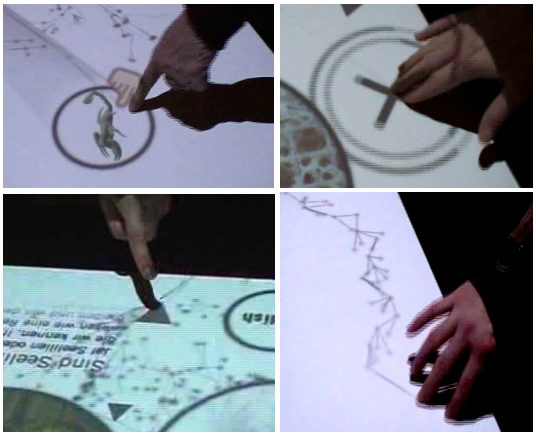

Figure 4. Top: question picture invites to touch. 'X' button expanding. Bottom: Scroll arrows, shoots appear where you touch.

Due to privacy laws in Germany, video surveillance in public spaces is severely regulated. Audio- or video-recording requires prior written consent. To collect video data, five groups were recruited to be shadowed throughout the museum (rewarded with free entry). This makes the researcher more of a participant observer, groups treating them over time like another group member, and eases recording interactions, improving audibility and visibility. Furthermore, it provides opportunity for in-situ interviews, participants usually freely commenting on what they like or dislike. The researcher accompanied these groups during their entire visit, videotaping all events around the exhibits in focus plus randomly throughout the museum.

The following groups were enlisted: three flat mates in their mid-twenties (a couple and a female); a young family with children aged three (m) and four (f); a couple aged 65, their mid-twenties daughter, a female friend of the daughter and her mother, all passionate hobby-paleontologists; six friends in their end-twenties that often split up in two groups; and a woman with her son (aged 4), his best friend (aged 5) and an 18 month old baby. Only the young family had been in the museum since its reopening. The visits lasted between one hour (groups with children) and three hours. This resulted in 30 minutes of video from five sub-groups interacting with the table (the young family did not make it much further than the dinosaur hall), which have been fully transcribed and analyzed.

2. Findings and Observations

2.1. A Diversity of Gestures

Observation and video analysis revealed varied and rich gestures, often used playfully and performatively (cf. [14, 17]). Most people immediately started using multi-fingered and bimanual gestures, and did not hesitate to touch the table simultaneously with other users. This contrasts with the observations by [6, 15] and is likely due to the fact that this table had little resemblance to traditional computer interfaces.

Different interface elements seemed to invite different types of gesture. In particular the shoots evoked rich multi-fingered interaction. Visitors stroked over the surface with fingers or a flat hand, almost caressing it, swiped it, shuffled their hands, tapped their fingers like a walking spider, or knocked on the table (see

figure 5). The bubbles and arrows evoked gestures more reminiscent of pointing or button pushing. Figure 6 shows that these were also quite varied, and not always performed with one finger, but with several or with other than the index finger. The bubbles, especially those with a black circle, frequently had people quickly tapping them like a mechanical push button. This was seen with the question bubble, the language toggle, and the 'X', and persisted even if it did not have the desired effect (with the 'X').

The organic shape and behavior of the shoots correspond to visitor's gestural interaction. As the shoots grow everywhere, they invite bimanual interaction. The button-shaped items evoke responses reminiscent of physical button-pushing (quick, hard pushes and hits) and of touch-screen interaction (one finger tapping). In contrast to e.g. the CityWall interactive window [14], there were only few 'throwing' or 'sliding' gestures, since the application did not support other actions other than tapping and dragging of text.

2.2. Discovering how to work the system

Overall visitors showed no signs of being intimidated by the technology and had little hesitation to touch and interact with the table (but often, out of curiosity, people looked up to the projector or explored how close they needed to bring their hand to the surface) and without hesitation interacted simultaneously. This is very similar to Ryall et al's observations [15].

Some features of the table interface worked well in providing cues to the visitors as to how to interact. For example, the hand icon invited users to touch the question bubble. Once visitors started interacting, the general functionality tended to be discovered quickly and was often picked up from observing other visitors. Yet close analysis of the videos and notes from the observations revealed several issues resulting in interaction problems. Even if these issues seem minor, they can determine success or failure of a museum installation. Here *immediate apprehendability* [1] is important - if an exhibit has a boring, effortful or confusing component, visitors are unsure about the reward for persisting, and are likely to move on. Visitors need to experience success early and feel competent, and to understand the purpose, scope and properties of the object almost immediately [1, 5, 7].

