# Supporting Interest and Knowledge Exchange Through Mobile Devices and Bookmarking in Science and Technology Museums

Unterstützung von Interesse und Wissensaustausch
mittels mobiler Geräte und Bookmarking
in Wissenschafts- und Technologie-Museen

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*To science,*
*enlightening us.*

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# Contents

# Abstract

Why are some exhibits interesting for a particular visitor? Is it possible to support this elicited interest during the museum visit with mobile devices that offer additional information or with the information that is available in the museum on the spot? Is it possible to support interest after the museum visit when visitors are able to bookmark the information that they personally found interesting during their visit and to view this information on a personal webpage after the visit? These three questions are addressed in the two studies of the present dissertation thesis in the context of science and technology museums. The first study was conducted in a laboratory exhibition about nanotechnology with 62 student participants and the two factors "availability of additional information" and "availability of bookmarking" on a mobile device. Availability of additional information had a strong effect on visit duration as a behavioral indicator of interest, but no effect on self-reported interest or knowledge measures. However, visitors with additional information reported more post-visit involvement with the topic, possibly indicating a "foot-in-the-door" effect of additional information. Bookmarking did not show an effect, as the exhibition webpage was rarely used. To alleviate constraints with paid student participants, a second study with higher ecological validity was conducted in an actual museum. The sample comprised 188 regular visitors, with the experimental group ($n = 75$) having immediate access to all exhibition information on the mobile device and being able to bookmark information, while the control group ($n = 113$) visited the museum unassisted. An exploratory factor analysis (PAF, varimax) led to the identification of four factors in the visitor-exhibit relationship that determine whether a particular exhibit is interesting for a particular visitor: Attraction Power, Instant Enjoyment, Familiarity, and Information Value. These four factors can explain why interactive and the by far largest exhibit is mentioned more frequently as the most interesting exhibit than their occurrence in the museum would suggest. The four factors can also explain subjective theories of museum curators and the theories of museum professionals regarding interesting

exhibits. A strong effect of the device was found for visit duration, but not for self-reported interest and knowledge. Bookmarking was rarely used by the experimental group. The influence of the device can be explained by Rounds' (2004) application of information foraging to the museum context if this theory is augmented by the effects of using a mobile device in the museum. Adding a virtual information space on a mobile device on top of the information space of the physical museum can enlarge the interest landscape for the museum visitor (Study 1) and support the visitor in exploring it (Study 2). This has beneficial consequences for visitor behavior — information is accessed, and visitors spend more time in the exhibition using the device before museum fatigue sets in, while self-reports show no difference as they were assessed after the visit (where interest has reached the same level for all conditions). Consequently, mobile devices can be used to support visitors' interest. While bookmarking is used by some visitors, no effects could be found, as museum visit wrap-ups by visitors were rare. Visitor motivation for museum visit wrap-ups must be supported first before bookmarking can have any effect.

# Zusammenfassung

Warum sind einige Ausstellungsstücke interessant für bestimmte Besucher? Ist es möglich, in Ausstellungen auftretendes Interesse mit mobilen Geräten zu unterstützen, die Zusatzinformationen zur Verfügung stellen oder die im Museum verfügbaren Informationen an Ort und Stelle verfügbar machen? Ist es möglich, nach dem Ausstellungsbesuch Interesse zu unterstützen, wenn Besucher interessante Informationen während des Besuches speichern können und diese nach dem Besuch auf einer persönlichen Webseite ansehen können? Diese drei Fragen werden in dieser Dissertation bezüglich Wissenschafts- und Technologiemuseen in zwei Studien untersucht. Die erste Studie wurde in einer Laborausstellung über Nanotechnologie mit 62 studentischen Versuchspersonen mit den Faktoren "Verfügbarkeit von Zusatzinformationen" und "Verfügbarkeit von Bookmarking" auf einem mobilen Gerät durchgeführt. Verfügbarkeit von Zusatzinformationen hatte einen starken Effekt auf einen Verhaltensindikator von Interesse, Dauer des Besuches, aber keinen Effekt auf die selbstberichteten Interessens- oder Wissensmaße. Besucher mit Zusatzinformationen berichteten allerdings über eine höhere Beschäftigung mit dem Thema nach dem Besuch, was möglicherweise auf einen "Fuß-in-der-Tür"-Effekt von Zusatzinformationen hinweist. Bookmarking zeigte keinen Effekt aufgrund der seltenen Nutzung der Ausstellungswebsite. Um die Beschränkungen von entlohnten studentischen Versuchspersonen aufzuheben, wurde eine zweite Studie mit höherer ökologischer Validität durchgeführt. Die zweite Studie wurde als Feldstudie in einem realen Museum mit 188 normalen Besuchern durchgeführt. Die Experimentalgruppe ($n = 75$) hatte sofortigen Zugang zu allen Ausstellungsinformationen auf dem mobilen Gerät und konnte Informationen speichern, während die Kontrollgruppe ($n = 113$) das Museum ohne technische Unterstützung besuchte. Eine exploratorische Faktorenanalyse (PAF, Varimax) wurde durchgeführt, welche zur Identifikation von vier Faktoren in der Besucher-Ausstellungsstück-Beziehung führte, die bestimmen, ob ein bestimmtes Ausstellungsstück für einen bestimmten Besucher interessant ist: Anziehungskraft, So-

fortiges Vergnügen, Vertrautheit, und Informationswert. Diese vier Faktoren können erklären, warum interaktive und das mit Abstand größte Exponat überzufällig häufig als interessantestes Ausstellungsstück genannt werden. Sie können auch die subjektiven Theorien von Kuratoren und die Theorien von Museumsforscher bezüglich interessanter Exponate erklären. Ein starker Effekt des Gerätes auf die Besuchsdauer wurde gefunden, allerdings nicht für die selbstberichteten Interessens- und Wissensmaße. Bookmarking wurde von der Experimentalgruppe selten verwendet. Der Einfluss des Gerätes kann erklärt werden, wenn man die von Rounds (2004) auf Museumskontexte angewendete "Information Foraging Theory" um die Effekte von mobilen Geräten im Museum erweitert: Wenn ein virtueller Informationsraum mit einem mobilen Gerät über den Informationsraum des physischen Museums aufgespannt wird, kann dies die Interessenlandschaft für den Museumsbesucher erweitern (Studie 1) und dem Besucher die Exploration der Interessenlandschaft des Museums erleichtern (Studie 2). Dies hat positive Konsequenzen für das Besucherverhalten — die Information wird abgerufen und die Besucher verbringen mehr Zeit in der Ausstellung mit dem Gerät, bevor Museumsmüdigkeit auftritt, während die Selbstberichte keine Unterschiede aufweisen, denn sie wurden nach dem Besuch erfasst (als das Interesse für alle Besucher wieder die gleiche Stärke erreicht hat). Entsprechend können mobile Geräte genutzt werden, um das Interesse von Besuchern zu unterstützen. Obwohl Bookmarking von einigen Besuchern verwendet wurde, konnten diesbezüglich keine Effekte gefunden werden, da eine Nachbereitung von Museumsbesuchen sehr selten ist. Die Motivation der Besucher, den Besuch eines Museums nachzubereiten, muss zuerst erhöht werden, bevor Bookmarking einen Einfluss aufweisen kann.

# Introduction

"Thank you — it was very interesting."
*Visitor Comment*

How was your last visit to a museum of science and technology? What did you see? Which exhibits[1] did you find interesting and why? Did you read the information about the interesting exhibits during the visit? Did you want to know more about the interesting exhibits than the museum provided on the exhibit labels? What did you remember after the visit? Could you describe the exhibits you found most interesting or explain them to others? And what about the visit before? And the one before that? Most museum visitors would probably agree that some exhibits elicited their interest during a visit, but it would be hard for them to state why. On the other hand, many would agree as well that if an exhibit was interesting, the information provided by the museum about the exhibit is often sparse and insufficient. And while they probably agree that some exhibits were interesting, they will likely have difficulties describing the exhibits in detail.

This is only to be expected: Often visitors come to a museum with little or no prior preparation and walk through the museum following their spontaneous interest. If an exhibit strikes their interest, they often can only refer to the limited label information that is available to find out more about the exhibit. Given that visitors' interest is highly heterogenous, it is unlikely that the label contains the information the visitor searches for. For example, one visitor might be interested to know more about the background of a technology exhibit, while another is more interested in societal consequences, and a third wants to learn more about the chances and risks of this technology. Some museums provide additional information (e.g., on flip cards) to alleviate this problem. But even if the visitor has found something of interest and the

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1    Following Allen (2004), I use the word "exhibit" for an individual element (e.g., a machine, an ancient vase, etc.) that is shown in the museum, while "exhibition" refers to the larger, themed collection of individual exhibits.

additional information is available, he or she might not remember it for long. While museum catalogues of exhibitions are usually available, they are often large and unwieldy. Even worse: our visitor would have to find the interesting exhibits again in the catalogue, and it would probably not be at hand when he or she is talking about the visit. Furthermore, the media landscape has changed. While a visit to the museum might have been one of the few educational opportunities during the 18th or 19th century, the museum today is only one of countless possible providers of information. With the internet and its masses of data available, how can the museum fit in? How can it be connected and integrated into the media landscape of the visitor? Is it possible to bridge the gap between the interesting and stimulating world within the museum walls and the life of the visitor beyond?

Let us imagine a different visitor entering a museum. Whether the visit was planned or not, the visitor comes across an exhibit which is a perfect match to her individual characteristics — due to yet unknown factors, it is highly interesting for her. Intrigued, this visitor wants to know more, and can do so by selecting the topics about the exhibit she is interested in on a small, mobile device. This digital device connects the visitor to a vast source of information that allows different visitors to receive precisely the information they are interested in. Some of the information is quite complex and in this stimulating museum setting she does neither have the time nor the peace of mind to really get involved with it. She may want to show some of the information to others after the visit. This visitor simply presses a button when she sees this kind of information, and the information is bookmarked. What is available in nearly every browser to remember interesting websites is used for exhibit information. While walking through the museum, the visitor encounters some other exhibits whose additional information she also reads or bookmarks. With these bookmarks, which are available online, the visitor can recall the visit and its exhibits, get involved with complex topics at her leisure in a suitable setting, and discuss them with others long after she has left the museum.

# Questions Addressed in the Present Dissertation

While this scenario seems to be very beneficial for the visitor and some museums have or do use mobile devices and bookmarking of information, the scenario described raises interesting questions:

1. Why are some exhibits interesting for a particular visitor?
2. Is it possible to support this elicited interest during the museum visit with mobile devices that offer additional information or the information that is available in the museum on the spot?
3. Is it possible to support interest after the museum visit if visitors are able to bookmark the information that they found personally interesting during their visit?

# Overview of the Present Dissertation

In this dissertation thesis, I try to answer these three questions. I will first look at museums from a theoretical stance in their role as important settings for informal learning, and at knowledge communication in museums. I will then focus on the central variable during museum visits: *interest*. This important psychological construct relates to all three questions. I will then focus on media in museums — especially mobile media — to support interest and facilitate knowledge communication. After this theoretical background I will derive the research questions and their operationalization. In the empirical part I will describe two studies that I conducted for my dissertation thesis and their implications for these three questions. The first study is an experiment in a controlled laboratory exhibition. The second study is a quasi-experiment under field conditions in a regular museum.

This dissertation thesis is situated in the domain of psychology. Technology will not be the focus, but the processes and outcomes that mobile technology allows for. Although some things must be technically possible (e.g., allowing the visitor to mark exhibits as interesting for themselves), they can be realized in many different ways (e.g., provided mobile devices, RFID cards, biometrical scanners, personal cellphones

with Bluetooth or WiFi; cf. Mayr & Wessel, 2007; Wessel & Mayr, 2007). While each technical solution has its own affordances, the psychological consequences should be similar. Consequently, the focus here is on the psychological processes and outcomes, not on the technological realization, which would soon be out of date. Thus, given the sequence of the three questions, mobile technology will be addressed relatively late in this text, on page 36.

However, it is expected that it is possible that these effects generalize to other settings. Today's smartphones, such as Apple's iPhone, are powerful (e.g., with respect to processing power or memory), well connected (WLAN, UMTS, 3G), and easy enough to use to allow information retrieval on the phone in everyday settings. Users are able to get more information about, say, a statue in a city square or a train the person is currently riding on. Wikipedia and other online sources are ideally suited for this kind of task. I will address this issue in the general discussion of this dissertation.

# Theoretical Background

## Museums

### Definition

Museums are defined by the International Council of Museums (ICOM, 2006) as "a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, *communicates* and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of *education*, study and enjoyment." [italics by the present author][2].

Museums have "evolved from sixteenth- and seventeenth-century "Cabinets of Curiosities", or 'Wunderkammern'" (Borowske, 2005; see also Figure 1 on page 10 for an illustration) to places for public education in the context of life-long learning[3]. In the course of this development, the role of the visitor has shifted as well. In the beginning, knowledge about the exhibits (or high status) was necessary to be considered worthy of the curators' attention (cf. Holland, 1911). Today, most museums aim to address visitors with different educational backgrounds at any stage of their formal education (e.g., children, university students, employees, senior citizens)[4].

While museums are highly heterogeneous, "differ[ing] in the nature and function of what they offer visitors" (Tallon, 2008), they share some cruicial characteristics: They display *authentic* exhibits that are *distributed in space* in an *informal* setting.

### 1. Authentic Exhibits

Museums spatially concentrate special objects that are, for example, rare, ancient, or difficult to find, especially in such a number and combination. While there may be

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2    Not all museums are members of this council and the definition may not be universally recognized, but it is widely accepted in the museum community, so I will use it here.

3    This does not mean that there are no private "Wunderkammern" anymore. A good contemporary example of a "Wunderkammer" would be the "Library of Human Imagination", which is owned by Jay Walker (Walker, J., 2008).

4    There are exceptions, of course, even within existing museums, where some curators still aim at their "equals".
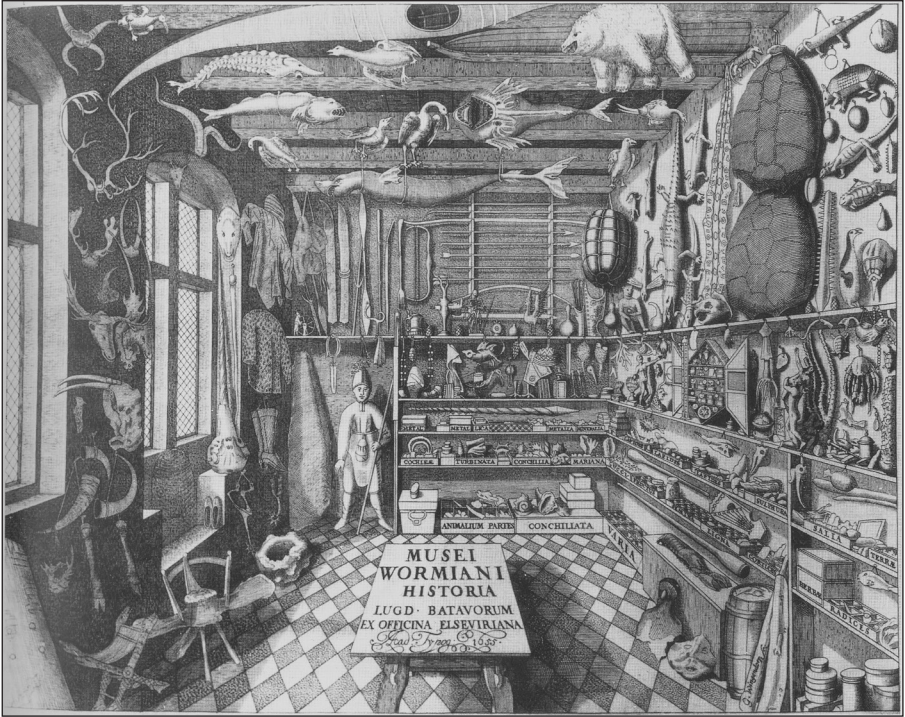
(Museum Wormianum, 1655; from Mundt & Krutisch, 1989)

*Figure 1:* Chamber of Curiosity

many reproductions or digitalized photographs, (usually) only the museum can display the original object, allowing visitors to learn "from objects rather than simply learning about them" (Hawkey, 2004). Visitors desire and expect "the real stuff" (with limitations; see Falk & Dierking, 2008; see also Tellis, 2004; Valdecasas, Correia, & Correas, 2006; Falk & Dierking, 1992). It is important to note that while reproductions or photos of the exhibits might be easily available online, the original object can have an unique attractiveness and an emotional impression that simply cannot be digitalized (cf. "aura", the feeling of awe created by unique or remarkable objects; Benjamin, 1936). Consequently, "objects are the unique attribute of museums and galleries, their USP [unique selling point]" (Hawkey, 2004; see also Mayr & Wessel, 2007).

## 2. Distribution in Space

Exhibits are almost always physical objects that are distributed in space (e.g., Korff, 2002; Schwan, 2005)[5]. Consequently, visitors move around between and around the objects, i.e., they are mobile. While this aspect may seem trivial, it has profound consequences for the kind of technology that can be employed to enhance the visit. I am going to introduce mobile devices in detail in the context of the second question on page 36.

## 3. Informal Setting

Museums are widely regarded as informal settings. However, defining informal learning is not easy. Dimensions of formal vs. informal settings are either regarded as a continuum from formal to informal learning or as matrices with a number of dimensions (Jones, Issroff, Scanlon, Clough, & McAndrew, 2006). Malcolm, Hodkinson, and Colley (2003) distinguish four aspects of formality / informality (process, location and setting, purpose, and content of learning) to analyze situations regarding their respective degree of formality / informality. They argue that "all (or almost all) learning situations contain attributes of formality / informality, but the nature of balance between them raises significantly from situation to situation" (Malcom, Hodkinson, & Colley, 2003). Mayr (2007) applied these four aspects of formal vs. informal settings to museums, concluding that museums fulfill more criteria of informal than of formal learning settings. While the degree of informality of the museum visit may vary (e.g., a completely self-directed single adult visitor vs. a pupil who participates in a guided tour during a school excursion), it is mostly a free choice setting. I will elaborate on this point on page 14.

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5    Although it would be possible to construct a museum where exhibits are handled like urns in some Japanese graveyards: Visitors of the cemetery visit a generic "grave" to which the urn of the deceased they came to see is moved. Similarly, cabins could be offered where visitors can select exhibits they want to see, which are then moved to a generic cabinet in front of them.

## Science and Technology Museums

While museums share several crucial characteristics (see page 9), the actual implementation and kind of information that is offered differs according to the type of museum. For example, there are huge differences between science and technology museums, which want to convey scientific concepts, and art museums, which aim at developing their visitors' appreciation of aesthetics (cf. Knipfer, Mayr, Zahn, Schwan, & Hesse, 2008). Consequently, I have to constrain the questions I want to answer to a specific kind of museum. In this dissertation, I focus on science and technology museums. Due to their focus on conveying scientific concepts and knowledge, and their close relationship with schools (i.e., class visits to museums), they exemplify the educational mission of museums and can offer a unique confrontation with topics that go beyond the possibilities of normal science courses in schools. They can "communicate scientific knowledge, uncover scientific discourses in our 'knowledge-creating civilization', and, in the long run, they can promote the acquisition of scientific literacy in visitors" (Knipfer, Mayr et al., 2008). The inferences made from studies in science and technology museums can probably be transferred to history, archeology, and ethnology museums, which are related to knowledge communication, but probably not to art museums, which focus on aesthetics, visual literacy, and individual interpretation and the creation of meaning (Knipfer, Mayr et al., 2008).

# Knowledge Communication in Museums

Science and technology museums have many advantages for life-long informal learning and for knowledge communication. However, these advantages also comprise challenges that must be addressed. I will elaborate on this issue regarding the visitors of museums, museums as settings for learning, visitor learning, and assisting visitor learning with digital media.

## Visitors

*Number of visitors:* Museums are very popular. In Europe, up to 52 percent of the population visit a museum at least once a year, resulting in up to 183.124 visits per 100.000 inhabitants (Hagedorn-Saupe & Ermert, 2004). In Germany alone, there are over 100 million museum visits each year (Institut für Museumskunde, 2005). On the one hand, this makes museums ideally suited to address large amounts of citizens, but on the other hand, this means that it is difficult, if not impossible, to address each visitor individually, i.e., by an personal human guide. Thus, exhibits have to speak for themselves, supported by museum labels or digital media.

*Diversity of visitors:* While museum visitors are typically better educated (Falk & Adelman, 2003), they are heterogeneous across and within different exhibitions. For instance, they differ in age, gender, prior knowledge (e.g., Samis, 2008; Walker, K., 2008; Falk & Dierking, 2008), interest (e.g., Falk & Adelman, 2003; Falk & Dierking, 2008; Csikszentmihalyi & Hermanson, 1995), ability, learning styles (e.g., Samis, 2008), aptitudes (e.g., Samis, 2008), personal history (e.g., Samis, 2008; Anderson, 2003), agenda (Falk & Dierking, 2008; Mayr, 2009), motivations and expectations (Falk & Adelman, 2003). Visitors come alone, in groups of peers, as part of organized groups (e.g., school visits, work outings), or as families (Antoniou & Lepouras, 2005). This high diversity is also changing over time (cf. the Contextual Level of Learning by Falk & Dierking, 2008). For example, interest and prior knowledge of the same visitor can develop over time, and both "strongly influences what and how individuals learn from their experience" (Falk & Adelman, 2003). Wessel and Mayr (2007) conclude that "[i]t is important to keep in mind that there is no 'typical visitor' of a 'typical exhibition' in a 'typical museum'". Consequently, exhibits and their supporting media must address visitors in their entire heterogeneity, which represents a significant challenge (Falk & Adelman, 2003). For example, Csikszentmihalyi and Hermanson (1995) write that "visitors come with such a broad range of interests and backgrounds that no single recipe for motivating them could possibly apply across the board". Hsi (2008) argues, that due to the personal learning experience, it "can be difficult to support all visitors

with technology tools that tend to be designed as one-size-fits-all applications". This heterogeneity has led museum researchers to audience segmentation research (Samis, 2008). Visitors have been classified in different types and visiting styles since the late 1970s (e.g., Commuter, Nomad, Cafeteria Type, Very Interested Person; cf. Borowske, 2005; browser, follower, searcher, researcher; Morris, Hargreaves, & McIntyre, 2004). For analysis purposes, Falk and Dierking (2008) argue that traditional demographics (age, race/ethnicity, social group, educational attainment) are less useful than prior knowledge, motivation for visiting the museum, and prior interest. Falk and Adelman (2003) grouped visitors according to entering understanding and attitudes and were able to perform a more fine-grained analysis and interpretation.