2.2.1. Inconsistent behaviors and latency issues.

Interface items that looked similar were assumed to behave similarly. Many items looked like bubbles, held in a circle. Visitors often tried to tap the big bubbles that contain changing images, but are non-interactive:

> *One of the young men in the group of young adults points at the big bubble showing the section of the evolution tree that the current question relates to: "and then you can". He touches the bubble and tries to drag the tree branches: "Can you do anything here?", tapping the text inside. A minute later he tries to drag the bubble contents again.*

Other bubbles had slightly different behaviors. The latency of the 'X' is meant to prevent accidental closing of a question-answer item, but differs from other objects. It often took visitors several attempts to close a question-answer item by tapping the 'X' rapidly and with force (like a mechanical pushbutton), an interaction that worked for the other items. Having the 'X' shrink and expand once (indicating the function to be invoked) before executing increased difficulties even more. Often people would, on seeing this initial response, release their touch, canceling the action.

In this case there is a conflict between preventing users from accidentally activating a function that

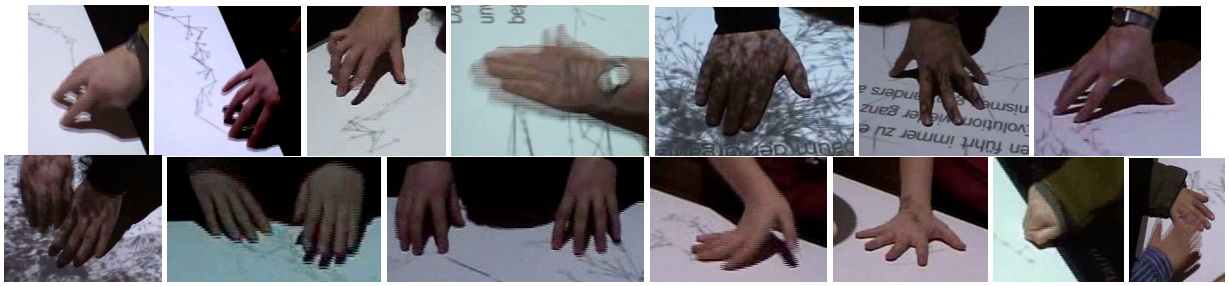

Figure 5. Gestures in playing with the shoots were multi-fingered, and often used the entire hand

Figure 6. Interaction with bubbles and arrows used one, but also multiple fingers, and tapping.

makes them lose content and ease of interaction. The visual resemblance with other bubbles that react quickly and to physical buttons triggers a response of quick tapping. In this specific case, the visuals need to indicate the need for prolonged pressing and of how much longer the touch has to go on (progress bar).

2.2.2. Scrolling text - which way?

The question-answer items are designed to blend into the overall aesthetics of the table, avoiding resemblance with classic computer interfaces. Text appears to be floating on the white surface, subtly blending in and out. Even though space for the answer is limited to a defined area, its frame is not visualized. For scrolling, two mechanisms are available: 1) the arrows left of the text and 2) direct manipulation dragging of the text itself. Some visitors first discovered the dragging mechanism and did not seem to take notice of the arrows. Others never discovered dragging. Furthermore, there were large differences as to how well people understood the scrolling mechanism. Discovering both mechanisms seemed to increase these difficulties due to a cognitive conflict.

In a shadowed group, a man explains to another group member: "this is good to show with this kind of graphics (points to the hand icon) but this here with the arrows (points to arrow), that you need to press here (scrolls down) that's difficult to show".

The scroll arrows work similarly to the scroll arrows in any text editor. A further cue of direction is given by downsizing arrows when getting towards the end/start of text. This was sufficient for many visitors to work out how to use them; but some struggled repeatedly with scrolling in the desired direction or to invoke a response at all. The adult family group being shadowed provides a particularly interesting example:

Elderly mother taps arrow down (text has already scrolled to the end): "that's no use, pressing this one". She quickly taps twice on the arrow up. Daughter: "I don't understand this". Mother: "It's somewhat obscure, the whole thing".