## Museums as Settings for Learning

*Educational Mission:* Museums predate compulsory education (Hawkey, 2004) and "have always played an important role as repositories of knowledge or artifacts of knowledge, but in the 20th century they have increasingly become active disseminators of knowledge" (Donald, 1991). Their educational mission is mentioned, for example, in the *Encyclopædia Britannica* (Holland, 1911)[6], most museums mention it in their trustee documents (McManus, 1993), and it is explicitly stated in the definition of a museum by the International Council of Museums (ICOM, 2006). This focus on the educational mission has a profound influence on exhibition design as well: "Visitors could not, after all, be expected to learn for themselves, to see the world from the curator's perspective, without support and guidance." (Hawkey, 2004). In some museums, esp. science museums, where concepts are important, the focus on the educational mission and the message the visitor should receive and understand became more important than the exhibits themselves (Hawkey, 2004). It is an open question, however, how to assist visitor learning best.

*Educational Necessity:* Smaller museums are often highly dependent on the formal education sector (e.g., school visits) for their income and visitor numbers (Hawkey, 2004;

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6    In terms and models of its time: "[museums are] powerful educational agencies, in which by object lessons the most important truths of science were capable of being pleasantly imparted to multitudes" (Holland, 1911) — a far cry away from the constructivism or constructionism of today, but education none the less..

e.g., the "Deutsches Museum" in Bonn has about 1000 visits per month, mostly pupils on school excursions[7]).

*Voluntarily accepted setting for free-choice learning:* Museums are not only an informal setting (see page 11), they are voluntarily accepted as settings for free-choice learning. Visitors are guided by their needs and interests (Schoonenboom et al., 2004) and move self-directed in the museum's setting (Rounds, 2004). Visitors desire an interesting, engaging, and shared experience, and they "expect to be mentally, and perhaps physically, engaged in some way by what they see and do" (Falk & Dierking, 2008). They expect novelty, elicitation of their curiosity (Rounds, 2004), fun, relaxation, and intellectual stimulation (Falk & Adelman, 2003). One museum researcher asserts that "all museum visitors want a personally meaningful, relevant experience over which they feel in control" (Giusti, 2008). Others (e.g., Smith & Tinio, 2008) claim that visitors want structure and freedom, i.e., guidance and the ability to explore. In an informal free-choice setting, learning is more intrinsically than extrinsically motivated. Visitors learn because they like to learn for its own sake, without external rewards or punishments (Csikszentmihalyi & Hermanson, 1995). If learners are intrinsically motivated, they have learning goals instead of performance goals and tend to attain higher achievement scores, develop their aptitudes further over time, and have shown higher creativity (cf. Csikszentmihalyi & Hermanson, 1995). This informal free-choice setting also means that visitors are free to learn what they want and to which degree they want to learn (e.g., deep vs. shallow learning; cf. Rounds, 2004). Visitors can decide for themselves what they would like to do; that is, museums cannot force a visitor to pay attention or to learn (e.g. Giusti, 2008; Borowske, 2005; Falk & Dierking, 2008; Malcolm et al., 2003; Mayr, 2007). Unlike formal settings such as schools, museums have no ways to "ensure" learning (e.g., rewards and punishments), as visitors "are not obliged to learn" (Giusti, 2008). Allen (2002) writes about "the power of choice in informal environments: Visitors are choosing where to spend every second of their time, and exhibits that do not engage or sustain them are quickly left behind, however

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7    This can be quite a surprise when a researcher is provided with the number of all visitors in advance and happily tries to conduct a study in which school children may not participate.

'potentially educational' they may be." Consequently, visitors experience not what the exhibition offers but what they choose to attend to (Serrell, 1997; cf. also the remarks of James, 1890, in the footnote on page 24). However, the setting still constrains the visitor and his or her options. Essentially, a visit to a museum is a balance between the affordances of the setting and the self-determination of the visitor: Visitors "put themselves in the hands of the museum" (Smith & Tinio, 2008, page 75) and are "highly responsive to what the setting affords" (Falk & Dierking, 2008, page 22).

This has profound consequences for the educational mission of museums. On the one hand, museums have to display the objects, and on the other they have to trigger visitors' interest and corresponding activities (Csikszentmihalyi & Hermanson, 1995; Rounds, 2004; Treinen, 1988).

*Learning from authentic exhibits:* The exhibits in museums (see page 9) allow learning in a way that is hardly possible in school contexts. Visitors can "see and explore phenomena impossible to see anywhere else" (Norman, 1993, p. 39). They can learn from the objects themselves instead of only learning about them, and discover information for themselves instead of simply receiving it (Hawkey, 2004). On the other hand, the often large number of different objects and complicated topics makes the setting complex and demanding. This places high demands on visitors' cognitive resources (Wessel & Mayr, 2007) and likely leads to cognitive overload (Allen, 2004). The main problem in conveying information to visitors is that visitors usually come to the museum with the expectation that they should see the entire museum during one visit (Csikszentmihalyi and Hermanson, 1995). This is rarely possible, as museums have often been "compared to an all-you-can-eat buffet with too many choices for the typical museum visitor to sample", resulting in a "hurried-visitor problem" (Hsi & Fait, 2005, p. 63/64). The demands of the setting usually place an upper bound for the engagement with an exhibition: After about 20 to 30 minutes, "museum fatigue" sets in (Serrell, 1997; Davey, 2005). Visitors stop engaging deeply with exhibits; they "lose their focused attention and begin to 'cruise,' looking for anything particularly compelling before moving on" (Allen, 2004, p. 20). Consequently, visitors try to achieve their

goal of seeing the entire museum by stopping only at some of the exhibits and spending little time on the exhibits where they do stop. This behavior has been described as "cultural window shopping" (Treinen, 1988). They typically only stop at 20–40% of the exhibits and less than 1% of the visitors stop at all of the exhibits (Serrell, 1998). The average dwelling time at exhibits is approximately 30 seconds (Hsi & Fait, 2005), which makes it highly unlikely that visitors can decode the didactic message of a single exhibit in that time (cf. Treinen, 1988) or "[are] able to fully explore the concepts, phenomena, history, or scientific relevance behind each exhibit in a single visit" (Hsi & Fait, 2005, p. 64). It is also unlikely that visitors will remember what they have seen after the visit. Rounds (2004) has argued convincingly that this visitor behavior can be explained by information foraging theory: Visitors employ strategies (search, attention, and quitting rules) to "achieve a net gain in 'interest' over the total visit, … commensurate with the energy and attention invested, and with the resources available in the environment of the museum." (Rounds, 2004, p. 397). However, every exhibit is an opportunity for deeper exploration — if visitors become engaged, they may stay for up to 10 to 15 minutes (Fleck et al., 2002).

## Visitor Learning

*Learning in a very broad sense:* Learning in museums today can be regarded as constructivist learning. Knowledge is not simply transmitted, but learners actively construct their own meanings and build their own cognitive structures (e.g., Falk & Adelman, 2003). Learning in museums does not only mean knowledge acquisition either (Csikszentmihalyi & Hermanson, 1995). It involves cognition but also sensory experiences and emotions (Csikszentmihalyi & Hermanson, 1995). Visitors "expect to enjoy [themselves] … and learn new things" (Falk, Moussouri, & Coulson, 1998, p. 117), and there is no contradiction between education and entertainment: Visitors who strongly want to have fun *and* to learn do learn more than visitors who only want to learn or only want to have fun (Falk et al., 1998).

*Problems in measuring learning:* This broad view on learning makes defining and measuring learning in museums difficult. Given that the museum experience is a personal

one and visitors are very heterogeneous with respect to their prior knowledge and interest, learning is unique to the specific visitor. There is no specific curriculum that a visitor must follow; neither can his or her achievement be assessed after the visit. Consequently, Falk et al. (1998) criticize "traditional methods of assessment, which rely upon everyone starting at the same place (e.g., 'no knowledge') and ending at a similar place (e.g., 'the correct answer')" as having "serious flaws." (p. 109). In comparison to schools where the range of prior knowledge is narrower (same age, similar background), interest is often neglected, and tests can evaluate learning gains made by students, visitors are too heterogeneous for simple pre-post-comparisons (Falk & Adelman, 2003). For example, depending on initial understanding and attitudes, knowledge gain varies across visitors (Falk & Adelman, 2003).

*Visit duration as measure of learning:* Serrell (1997) argues convincingly that the "amount of time visitors spend and the number of stops they make in exhibitions are systematic measures that can be indicators of learning" (p. 108). She refutes common challenges to analysis of time alone like "epiphanies in seconds" (p. 110) and "time as a measure of struggling to understand something difficult" (p. 111): epiphanies can be traced back to longer periods of preparation (see also research on problem solving and creativity, e.g. Runco, 2007) and most visitors would not invest time and attention in exhibits that are difficult to understand — "unless visitors quickly get some enjoyable, provocative, or personally meaningful feedback from an exhibition, their attention will turn elsewhere." (Serrell, 1997, p. 111). She also cites a correlation between time in the exhibition and number of exhibits used as indirect support for the usefulness of using these measures. Other researchers like Donald (1991, p. 374) warn against using these measures and argue they are rather "condition[s] for learning rather than [a] measure[s] of learning". However, research by Falk et al. (1998, p. 112) supports the validity of using time in the museum as indicator for learning. Their results show a relationship between learning and length of stay: "Individuals who spent longer amounts of time in the exhibition showed significantly greater concept learning ... and mastery learning ... than did those who spent less time in the exhibition".

*Multiple pathways for learning:* Museums offer multiple pathways for learning. Knipfer, Mayr, et al. (2008) identified three pathways of knowledge building in museums: 1. expert scientific knowledge to the visitor (museum-to-visitor), 2. knowledge exchange among visitors (visitor-to-visitor), and 3. a "feedback loop" (visitor-to-museum). While the information provided about the objects by the museum is very important (path 1), visitors also learn much by exchanging knowledge and by conversational elaboration of received information (path 2, see for example, Leinhardt, Crowley, & Knutson, 2002). However, knowledge exchange or even conversation between unfamiliar visitors is difficult. Even if exhibits only work with multiple visitors, visitors who did not know each other before the visit rarely talk to each other during the visit (e.g., Hindmarsh, Heath, vom Lehn, & Cleverly, 2002).

## Visitor Learning and Digital Media

To fulfill their educational mission, museums have "to find new ways to connect people, ideas, and objects" (Filippini-Fantoni & Bowen, 2008, p. 81). They often try to meet visitors' expectations by turning to new technology to "deliver new interactions and experiences" (Tallon, 2008, p. xvii). Consequently, museums make frequent use of media and new technological developments in particular (e.g., Hawkey, 2004; Schwan, Zahn, Wessel, Huff, Herrmann, Reussner, 2008)[8]. Modern media can, for example, be used for reconstruction, presentation, orchestration, marketing, thematic-didactic uses, contextualization, overcoming space restrictions, and conservation purposes (Deutsches Historisches Museum, 2009). Digital media can also connect scholarship and the educational strands of the museum (Hawkey, 2004), e.g., by allowing easy updates of the information in the exhibition depending on recent research findings. Digital media is especially suited to provide visitors with choice, thus allowing flexibility and freedom. Visitors can find their own pathways through the museum and walk them at their own pace (Hawkey, 2004). This aspect is described in more detail in the theoretical background of Question 2 (page 35) where mobile devices are discussed.

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8    Interestingly, new digital technologies have also been exhibits in their own right, e.g., the exhibit "Hello! Welcome to Tate Modern 2007" by Andrea Fraser, which shows mobile devices used in the Tate Modern as an art project itself.

Additionally, digital media can also help to transcend the museums walls (e.g., Hsi & Fait, 2005), to build a bridge into the everyday life of the visitor — more on this aspect in the theoretical background of question three on page 45 where bookmarking of exhibit information is discussed. However, museums place a high demand on the technology used — both from a design and hardware point of view: Visitors vary widely in their media and computer literacy and often handle the devices more roughly than they would with their own technology (Gammon, 1999a, 1999b).

In conclusion, museums have a tremendous potential to be an important contributor to life-long learning, but their high attraction for heterogeneous visitors also poses significant challenges to realize this potential. I will now focus on the most important aspect for life-long learning in museums: *visitors' interest*.

# Visitors' Interest

What is required for visitors to learn in a museum and — consequently — for museums to fulfill their educational mission and role as places for life-long learning? Given the definition of museums (see page 9) and the conditions for learning in museums (see page 12) I propose that *the interest of the visitor is the crucial variable*. I will first give a brief overview about interest and then come back to interest during (and after) museum visits.

## Interest from a Psychological Perspective

Interest is a central psychological variable and "psychologist and educators have always been interested in the topic of interest" (Schraw & Lehman, 2001, p. 24, who also give a good review of the research history). Unfortunately, research on interest is eclectic and sprawling (Silvia, 2005): Different models exist for different subject and content areas (e.g., art, text, vocations, learning, cf. Silvia, 2005) and researchers still do not have a clear understanding on how to support the occurrence of interest or its development (Hidi & Renninger, 2006). Hidi and Renninger (2006; see also Hidi, 2006, Csikszentmihalyi & Hermanson, 1995) argue that interest has biological roots and is evolutionary necessary for survival, consequently, it is something that can be

addressed in any person, because everyone has the potential to be interested, albeit not in the same object.

Interest is often defined in regard to a person-object relation (person-object theory or interactive view between person and content; cf. Hidi, 2006), consisting of a cognitive (knowledge), emotional (positive value) and value-related (self-intentionality, intrinsically motivated) aspect. Other researchers (e.g., Silvia, 2005), have defined interest as an emotion, using appraisal theory (i.e., as a function of novelty check and coping potential). However, this was criticized, as cognition and affect contribute to interest as well. In addition, the influence of cognition increases as interest develops (Hidi, 2006; see also Hidi & Renninger, 2006). In the context of museums with their exhibition objects, the person-object theory seems perfectly suitable as theoretical basis. In the context of the person-object theory, interest has, among others, the following characteristics:

*Object-relatedness:* Interest is always object- or content-specific; the object can be physical or abstract, for example, an activity, subject, topic, domain, task, text, ideas, events (Hidi, 2006; Hidi & Renninger, 2006; Durik & Harackiewicz, 2007). Museums offer multiple objects and, consequently, many possibilities for objects to be interesting.

*Outcome of an interaction between a person and an object:* While interest is object-related, the potential for interest is in the person. This means that interest itself is the result of an interaction between a person and an object (Hidi & Renninger, 2006). Consequently, interest is an "active process — i.e. it is never passive or indifferent" (Mitchell, 1992, p. 2, recurring to Dewey, 1913).

*Cognitive component:* Interest has a strong cognitive component (e.g., Hidi, 2006; Schraw & Lehman, 2001; Sansone & Thoman, 2005). An interested person usually wants to know more about the object of interest, thus showing an epistemic orientation. This illustrates the connection between interest and learning and the hope of museums to stimulate the interest of their visitors to facilitate knowledge acquisition of visitors.

*Affective component:* Interest can occur in affectively negative situations, and moments of frustration are possible during an interested engagement (e.g., Sansone & Thoman,

2005). However, interest typically has a positive affect which is crucial for interest development (Hidi, 2006, Sansone & Thoman, 2005).

*Value-related component:* Objects of interest have a high subjective meaning for the interested person — an emotional and value-related valence. Consequently, interest is intrinsically motivated. It has been argued (e.g. Silvia, 2005) that the function of interest is to motivate exploration and information seeking, which makes sense in the absence of goals and expected rewards only. Given the informal, free-choice setting of museums, interest is likely to occur there.

*Elicitation:* Regarding its occurrence, Hidi (2006) argues that "experiencing interest involves affect from the outset of experience and can be assumed to be combined or integrated with cognition as it develops". Hence, museums should elicit the visitors' emotions first.

## Situational vs. Dispositional Interest

Research often distinguishes between situational and dispositional[9] interest (e.g., Hidi, 2006). This distinction goes back to Krapp (1989) and has found empirical support (e.g., Mitchell, 1992).

*Situational interest* is "environmentally triggered, involves an affective reaction and focused attention" (Hidi, 2006). It is always a state that is evoked spontaneously, is transitory, i.e., fleeting (Schraw & Lehman, 2001), and "appears to fade as rapidly as it emerges, and is *almost always place-specific* [italics by the present author]" (Schraw & Lehman, 2001). However, it also can last for long periods of time (Hidi & Renninger, 2006). Triggers[10] are usually objects or situations that have a certain degree of uncertainty, challenge, novelty (Csikszentmihalyi & Hermanson, 1995), are unusual or relevant in a particular context (Schraw & Lehman, 2001; see also Valdecasas et al., 2006, and Borowske, 2005) or connect to prior experience (Hidi & Renninger, 2006).

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9    Similar terms for dispositional interest used in literature are, for example, "individual interest", "topic interest", "intrinsic interest", and "personal interest". I use the term "dispositional interest" instead of the often used term "individual interest", because I consider interest to be always "individual". Even "situational interest" must address something in the individual.

10   There has been extensive research regarding interest in texts and text-based, task-based, and knowledge-based triggers of situational interest. However, they are not relevant for this research.

While situational interest is amenable to be triggered by the right setting, due to its fleeting nature it usually has only a small effect on knowledge acquisition. Situational interest has been further subdivided into a catch and a hold component. While catch is related to stimulation and focused attention, hold is related to meaning and importance (value) of the object (Durik & Harackiewicz, 2007). Using the catch and hold differentiation, situational interest has two phases: in the first phase interest is triggered, and in the second phase, interest is maintained (Hidi, 2006; see also Mitchell, 1992, for an empirical study supporting the distinction between catch and hold).

*Dispositional interest*, on the other hand, is content specific but context general (Schraw & Lehman, 2001). It is a "relatively enduring predisposition to reengage with particular content" (Hidi, 2006) independent of the particular place the person is in (Schraw & Lehman, 2001). This interest has high personal value and meaning and is often accompanied by knowledge about the content (Hidi, 2006; Hidi & Renninger, 2006; Csikszentmihalyi & Hermanson, 1995). This content itself or related new content easily triggers the state of interest (Hidi & Renninger, 2006). Dispositional interest "is an evolving relation of a person and a particular subject content that is specific to the individual" (Hidi, 2006, referring to Renninger, 2000). Hence, visitors usually differ in interest when they come into the museum (see also Sansone & Thoman, 2005). Once dispositional interest becomes triggered, it becomes actualized (dispositional) interest, i.e., the psychological state of interest that, in this case, is related to an existing (or developing) predisposition (Hidi & Renninger, 2006; Renninger, 2000).

Hidi and Renninger (2006) propose a four-phase model of interest development, dividing situational and dispositional interest into two sub-phases each and proposing a development from the two situational interest phases to the two dispositional phases.

## Effects of Interest

Interest is an extremely useful state in learning contexts — it goes along with active engagement, focused attention, higher learning and effort (Schraw & Lehman, 2001; Silvia, 2005). Important effects of interest are on:

*Attention:* Human attention is limited and scarce, and interest determines what gets

this attention (Csikszentmihalyi & Hermanson, 1995)[11]. The influence of interest on attention was found in many studies (cf. Hidi & Renninger, 2006). This further illustrates the importance of interest during museums visits: In a setting "with too many choices for the typical museum visitor to sample" (Hsi & Fait, 2005, p. 63/64), interest determines which exhibits get attention and for how long.

*Goals:* Interest (anticipated or felt) predicts task choice reliably (Sansone & Thoman, 2005). It has been used in research on intrinsic motivation when participants can choose to do the target activity immediately after the experiment to assess if they are intrinsically motivated. It is also a good predictor for college students' choice of their academic majors (cf. Hidi & Renninger, 2006).

*Learning:* Interest determines not only *what* people learn if they are free to choose, but also *how well* they learn it (Schraw & Lehman, 2001). Interest is related to higher learning (cf., for example, Hidi, 2006; Hidi & Renninger, 2006; Schraw & Lehman, 2001; Sansone and Thoman, 2005), and people with high dispositional interest "can overcome low ability and/or perceptual disabilities" (Hidi, 2006). In addition, less time is required for learning if the object is interesting for the person (Shirey & Reynolds, 1988).

*Cognitive performance:* The positive affect that is associated with interest contributes to cognitive performance (Hidi & Renninger, 2006), e.g., by allowing for a wider array of thoughts and choices of activity (Hidi, 2006).

*Persistence:* Interest influences the time a person persists on a task (Hidi, 2006). Sansone and Thoman (2005) suggest that interest also influences subsequent engagement, particular for long-term activities.

*Epistemic development:* If interest becomes dispositional, people usually engage in the interesting activity quite frequently, leading to greater knowledge and skill (see Hidi & Renninger, 2006).

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11   This point was also made by William James nearly 120 years ago: "The moment one thinks of the matter, one sees how false a notion of experience that is which would make it tantamount to the mere presence to the senses of an outward order. Millions of items in the outward order are present to my senses which never properly enter into my experience. Why? Because they have no interest for me. My experience is what I agree to attend to. Only those items which I notice shape my mind — without selective interest, experience is an utter chaos." (James, 1890).

However, the relationship between interest and knowledge is difficult. While interest influences learning (e.g., topic, persistence, ease, performance), topic knowledge is frequently unrelated to interest (cf. Schraw & Lehman, 2001). While an interested person should learn better, this person does not necessarily need to have high knowledge — at least not at the first onset of interest.

## Measurement of Interest

There are many different measures and scales for assessing interest, depending on the theoretical background and the research question. Measures include, for example, rating scales, behavior observation, logbook and diary methods, or interviews.

*Subjective Self-Reports:* Interest is often assessed via self-reports using likert scales. For example, Silvia (2005) assessed interest via subjective self-reports by using a four-item scale: whether the object was interesting, boring (reverse scored), made the person feel curious, and whether the person would be interested in similar objects. The four items had an Cronbach's α of .88; the scale was thus considered useful and reliable.