The two continue to explore how to interact with the interactive table, but keep pressing the wrong arrow. It takes them together (in conversation) about 1:40 minutes to understand the interaction with arrows.

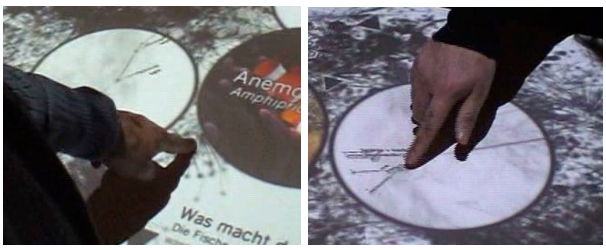

Figure 7. Left: Tapping wrong arrow (up) when text is already moved to the top. Right: attempting to manipulate big (non-interactive) bubbles)

Daughter explains: "now you are at the bottom (points to arrow for scrolling down), then one can press up here again (presses hard on arrow up) but with me there is nothing happening". Mother: "You can press here (presses the 'X') then it is gone".

The daughter tends to explain the interaction model, as her understanding gradually evolves. But she repeatedly struggles doing things herself, because her rapid tapping gestures do not break the threshold latency. Her mother, moving slower, is quicker in achieving results. Pressing the wrong arrow continues on in this group, and the daughter repeatedly comments: "this is tricky" ("das find ich schwierig").

After a while the daughter discovers the direct manipulation dragging mechanism and shows it to her father. Even though he seemed to have no problems reading and scrolling text so far, he then suddenly selects the wrong arrow when attempting to scroll.

Selecting the wrong arrow to scroll was observed a great number of times, listed in the observational notes. Close analysis of the interface behavior provides an explanation. Direct manipulation dragging implements an interaction model that takes the text itself as manipulated object that is pulled up/down like a sheet. The arrows resemble a window scrollbar, where the viewing window moves over the text. Having these interaction mechanisms next to each other results in a perceptually conflicting mapping, that one participant referred to as "somehow twisted". Dragging down enables seeing text further up in the document, whereas touching the lower arrow (which points down) scrolls down, towards the end of the text. Once somebody has made the switch to the direct dragging interaction model, the arrows seem to act counter to expectation.

A minor problem with dragging text was due to the aesthetic decision to have text floating on the table with no visible framing. While aesthetically pleasing, this provides no clue as to where the active region stops. Thus, sometimes visitors would drag their fingers beyond the active region, and scrolling would cease to their surprise. In addition, the missing frame makes it less likely that people recognize the similarity of the arrows with text editing scrollbars.

2.2.3 Problems of the capacitive sensing technology

Some interaction problems are specific to capacitive sensing. Accidental input is even more likely than with a touch-based surface (cf. [15]), as input can be detected at a short distance from the surface. This can lead to confusion about the interface's behavior:

The daughter in the adult family group, trying to understand the language settings, points to the circle which says 'English' and says: "Nope, if you

press German here". Her pointing finger activates a language change to English. She says: "No, if you press (points) German" and her mother continues "then you can read English".

It is a common behavior to point to the thing one talks about. Capacitive sensing makes it difficult for people to point to their point of reference without changing its status. Later, the daughter is positioned sideways at the table next to her father. When trying to drag and scroll the text up, she needs to move her hand over the text in order to touch the lower end of the text to then drag her finger upward. The initial action of reaching over the text has the text scroll down for a moment, counter to her intention, before it finally scrolls up. During general observations around the table the researcher saw several instances of people pointing at something they were reading, and the text unexpectedly scrolling in reaction.

2.4. Visitor Engagement with the Table

2.4.1. Activity At and Around the Table

During 1 hour and ten minutes of logging whether passing visitors would look at, observe, interact, and read text, more than 200 people went past the table. About 100 people did not touch the table, of which 40 went past with not more than a glance. Another 40, predominantly small children, touched the table, playing with the shoots. 70 people actively read questions and answers, opening 'bubbles'. Half of these left after reading one item. This leaves only about 17% of visitors that engaged deeper and longer with the contents. On the positive side, more than half of all visitors interacted with the table and another 25% observed others reading and interacting. These numbers are slightly above the usual for museum exhibits [7, 11].