*Forced Choice:* One problem of measuring interest with rating scales is that interest is often a highly positive attribute. Social desirability leads some participants to answer (or rather claim) that they are interested in anything. For this reason, forced choice between all possible combinations of options, always two at a time, is sometimes used instead of Likert rating scales. Participants are asked whether they are more interested, for example, in modern or in classical art. They cannot state to be equally interested in both but they have to name a preference. The huge advantage of this method is that it leads to a more differentiated result and is of higher practical usefulness: While a person might want to learn everything about everything given unlimited time and energy, the amount of time and energy available is restricted in daily life and for the duration of a human lifetime. People cannot learn anything; they must make choices, and thus, in accordance with the definition and consequences of interest (e.g., choice of goals), the object of highest interest is chosen. If the aim is to find out whether a person would engage in a topic, forced choice might lead to more valid answers. However, given that each item has to be compared to all other items,

forced choice can only be used for few items, as the number of comparisons increases rapidly the more items are used.

*Behavioral Measures:* Another way to avoid the problems of Likert rating scales is to use behavioral measures. Time on task is often seen as a valid indicator of interest. For example, Silvia (2005) used viewing time for polygons as indicator of participants' interest. He supports this choice with studies that show a correlation between viewing time and self-reported interest and studies that show that manipulations of novelty and complexity affect viewing time and self-reported interest. Time on task is also used when participants are told that they continue with an activity "as long as they like", using the time they spend on the task as an indicator of their interest. Hence, time on task, i.e., visit duration in a museum, is not only a good indicator for learning (see page 18), but also a valid indicator for interest (if the visitors were not interested, they could and probably would simply leave this free-choice setting). As Serrell (1997, p. 110) wrote: "visitors tell us with their feet" whether an exhibition is well used or not. In this dissertation, rating scales, forced choice (Study 1 only) and behavioral indicators of interest are used. Given the previous considerations, behavioral indicators (time in the exhibition, but also usage of the device) should provide higher validity than self-reports with Likert rating scales.

## Support of Interest

Given that the potential for interest is in the person and reveals itself in a person-object relationship, the misconception is frequent that interest cannot be supported, i.e., that persons are either interested or not, and that, in case they are, there is no way to influence interest development. However, interest can be situationally activated, i.e., it can be triggered by the (changeable) setting or situation — and therefore it can be supported even without prior existing dispositional interest. The content-specificity of interest also "provides educators with information as to how students' motivation could increase through development" (Hidi, 2006). Besides these theoretical considerations (see also, for example, Mitchell, 1993; Hidi & Renninger, 2006), there is empirical evidence that interest can be supported. For example, it is "possible to change interest by

changing the text, encoding instructions, or the individual's motivation to engage in the task" (Schraw & Lehman, 2001, p. 49). Hidi and Renninger (2006) give an example of the abilities of music teachers and regular teachers to support the interest of their students (and thereby helping to develop dispositional interest). Based on empirical studies Hidi and Renninger (2006, p. 112) conclude that "other individuals, the organization of the environment, and a person's own efforts, such as self-regulation, can support interest development".

Support of interest is not only possible, it is often required. In the article about their four phase model of interest, Hidi and Renninger (2006, p. 112) point out that "without support from others, any phase of interest development can become dormant, regress to a previous phase, or disappear altogether". Especially in early phases of interest development, support is needed — if interest becomes more and more dispositional and thus self-motivated, the support can slowly fade out (Hidi & Renninger, 2006). Similarly, if the engagement with a new activity, e.g., an exhibit, is not rewarded intrinsically, a person will not engage him- or herself long enough in it for positive consequences to occur (Csikszentmihalyi & Hermanson, 1995).

How can interest be supported? Positive feelings about the activity, offering choice in tasks, promoting a sense of autonomy, innovative task organization, support in relevant knowledge development, project-based learning, using computers, using meaningful topics, personal relevance, a manageable gap in knowledge, or promoting self-competence may support interest (Hidi & Renninger, 2006; Sansone and Thoman, 2005; Loewenstein, 1994; Mitchell, 1992). Sansone and Thoman (2005) argue that the satisfaction of the psychological needs of autonomy, competence, and relatedness (self-determination theory; cf. Ryan and Deci, e.g., 2000) "can be precursor to the experience of interest". These are all needs a museum could satisfy. Berlyne (e.g., 1966) has conducted research on structural stimulus characteristics that lead to curiosity and exploratory behavior and which might also lead to interest (cf. Csikszentmihalyi & Hermanson, 1995). These characteristics are novelty, surprisingness, complexity, and ambiguity. While the explanation of Berlyne is no longer accepted, the effect of nov-

elty and complexity was found to be very robust and can be explained by appraisal theory (Silvia, 2005). Complexity was found to be dependent on ability: only people with high ability find highly complex objects interesting (Silvia, 2005). While changing situational constraints will probably only lead to situational interest (i.e., fleeting, location-specific interest with weak effects), this situational interest is the first step in developing dispositional interest (cf. Hidi & Renninger, 2006) and shows many beneficial effects in addition (see page 23).

## Self-Regulation of Interest

Sansone and Thoman (2005) argue that interest can be self-regulated by a person. Intrapersonal (e.g., competing against oneself) and interpersonal (e.g., working with another person) strategies can be used to motivate prolonged engagement with an otherwise boring activity if there is a good reason to do so. This can self-generate interest in the boring activity and maintain the motivation to persist with a behavior. This self-generation has implications for the measurement of interest — if persons generate their own interest, then the interest measured after the task does not adequately reflect the interest in the task but is strongly influenced by their knowledge of and skills in using self-regulation strategies (cf. Sansone & Thoman, 2005). This might have a similar effect on performance as, for example, seductive details[12]. However, this depends on the goals the person is expected to achieve. In an free-choice setting like a museum, self-regulation of interest would only be detrimental if the person used strategies that prevent engagement with the material, e.g., that are aimed to bridge the time the person "has to spend there".

## Interest and Museums

The history of museums and the role of learning in museums shows that interest has

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12   Seductive details are information that is not directly related to the content of instruction (Mitchell, 1992) but interesting for many people. It can motivated engagement with the activity but it can also draw attention away from the content that should be learned (Sansone & Thoman, 2005). For example, in trying to raise interest in the physical principles behind a lightning, a teacher might mention the number of people killed by lightning each year. This non-essential information is a two-edged sword — it can raise interest which would result in higher learning (see page 23), but it can also distract the learner, resulting in lower learning.

always been a central part of museums. Chambers of Curiosity[13] were collections of interesting objects whose aim was to foster curiosity and wonder (Valdecasas et al., 2006; see also page 9). For example, Peter the Great used agents for his collection (Petrograd Museum), who were "explicitly instructed to collect, among other things, 'strange or interesting items'." (Valdecasas et al., 2006). While Valdecasas et al. (2006) criticize that the sense of wonder of early collections has been lost (e.g., due to information overload and the dissemination of information via other sources — much is already known by the visitor prior to the visit), interest is of crucial importance in todays museums. Interest motivates at least some of the visitors to visit the museum, it varies considerably in visitors (e.g., Falk & Adelman, 2003, Csikszentmihalyi & Hermanson, 1995) and is not correlated to education level (Falk & Adelman, 2003).

Interest determines which exhibits visitors attend to (Csikszentmihalyi & Hermanson, 1995; Rounds, 2004; Treinen, 1988), at which they have a closer look during the museum visit, and what they review after the visit. While this selective visitor behavior may look inefficient on the surface, Rounds' (2004) comparison of visitor behavior as information foraging behavior shows that this behavior is rational. It further illustrates that visitors try to maximize their total interest value of the visit by using "simple heuristics to find and focus attention only on those exhibits with high interest value and low search costs" (p. 389). Visitors evaluate a museum visit by the "amount of 'interest' gained" compared to the effort they have expended. Consequently, museums cannot ignore interest (Csikszentmihalyi & Hermanson, 1995)[14] and they strive to elicit interest even if the visitor was not previously interested in the topic.

Museums can be especially suited to raise visitors' interest due to their many objects as possible starting points for interest (person-object relation; interest is object-related) and their free-choice character. Allen (2004, p. 17) states that "[t]he environment pro-

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13   While they were called "Chambers of Curiosity" and not "Chambers of Interest", the criteria for objects to be considered worthy to be exhibited point more to interest than to curiosity: Curiosity is a general attribute of a person with interindividual differences between persons (i.e., one person is more curious than another), while interest a person-object-relationship with intraindividual differences (i.e., within a person for different objects) — cf. Csikszentmihalyi and Hermanson (1995).

14   Or rather: good museums cannot ignore interest. Visitor-oriented museums use audience and evaluation studies to learn about their visitors' interests and perceptions. For an overview, see Reussner (2009).

vides myriad personal choices, without any teachers forcing learners to do something unappealing, without curricular constraints, without testing or accountability" and continues with a quote by Frank Oppenheimer, the founder of the Exploratorium[15] who often said that "No one ever flunked a museum".

However, museums can get it wrong; if not with a whole exhibition, then at least on the exhibit level. Rounds (2000, p. 188) writes: "more often than not, I find the exhibits in science museums boring. And when I watch other visitors carefully, I become convinced that much of the time they may be trying hard, but they're bored, too.". Given the high importance of interest, this raises the question: *What exactly makes an exhibit interesting for a visitor in a museum?* This is the first question that guides this work. It will be further specified on page 32.

Once exhibits have raised interest, they can serve as starting points or reinforcements of dispositional interest. Csikszentmihalyi and Hermanson (1995) write that museums are often named either as starting points or as important contributors to the cultivation of interest which led to successful careers and are places "where information lost its abstractness and became concrete" (p. 67). Quoting the Institute for Learning Innovation (2007), Knipfer, Zahn, and Hesse (2008) argue that people "develop their interests … towards emerging scientific topics mainly in out-of-school environments", environments which include museums. Hidi and Renninger's (2006) four-phase model also supports that museums can contribute to or support the development of stable dispositional interest. However, given the time frame necessary to develop (stable) dispositional interest, this aspect is hardly suitable for a dissertation. But even without developing into dispositional interest, actualized or situational interest should be supported for the many beneficial consequences of high interest for learning (see page 23). *But how can museum support visitors' interest during the museum visit*, given the high heterogeneity of visitors' interest and the constraints of the museum setting? I argue that *mobile devices might provide a possible way to support visitors interest during the museum visit*. This is the second question that guides this work. It will be further

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15    The Exploratorium (http://www.exploratorium.edu) is a large science center in San Francisco that is also very explorative in using new media to improve their exhibits.

specified on page 35.

While museums are fascinating places, they are only a very small part in the world of their visitors. Nevertheless, museums hope to have a lasting impact on the life of their visitors. Given that much of the interest during a visit is probably situational, i.e., fleeting, interest, it is questionable how much of this interest remains after the museum visit. This is similar for knowledge — given the cognitive overload that is to be expected during a museum visit, how much of the visit can be remembered, e.g., for reflection or discussion with others? The third question of this work addresses *whether it is possible to support visitors' interest and knowledge exchange after the museum visit by facilitating remembrance of those exhibits the visitor found interesting during the visit.* It is further specified on page 45.

# Preliminary Conclusion

Due to the characteristics of the museum setting (see page 9), the ways knowledge is communicated in museums (see page 12), and the central importance of interest and its amenability to outside influence (see page 20), I have derived the three following research questions[16]:

1. What makes an exhibit interesting for a visitor?[17]
2. (How) can interest be supported with mobile media during the visit?
3. (How) can emerged interest be supported after the museum visit?