Given the short period of observation this data can only give us an indication of general visitor behavior. Still, the sample confirms the observations gained in overall surveillance of how many people actively engaged with the contents. The rapid flow and high numbers of visitors unfortunately made it impossible to keep track of holding times.

2.4.2 Chains of Use/Non-Use and Discovering the Interactivity

The role of the presence of other active users for noticing a display and learning how to use it [9, 14], was termed the 'honey pot effect' by Brignull [4]. Observations and notes reveal a pattern of phases of high usage of the table alternating with non-usage.

When the table was used, people would often stop and look, and some would start interacting. Thus a 'chain' of ongoing use evolved with changing participants, which could endure for up to 10 minutes. Interaction with the table is visible and visitors can observe and learn from observing others how to use it (cf. [4, 14, 18]). The size of this table eased simultaneous access, so that visitors did not need to queue. Once the room was empty, a similar (but shorter) chain of non-usage often occurred. Several people would enter the room after another, sometimes briefly looking at the table and often completely ignoring it. Incidents from the notes indicate that visitors often did not realize at first that they could interact with the table when not in use (cf. [9]). Frequently, interactivity was discovered by accident, leaning over to see better or sliding hands over the table in passing. Most often children would first detect the interactivity, having less hesitation in touching objects (cf. [1, 11]) (sometimes reprimanded by parents "don't touch/nicht anfassen")

Providing a clear indication and invitation to interact is thus still an issue for design. The following vignette illustrates how the interactivity is discovered after initially thinking the table is only a projection:

The room is empty. A young couple walks past. Almost out of the aisle, he turns around and back to the table. She now touches it. He says: "Ah!".

In the following vignette it takes seeing other people interacting to do so. Despite the positive statement about the table, the woman only reads one item of text, not engaging deeper with the thematic contents:

A woman that passed through earlier comes by on her way back and sees another group interacting. She says: "Oh, you can [*interact*]*!", goes to the table and reads aloud "primeval time crayfish". She scrolls, reads silently, says: "great" and leaves.*

2.4.3. How-to Rather than Thematic Conversations

Shadowing groups during their entire visit enabled a comparison of types of conversation, confirming impressions gained during unobtrusive observations throughout the museum. Social interactions around the table were found to differ from those around other exhibits by dealing mainly with 'how to interact' and rarely relating to the actual theme and contents.

Visitor studies have shown that families in museums share information and discuss what they are looking at; parents pose questions, point out interesting things and answer questions, guiding children's thinking and attention while looking at objects [11, 16]. In accord with this, children were often seen to ask parents about the videos and animations in the embedded displays, and parents to engage in educational conversations with them:

A 5 year old, pointing at video on an embedded display of a dynamic legend: "What is this?" Mother: "Lava, it is very hot." Mother points at the next video: "do you know what this is?" Son: "a

volcano." Mother: "How much volcanic stone might this have spat out?"

In contrast, few educational conversations were observed at the table except for reading aloud, and giving children instructions to scaffold their interactions:

Father to son: "you have to click on that, the picture, then it explains to you"

Father reads to child: "the Salamander - if you touch here, then it goes down" (points at arrow)

Even though the question-answer format could be thought to invite groups to use the table for a 'quiz game', this was never observed to happen. Occasionally children or teenagers would engage in a race of 'who can open the next or the most text bubbles and close them again'. In general, conversations around the table tended to be short and fragmented, consisting of brief phrases with long pauses. They mostly dealt with the 'how' of interaction, in sharp contrast to the behavior observed around other exhibits and with the dynamic legends.

At these, the adults being shadowed pointed out and commented on facts new to them or told anecdotes related to the exhibits (e.g. from their own involvement in searching for fossils or first hand experiences with the animal species). With the adult family, commenting or telling anecdotes only occurred once or twice during 17 minutes around the table.

Unlike the CityWall [14] or the ToneTable [17], the 'Tree of Life' table did not result in collaborations among users relating to the contents. Different to these, its content is predetermined and cannot be further manipulated to create personal and shared collections and representations; it mainly supports reading, a primarily individual activity.