## Pre-existing Research in Museums

Finding good pre-existing psychological research papers about museums is difficult. Many museums do conduct research, but their studies often concentrate on a particular exhibition and are oriented towards evaluation (and thus lack generalizability). The studies also are rarely published in peer-reviewed journals and thus are hard to find. Some museums researchers address museums in general (e.g., Falk, Dierking,

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16   The question could be extended to include non-visitors and try to get this group to visit museums' including preparation for the museum visit. To keep this dissertation manageable, the question of interest was constrained to actual visitors who visit the museum, from the point when they enter the museum.

17   Note: It would have no positive consequence to find ways to support interest during and after the museum visit if visitors did not find anything interesting that can be supported.

Gammon, Crowley, Graf) but there is little work about museums from a psychological perspective. Consequently, the theoretical background for the analysis and operationalization of these three questions will be based on work of museum researchers and utilize and transfer findings from psychological research. However, much of the work is exploratory. Due to the complex and free-choice setting I had to make many decisions on my own without prior research to guide me.

## Question 1: What Makes an Exhibit Interesting for a Visitor?

Visitors have to be interested in an exhibit to engage with it and learn something from it, but what makes an exhibit interesting? Unfortunately, while there is much research for text, little research has been published regarding interest in exhibits, especially from a psychological perspective. Csikszentmihalyi and Hermanson (1995) write that "we still are far from knowing what the fundamental dimensions of situational interest are" (p. 72) and regret a lack of research that makes museum work more "an art rather than a science" (p. 73). Currently, curators choose those exhibits[18] they consider fitting to the conception of the exhibition and interesting for their target audience. However, if curators are trying to address a wide heterogeneity of visitors, their expert perspective may be a hindrance in achieving this if it differs too much from the perspective of the everyday visitor. Curators often follow their subjective theories. For example, Csikszentmihalyi and Hermanson (1995) refer to Michael Spock, an experienced museum professional, who "says that dinosaurs and mummies are surest exhibits to attract attention" (p. 72). Summing up what they have learnt from talking to museum professionals, Csikszentmihalyi and Hermanson (1995) conclude that exhibits attracting attention are the ones that are mysterious (e.g. ancient), evoke awe or the thrill of fear without actual danger (e.g., dinosaurs and mummies), pleasant displays with bright colors, interactive exhibits, and exhibits of large size. Given the somewhat different agendas and the frequent lack of contact between curators and visitors, the

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18    If they have the choice: Given time and financial constraints, the first step in exhibition design is often to see what is already available and can be readily used (Reussner, personal communication).

curators' subjective theories might not be the best basis for exhibition design.

In museum research, there are different positions regarding what makes exhibits interesting.

*Idea is either interesting or not:* Rounds (2000) argues that scientific ideas by themselves are either interesting or boring, and that, consequently, the interesting ideas should be exhibited. He does not disagree that the personal, social and physical contexts (cf. Falk & Dierking, 1992) do make a difference but argues that "it still makes a difference what we put in the exhibits" (p. 189). He sees interestingness of scientific ideas (exemplified by the exhibits) as dependent on their generality, simplicity and accuracy. Only two out of these three aspects can be realized by a single exhibit, and he argues that simple and general (but not necessarily accurate) ideas are most likely to be interesting to visitors of science museums. They have "metaphorical power" (p. 197), "capture the public imagination" (p. 195), and are "cross-over ideas that move out from the scientific discipline where they were born into the culture at large" (p. 195). Examples of these kinds of ideas are the theories of Evolution, Relativity, and Chaos.

*Presentation style is crucial:* Valdecasas et al. (2006), on the other hand, argue that the "emotional response depends more on the way we look at things, or the way we display them, than on formal content" (p. 37). It is not the object itself but the way it is presented that produces curiosity and wonder, e.g., "a photo of a fly can be a very common experience, but a magnified 3D view of its leg can inspire awe and mystification" (p. 38). Consequently, the exhibit must only be new or put something known into a new perspective. Borowske (2005) argues in a similar direction by proposing juxtaposition to attract the attention of visitors. Objects that are (at first glance) unrelated can be placed together, or familiar objects may be placed in an unfamiliar or incongruous context.

*(Meaningful) Interactivity:* Ansbacher (2003) argues that it is not the idea itself nor the presentation of the exhibit, but the interactivity an exhibit provides. An interesting exhibit is an engaging exhibit; there is something "to actually see and do at the exhibit" (Ansbacher, 2003, p. 167) and it can be understood by the visitor without interpreta-

tion. He argues for experience-based exhibits that have a worth in themselves and do not simply illustrate the educational message of the exhibit label. The argument for interactivity and immediate understanding without interpretation is also made by Allen (2004), who argues for "immediate apprehendability" (p. 17), a concept that she relates to affordance and user-centered design. An exhibit must be understandable without thinking and motivating in "every intermediate step in the visitors' experience" (p. 18), otherwise the visitor is likely to quit. However, she is critical of interactivity as a silver bullet solution — "while recognizing the power of interactive experiences, we should be skeptical about sweeping claims that interactivity is essential to learning, or even that it necessarily creates the most powerful, memorable, or attractive experiences in our museums" (p. 25). She also criticizes "'gratuitous interactivity', where the interactive features of an exhibit are unrelated to its central phenomenon" (p. 30) and which can be related to seductive details in psychology. She points out that interactivity must be meaningful, that visitors must be able to focus, recapitulate, review, and exercise not only their fingers but also their minds (Allen, 2004).

The issue becomes more complicated when not only immediate attention of a visitor to an exhibit is assessed, but also whether the exhibit manages to hold the visitors' attention for some time. Museum research uses the terms *attraction* (or attracting) vs. *holding power*: Attracting power is the number and kinds of visitors who approach a particular exhibit (see Donald, 1991), while holding power is the amount of time a visitor examines an exhibit ("total number of seconds visitor stops at an exhibit divided by the minimum number of seconds necessary to read and see an exhibit"; see Donald, 1991, p. 372). In psychological terms, an exhibit must not only "catch" visitors' interest but "hold" it as well (cf. Mitchell, 1992; Csikszentmihalyi and Hermanson, 1995).

A problem of many conceptions of museum research regarding interesting exhibits is that interest is too object-specific. Interesting ideas (Rounds, 2000), mode of presentation (Valdecasas et al., 2006; Borowske, 2005), interactivity (Ansbacher, 2003; Allen, 2004), are properties that are situated completely or partly in the object, the exhibit

itself. Given the definition of interest as person-object relation and the potential of interest in the person which is triggered by an object and shows itself in the interaction between person and object, interest cannot be seen as something that is situated in the exhibit itself. Colloquial language is also misleading at this point: while people might say "It is interesting", a more accurate statement would be: "It is interesting *to me*". Consequently, the relationship between the exhibit and the personal characteristics of the visitor who finds it interesting, must be analyzed — and not (only) the (objective) properties of the exhibit itself. It is likely that the relationship between a specific visitor's personal history and the affordances of the exhibit itself determine the interestingness of an exhibit. Even if there are common objective exhibit characteristics of exhibits that are frequently named as most interesting (e.g., interactivity, size), there might be subjective factors in the visitor-exhibit relationship that determine the interestingness of an exhibit for each particular visitor.

But what are these factors? What determines the interaction between the object and the person that leads a visitor to regard the exhibit as most interesting? This is the first — exploratory — question that is addressed in this dissertation thesis.

Formulated as a hypothesis, the first hypothesis is that exhibits that are interactive (H1.1) or of exceptional size (H1.2) are more often named as interesting than expected by chance. On the other hand, no hypotheses can be made for the subjective factors in the visitor-exhibit relationship that determine the interestingness of an exhibit for each particular visitor save that these factors exist (H1.3).

## Question 2: (How) Can Interest Be Supported During the Museum Visit?

Museums are very well suited to elicit the interest of visitors (see page 28), and Question 1 will shed some light on what makes an exhibits interesting for a particular visitor. But given that visitors are interested in an exhibit, do they follow their interest? Do they read the information texts and think about them? And are there ways in which museum can support visitors' interest, i.e., facilitate visitor engagement with the exhibition and its exhibits?

# Mobile Media

Given the characteristics of a museum (see page 9 and page 14), four aspects are relevant to determine what is needed to support visitors interest:

*1. Visitors are mobile:* Exhibitions consist of physical objects (see page 9), which (usually) means that visitors are mobile. In contrast to learning in a classroom or working at home in front of a computer, they have to go towards the objects. Any way to support interest must either be available at every exhibit or be mobile as well.

*2. Interest is fleeting:* The main problem of interest during museum visits is that it is most likely situational interest. Situational interest is fleeting and context-specific (i.e., location-specific, see page page 22), which means that it has to be fulfilled or "used" on the spot while the visitor stands in front of the exhibit. Even actualized dispositional interest, which equally (and, in comparison to situational interest: reliably) results in interest as a state, likely suffers from similar problems. A few seconds after the visitor has continued walking through the museum it is likely to have faded away. The "magic of the moment" is lost — the "hot moment" when the visitor was open to learn more about the exhibit has passed. Any support must be available immediately where ever the visitor is.

*3. The environment is shared:* It is rare that visitors have an exhibition to themselves. The setting is shared with other visitors which means that labels are not always visible and media terminals are not always available. Consequently, any support must be a personal solution that allows the user immediate access to it.

*4. Visitors are heterogeneous and therefore have different informational needs:* Visitors differ in prior knowledge and interests. Even if visitors are attracted by the same exhibition object, their interests may refer to completely different aspects of it. Whereas one visitor is interested in the history of an exhibit, a second one may want to know more about the material, while a third one remembers something he or she has seen before and is motivated to look it up. Labels, which often contain the essential information, are mostly not broad and deep enough to satisfy the interest of heterogeneous visitors. Their physical space is limited, and too much text on labels does not motivate visitors

to read them. This also requires a personal solution with a broad knowledge base.

Given these constraints, *mobile media* seems to be especially suited for this setting[19].

Mobile media address the four characteristics in the following ways:

*1. Visitors are mobile — so is mobile media:* Mobility is the defining characteristic of mobile media. While there are different definitions of mobile devices (see, for example, Naismith, Lonsdale, Vavoula, & Sharples, 2004; Paris, 2005), the crucial aspect in this case is that learners can move while using them: Information can be accessed on the move and the device can be positioned in front of the exhibit so that the visitor can best view the object and the information about it (Gammon & Burch, 2008). Speaking in hardware terms, personal digital assistants (PDAs) and smartphones exemplify this quality, whereas Tablet PCs are usually too heavy to carry around for a longer time, and notebooks can hardly be used while moving[20].

*2. Interest is fleeting — mobile media allow immediate access:* Mobile media, especially screen-based devices like PDAs and smartphones, allow easy and direct selection of information. Maps allow visitors to select exhibits they are interested in, and the available information can be ordered in topics for quick selection (see, for example, the mobile device at the Mercedes Benz Museum in Stuttgart, Germany). The trite "anytime, anywhere" mantra for mobile devices exemplifies this point.