The logging of interactions revealed that about 17% of visitors engaged more deeply with the table by reading multiple question-answer items, usually silently and rapid. Many people were observed to only read one item, and then to leave. Considering that average holding time at exhibits is well below a minute, and generally (if at all) between 12 and 27 seconds [11], this may be satisfying. But given the cost investment and high profile of the table (as one of a few media highlights) a deeper engagement and memorable experience would be hoped for.

2.4.4. Visitors Comments – Mostly Critical

Most explicit comments about the table from the people shadowed were rather critical. Most groups were unsure about the purpose of the installation (an important part of *immediate apprehendability* [1] which provides an incentive to persist in interaction).

The flat-sharing young adults referred to the entire new wing as 'glossy high-tech' and commented on the table as 'gadgetry, razzle-dazzle for effect' while unsure what it was meant to convey. The adult family group (which spent 17 minutes at the table) commented on the table as a "toy for children". The father thought the table could be installed in schools, and might be useful to keep children at the entry queue busy, a further indication that the table was perceived as 'for children'.

A member of the young adult group after the first minute of interaction remarked to his friend "I don't understand it either – but it is cool". He later complained that the table is obviously about the tree of evolution, but that the questions "are completely random, what one picks out – you don't know what it is meant to mean – Why this question now?", and that the table is mainly "fun for play". His friend remarks: "I don't really understand how it works". Another group member after about 6 minutes of interaction questions: "but seriously/earnestly – what is this about?" and a woman agrees: "it is nice to play, but what is it about?" (all quotes translated from German).

3. Discussion and Conclusion

To enable visitors to move into deep engagement while getting something out of interaction from the very start, museum researchers recommend supporting multiple layers of activity [5, 7]. While playing with the shoots and reading the question-answer pairs can be considered to be two levels of engagement, there are no further layers that allow users to delve deeper. Instead, the model of interaction is browsing of seemingly unrelated information (see visitor comments) and results in channel zapping behavior. Curiosity provides an incentive for visitors to close the text they just read in exchange for the next question. The previous information disappears, preventing a return to it. In effect, there is little active engagement with the information, and almost no discussion about the contents. In this case, the fluid nature of digital media seems rather a disadvantage, compared to more static media (such as the 'dynamic legends', which consist of static text and a small set of videos or animations selected by touching markers in the text).

The table furthermore differs from other installations and supportive media (e.g. dynamic legends) by being an unconnected stand-alone object. The Jurascopes, for example, are situated in the same hall as the dinosaur skeletons viewed through them, which has visitors refer back and forth and point out the real counterparts to the animations seen through them. Dynamic legends provide background information to exhibits located directly in sight. Other studies found that visitors prefer having information close to related

exhibits and recommend allowing visitors to focus on the exhibits instead of distancing them from their objects of interest [5, 9, 11]. It is still the real artifacts in museums that inspire a sense of awe and wonder, having the aura of authenticity. An alternative design approach for museum tabletops might aim at supporting calm and reflective interaction [17] or to present phenomena and activities that initiate sense-making, construction and testing of hypotheses, discovery and meaning making, or dialogue and emotional learning [5, 18].

This paper presented findings from an open-ended field study, observing visitors in a museum around an interactive table. We have seen how interface design that does not resemble computer displays evokes a rich repertoire of multi-fingered and bimanual gestures, with organic elements evoking rich multi-finger gestures, and button-like objects mostly pointing and button-pressing. While the table in question is very aesthetic and at first sight seems easy to use, close analysis revealed noticeable glitches in interaction, requiring visitors to invest effort into learning how to 'work the interface'. This seemed to distract from the actual content, leading to short holding times. Analysis of interaction patterns further shows that the system with its model of information-browsing initiated few content-related discussions. Also, visitors predominantly perceived the table as a toy for children. This indicates that information-browsing applications may be inappropriate for a museum context, not fulfilling the potential of interactive tabletops.

9. Acknowledgments

Thanks to ART+COM for background information (Jussi Ängeslevä, Anna Schäfers, Mina Hagedorn), the Museum für Naturkunde (especially Gesine Steiner) for supporting this research and granting free entry to participants, all the groups I shadowed, and to Johann Habakuk Israel for help with snowball mailing in search for participants. This research was funded by German DFG fellowship grant Ho3901/1-1.

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