*3. The environment is shared — personal device:* Mobile devices in themselves are personal devices: "there is a one-to-one relationship between the visitor and the medium, with the visitor in control" (Tallon, 2008, p. xviii). The small screens are best suited for a single user, although they can be shared (e.g., shown to others). The personal device allows users to access the content that interests them the most whenever they want to — they "can offer choice and individualized learning options to visitors" (Falk & Dierking, 2008, p. 20). This property of mobile devices is explicit in the "P" of "Per-

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19   I am reviewing, continuing, and expanding thoughts that were the basis of two papers of Eva Mayr's and mine regarding the potentials and challenges of mobile media in museums and how mobile devices can be used in exhibition contexts to improve the visiting experience, increase learning, and satisfy interests. Both were written in shared authorship and published as Mayr and Wessel (2007) and Wessel and Mayr (2007).

20   And are "mobile like a brick" (Soloway during his "IADIS mobile learning conference 2007" keynote). However, this often depends on the actual situation: For a visitor sitting in a wheelchair a notebook (fastened to the chair) is usable on the move.

sonal Digital Assistant" but also implicit in smartphones: With the association of a cellphone number to a specific person (and not to an apartment and all its inhabitants), their many non-phone-related functions and data they contain, they are personal devices that are rarely shared. Mobile media can also be an artificial companion for single visitors, giving them something to do during the visit.

4. *Visitors are heterogeneous and consequently have different information needs — vast (unlimited) storage capacity:* Mobile digital devices offer vast, if not unlimited (e.g., via an Wifi or 3G Internet connection) storage space for information. They open a constantly available virtual space beyond the physical exhibition space that can be furnished with any information desired, most of all more detailed and varied information about exhibits (e.g., Gammon & Burch, 2008; Manning & Sims, 2004). Where could the additional information come from? Statistically, only 7% of the material a museum owns is exhibited (Deutsches Historisches Museum, 2009). Mobile devices can thus offer images and information on related objects in storage, from other museums, or from museum databases (e.g., Filippini-Fantoni & Bowen, 2008; Manning & Sims, 2004; Collins, Mulholland, & Zdrahal, 2009), from museum community knowledge (Collins et al., 2009) or from Tour Guides (Collins et al., 2009). Mobile devices can also connect to other sources of information, for example, to Wikipedia (en.wikipedia.org), the world's largest encyclopedia. Wikipedia has a vast breadth and depth of information, is available for free, uses the GNU Free Documentation License, and can even be downloaded to a large memory card for offline scenarios. Additionally, it is constantly being expanded and improved, allows the visitors to make changes as well, and it is available in 266 languages (Wikipedia, 2009a), although with (equally) vast differences in the amount of available articles. While Wikipedia is not accepted by many in the museum community, its quality is comparable to the *Encyclopædia Britannica* (Giles, 2005; but see *Encyclopædia Britannica*, 2006, and *Nature*, 2006), and its use corresponds to the ideas of the post-museum (Hooper-Greenhill, 2000, p. 152) where knowledge is constructed by the visitors. Consequently, "mobile devices expand the physical exhibition space into a virtually augmented information space – beyond size restricted

labels." (Wessel & Mayr, 2007, p. 3).

It is difficult to find another medium that is as well suited to support interest during museum visits as mobile media (cf. Tallon, 2008). Falk and Dierking (2008, p. 20) conclude: "Digital media, well designed and wisely used, are important tools that can enhance visitor interaction and learning in museums, ensuring that these environments inspire and provoke curiosity and further understanding among visitors with varying backgrounds, interests, and knowledge levels."

Besides these strengths for provision of information, mobile media has a number of further advantages (see Table 1).

Given these strengths, it is no wonder that mobile devices have a long history in museums. It began with the first audio guides in 1952 (Bradburne, 2008), included interactivity (with a punch card reader) in 1973 (Tallon, 2008); direct access to information in 1993/4 (Tallon, 2008; Proctor & Tellis, 2003), multimedia-tours since the mid-1990s (Filippini-Fantoni & Bowen, 2008), control of exhibits (e.g., Petrosains, using Apple Newtons) in 1996 (Wikipedia, 2009b), and wireless multimedia tours (Tate Modern) in 2002 (Filippini-Fantoni & Bowen, 2008). While pure audio guides are very well established (Proctor & Tellis, 2003; Tellis, 2004), screen-based guides must still prove their worth in the museum world (e.g., Tellis, 2004; Proctor, 2005). Nevertheless, museums are excited about mobile media, especially screen-based mobile guides, and their possibilities. Tellis (2004) writes that "there is no doubt that the current capabilities of the wireless PDA platform represent the most exciting development in museum education appliances in the past two decades.". While he might be prejudiced due to the fact that he is working for a major electronic guidebook company (Antenna Audio), his point of view is shared by museum researchers like Hsi (2003) and others, albeit with some caution. Mobile devices have a number of advantages for the museum as well (see Table 2), but a large number of possible negative effects of mobile media have also been mentioned.

| Advantage of mobile media | Source |
|---|---|
| closely match life-long learning (individualized, learner-centered, situated, collaborative, ubiquitous, life-long) | Sharples, 2000 |
| match balance between structure and freedom | Smith & Tinio, 2008; Giusti, 2008 |
| can show multimedia content | Fleck et al., 2002; Hsi, 2003; Falk & Dierking, 2008; Filippini-Fantoni & Bowen, 2008 |
| can use audio for text | Walker, 2007 |
| allow communication with other visitors | Gammon & Burch, 2008; Mayr & Wessel, 2007; Manning & Sims, 2004; Proctor, 2005 |
| allow communication with educators/teachers | Manning & Sims, 2004; Tellis, 2004 |
| allow communication with museum services (e.g., booking/event info) | Filippini-Fantoni & Bowen, 2008; Tellis, 2004 |
| explicit and implicit adaptation of information | Hsi, 2002; Hawkey, 2004; Fleck et al., 2002; Tellis, 2004; Mayr & Wessel, 2007 |
| guidance/orientation (e.g., maps, suggested tours/exhibits) | Hsi, 2008; Filippini-Fantoni & Bowen, 2008; Gammon & Burch, 2008; Tellis, 2004 |
| location-based services | Filippini-Fantoni & Bowen, 2008; Wessel & Mayr, 2007 |
| interactivity/engagement (e.g., single and multiplayer games; voting and polling; participatory simulations) | Filippini-Fantoni & Bowen, 2008; Manning & Sims, 2004; Mayr & Wessel, 2007; Hsi, 2008; Gammon & Burch, 2008 |
| scaffold conversations (guidebook as support tool) | Hsi, 2003 |
| few demands on the visitor | Fleck et al., 2002 |
| preserve the esthetics of the gallery | Filippini-Fantoni & Bowen, 2008; Semper & Spasojevic, 2002; Mayr & Wessel, 2007 |
| preparation of a visit | Hsi, 2002; Mayr & Wessel, 2007 |
| accessibility (e.g., seniors, urban youth, migrant families, multigenerational and multilingual families, disabled, children) | Tallon, 2008; Filippini-Fantoni & Bowen, 2008; Hsi, 2008; Tellis, 2004; Giusti, 2008; Proctor, 2005; Gottlieb, 2008 |
| meets connectivity expectations of the visitors (able to access any information at any time) | Tallon, 2008 |
| can present information that is not there (e.g., digital reconstructions of ruins) | Grewe & Schulze, 2007 |
| facilitate remembrance of information and knowledge communication | see Question 3 on page 45 |

*Table 1:* Further advantages of mobile media for visitors

## Possible Negative Effects of Mobile Devices

They key concern is that mobile devices might prevent visitors from having a personally rewarding experience (Tallon, 2008). Criticism against mobile media is directed at

| Advantage of mobile media for a museum | Source |
|---|---|
| can cover the entire museum | Tallon, 2008 |
| security (device/visitor tracking, security alarms) and queue monitoring | Tellis, 2004; Filippini-Fantoni & Bowen, 2008 |
| support for museum personnel (talking labels/explainers/tour guides) | Hsi, 2008 |
| outreach to new audiences (e.g., disabled, young) | Filippini-Fantoni & Bowen, 2008 |
| real-time updates of content information/interface with the museum's content management system | Mayr & Wessel, 2007 |
| feedback to curators | Mayr & Wessel, 2007; Collins, Mulholland, Zdrahal, 2009 |
| revenue (if licensed to external company) | Tallon, 2008 |
| return visitors and visitor tracking beyond the single museum | Hsi & Fait, 2005 |
| retail promotions and wireless commerce (offering goods from museum shop) | Tellis, 2004 |
| visitor surveys and logfile analysis | Tellis, 2004; Mayr & Wessel, 2007; Wessel & Mayr, 2007 |

*Table 2:* Advantages of mobile media for the museum

the personal, social, and physical level of visitors and museums in general.

On the *personal level*, mobile media could offer an "embarrassment of riches", i.e., they offer too much and consequently overwhelm the visitor (Gammon & Burch, 2008, p. 49). The "wow" factor of the device can distract from the exhibits (Semper & Spaso-jevic, 2002), and when tested for its suitability, the pilot group may evaluate not the quality of device but be biased by "the excitement and attention of being part of something new" (Proctor, 2005, p. 28). It also opens a rift between the real and the virtual contexts which the visitor must bridge (Hsi, 2003). If the device covers only part of the exhibits, it forces visitors' interest to these exhibits (Tallon, 2008), and visitors spending too much time in front of these exhibits could clog up a gallery (Tallon, 2008). Strong reservations concern the distraction of the visitor-exhibit interaction through mobile devices, the "lure of the screen" (Proctor, 2005; Filippini-Fantoni & Bowen, 2008; see also Semper & Spasojevic, 2002; Fleck et al., 2002; Collins et al., 2009; Walter, 1996), resulting in a "heads-down" phenomenon of visitors (Hsi, 2003) and attention split (Hsi, 2008), although strategies to counter such behavior exist (e.g., back-and-

forthing, where visitors have to look at the exhibit to make sense of the information on the device; see Exploratorium, 2005). Gammon and Burch (2008, p. 39) conclude: "While some studies indicate that digital technology can be a distraction, there is considerable counterevidence that when it is properly designed, it can actually increase visitors' engagement with other exhibits.". The greater freedom to "delve deeper" (Parry, 2008) might also remove the visitor from museum influence, i.e., the story the museum is trying to tell (Parry, 2008). There have also been concerns that the technical expectations of visitors are impossible to fulfill, e.g., visitors expecting technology to work like in the movies, or a mobile internet connection to work with the speed of their personal computers at home (Proctor, 2005). In addition, visitors are easily frustrated by technology that does not work perfectly (Proctor, 2005; e.g., through unstable WLAN networks or low accuracy of location-based systems). Visitors can also be physically and mentally overwhelmed by the technology: They have to carry an additional object that impedes exploration with hands-on exhibits (e.g., Hsi, 2008), and low computer literacy might leave some visitors unable to use the device correctly. Some museum professionals think that visitors may not want mobile media and suffer from "technology fatigue" (c.f. Filippini-Fantoni & Bowen, 2008). Others think that it excludes senior citizens; however, this prejudice has been challenged (Giusti, 2008), especially when other senior citizens work for the museum and explain the guide (Teufel, xpedeo, a mobile guide company, personal communication).

On the *social level*, mobile devices are often regarded as "anti-social" (Tallon, 2008), i.e., they decrease visitor-visitor interaction (Walter, 1996; Wessel & Mayr, 2007; Gay et al., 2002; Proctor, 2005, Filippini-Fantoni & Bowen, 2008). This might reduce elaboration of information during conversation and inhibit social navigation (mimicking other visitors; see Mayr & Wessel, 2007). This problem is even more pronounced when headphones are used that prevent visitor communication (see Gammon & Burch, 2008; Proctor, 2005). However, counters to these problems have been proposed, e.g., facilitating sharing of information and leaving visitors the choice to explore on their own. While museum visits are often a social experience (Gammon, 2004), there are

persons who prefer visiting the museum alone, even if they arrive in a group (Packer & Ballantyne, 2005).

On the *physical level*, there are concerns that digital handhelds "dumb down" the museum setting and turn it into a theme park (Parry, 2008). Some museum personnel see museums as a media free zone where exhibits should stand alone (cf. Mayr & Wessel, 2007); however, even a simple label is a medium which enhances (or, depending on the perspective, blemishes) exhibits and helps visitors to understand it (or prevents them from hearing the exhibit speaking for itself and destroys its unique and fragile aura). Some criticize the qualities of the device itself, e.g., the difficulty of entering information on a PDA (Hsi, 2008, Mayr & Wessel, 2007), the yet unproven technology for a museum setting (Proctor, 2005; especially regarding navigation, e.g., context sensitive service, see Filippini-Fantoni & Bowen, 2008), the small screens (which come as price of portability; Wessel & Mayr, 2007; Filippini-Fantoni & Bowen, 2008), or the lack of ruggedness of devices that were conceived for use in corporate management and that do not fare well in a museum or science center setting (Fleck et al., 2002; Mayr & Wessel, 2007; see also Gammon, 1999a, 1999b).

From the *museum perspective*, mobile media are sometimes regarded as a hype. Molitor (2001, page IV - 1) writes: "Why are we doing this? Is it just because the stuff is out there and we're hip and cutting edge, or is this adding something fundamentally?", a question that is answered negatively by some museums. Even if museums do want to "add something fundamental", mobile devices are often beyond the capabilities of a museum: Costs for hardware, localization services, software, and especially the content production are beyond many museum budgets, especially when not only initial costs but maintenance and replacement is taken into account (Filippini-Fantoni & Bowen, 2008; Proctor, 2005). The fact that many screen-based mobile guides did not live up to their high expectations and were cancelled after pilot trials or a few years (see, for example, Proctor, 2005; Filippini-Fantoni & Bowen, 2008) is especially discouraging. If introduced, museum personnel has to be trained to use them, otherwise they will be reluctant to hand out technology they do not trust (Proctor, 2005),

because they have to handle visitor complains. Consequently, "fool-proof" systems are needed.

Despite these (many) concerns, digital mobile devices are generally accepted by visitors, and there are many counterstrategies against the possible negative side-effects of mobile media. For example, not everything that is possible should be offered to visitors to prevent overwhelming them (cf. Fleck, 2002). Even the problems of initial cost and maintenance can be bypassed if visitor devices are used (see Antoniou & Lepouras, 2005; Tallon, 2008; Collins et al., 2009), given that smartphones become more and more common, powerful, and useful for educational purposes (see The New Media Consortium and EDUCAUSE Learning Initiative, 2006, 2007, 2008, 2009) and museums can focus on content delivery over their WiFi network (see for example, Wessel & Mayr, 2007). However, these concerns illustrate that both positive and negative effects of digital mobile media have to be analyzed carefully. Visitors attention is a critical resource (cf. Fleck, 2002), and the mobile device has to be as easy and subtle as possible in supporting interest[21], which leaves visitors free to explore the setting they came to see.

Unfortunately, despite these concerns, museum research regarding actual effects of mobile media is sparse. Tallon (2008) bemoans that "[f]or a medium with such an extensive existing usage and wide-reaching potential, there is a distinct lack of rigorous, accessible, and published research", and Wessel and Mayr (2007) criticize that "a common problem with mobile devices in museums and with exhibitions in general is evaluation or rather lack thereof". Research on mobile learning offers arguments why mobile devices are motivating; however, they are often untested, are likely to suffer from a "newness effect", or related to other contexts (see, for example, Jones et al., 2006) or rely on technical availability than on actual usage evaluations. However, availability does not equal usage, let alone beneficial effects (Wessel & Mayr, 2007).

Consequently, I will analyze the effects of mobile media, which provide additional information or facilitate access to existing information in front of the exhibit, from a

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21   This has been put succinctly by Teufel (who works for xpedeo, a mobile guide company; personal communication): "Every button is one button too many.".

psychological perspective. Mobile media allow the exploration of exhibits in the "hot moment" when visitors are interested in them. But is it possible to support interest in this way, i.e., does this lead to deeper engagement with the exhibit, longer visit durations, and higher interest? This is the second question that is addressed in this dissertation thesis. Formulated as a hypothesis, I propose that providing additional information (H2.1) or facilitating access to existing information in front of the exhibit (H2.2) does support interest by means of longer visit duration, higher interest and learning.

## Question 3: (How) Can Interest Be Supported After the Museum Visit?

While interest during the exhibition visit is crucial, museums want to achieve more than just influence visitors during their stay: they hope to have a lasting impact on the visitors (e.g., Stevenson, 1991) beyond the individual visit. One reason for this is that meaning making also occurs after the visit (e.g., Donald, 1991), i.e., by "what happens subsequently in the learner's environment" (Falk & Dierking, 2008, p. 22). But how can museums transcend their walls and have influence on the lives of the visitors beyond? How can a short and fleeting state of interest during the museum visit have consequences long after the visitor has left the museum?

What remains of the visit? Museum research has looked into the frequency and persistence of museum visitors' memories. Falk and Dierking (1990) report about the earliest childhood memories of museum visits. Visitors often remember the social dimension (for example, their fellow visitors, their shared activities, etc.) and even "three or more specific aspects of what they did" (Falk & Dierking, 1997). McManus (1993), in her review of museum studies, concludes that "people do clearly remember for long periods casual visits made to museum exhibitions" (p. 378) and that "the range of memories can be very wide and they are often quite personal" (p. 378). She found that 51% of all memories related to objects or things in the gallery, 23% episodic events or experiences, 15% feelings or emotions, and 10% summary memories or distilled conclusions that occurred after visitors had time to think about their visit. Stevenson (1991) found a high and vivid recall of hand-on exhibits by visitors of a science muse-

um several months after their visits. Not surprisingly recall is very high immediately after the visit — "everyone is able to talk about the exhibits in detail" (Stevenson, 1991, p. 530). Visual recognition is also very good, in a study by Fivush (1983, cited in Anderson, 2003), there was no decrease in visual recognition performance by children one year after their museum visit. Anderson (2003) reviews studies on memory of exhibition visits and comes to the conclusion "that visitors' social contexts are important and memorable elements of their experiences in informal settings" (p. 405) and points out the high salience of visitors' episodic memories of their museums visits. He shows the dominating and mediating influence of visitors' socio-cultural identity during the time of the visit in his analysis of visitors' memories of world expositions (Anderson, 2003). Despite the visit being a highly remarkable event, only less than 20% of the study participants could "describe in any detail what was on display or in the pavilions of either Expo, despite in-depth probing during the interviews" (p 408). He explains this effect with changes in socio-cultural identity the visitor has experienced since his or her visit. A notable exception are visitors with "specific personal interest in a particular exhibition theme or country" who performed better on recall (Anderson, 2003, p. 409). Similar effects of preexisting (i.e., dispositional) interest were found by McManus (1993, p. 369), where "interest which existed before the visit could evoke detailed recall of related material in the museum". She further reports that "the visit had become personalized for each family member" and that "a small number of exhibits … could be recalled by most family members" (McManus, 1993, p. 309). Research by Stevenson (1991), which focused on family visits, shows the strong effects of conversation: 99% of the family members had either talked to each other or to others about the visit after they had left the museum. It stands to reason that this conversation influenced them to remember much of the visit in clear detail. However, most memories were descriptive and episodic, although there were indicators that "cognitive processing leading to the formation of semantic memories does take place" (McManus, 1993, p. 523, about Stevenson's 1991 work).

Given these findings and the theoretical considerations about learning in museums

discussed above (see page 14), the following problems to post-visit engagement seem clear:

*Not the right mode for reflection:* Norman (1993) warns that museum visits are often done in an experiential mode of cognition, i.e., "without conscious reflection", pattern- and event-driven: "Rich, dynamic, continually present environments can interfere with reflection: These environments lead one toward the experiential mode, driving the cognition by the perceptions of the event-driven processing, thereby not leaving sufficient mental resources for the concentration required for reflection." (p. 25). He further states that "[e]xperiential learning isn't enough, of course, but it is indeed a good motivator and therefore a sensible starting point. As Quin puts it: 'There is a general consensus ... that exhibits on their own are not good at teaching. They are about inspiration. And interest, once aroused, must be taken advantage of — by schools, and through all the activities other than exhibits developed by museums and science centres.'" (p. 21). While museum visits seem ideally suited for raising interest, deep engagement with the content should be done somewhere else (e.g., Paula Lutum-Langer, "Haus der Geschichte" Stuttgart, personal communication). However, it seems unlikely that situational interest, as a fleeting and transitory state, will remain in the visitors' mind after they have left the exhibition (or even the exhibit). While actualized dispositional interest occurs reliably, it is also a state that might not occur too frequently outside the museum. Consequently, the visitor's experience must be extended beyond a single visit (Hsi & Fait, 2005). It must be an extended learning experience and connect "the context of a museum visit to activities that take place … after it, and that allows a visitor to communicate with … him- or herself over time" (Rudman, Sharples, Lonsdale, Vavoula, & Meek, 2008).

*Interest requires continued support to develop:* Reinforcing experiences are also needed for the development of interest. Even if visitors find something interesting during their visit and follow it, support is needed in the early phases of interest development (from situational to dispositional interest; see Hidi & Renninger, 2006). However, post-visit reflection is probably hindered by lack of semantic memories.

*Too much information to remember:* Given the hurried visitor phenomenon (Hsi & Fait, 2005), the huge amount of possible exhibits to sample (Hsi & Fait, 2005), and visitors' strategies to maximize their interest (Rounds, 2004), it is no wonder that "visitors are frequently overwhelmed by the vast amount of information presented" (Barry, 2006), and the time spend at an exhibit is often too short to decode its didactic message (e.g. Treinen, 1988; see also page 14) and probably also for remembering the exhibit for later reflection. This not only prevents visitors from learning during the visit but also from reengaging with the content after the visit. "People need reinforcing experiences" (Walker, K., 2008, p. 111) and not just a single confrontation to retain their memories over time (Filippini-Fantoni & Bowen, 2008). While visitors can describe what they have seen and felt, it is probably more difficult for them to describe the exhibits in great detail. Even if they have bought a catalogue, they have to find the interesting exhibits in it again although they had already decided what was interesting for them during the visit by engaging with it or bypassing it.

*Knowledge exchange facilitates learning but requires common ground:* Lack of clear semantic memory of exhibits not only prevents private reflection but also discussion with others. A large body of research by both museum researchers and psychologists, points to the positive effect of social interaction (particularly communication) for learning (e.g., Hooper-Greenhill & Moussouri, 2002; Gammon & Burch, 2008; Allen, 2002). However, conversation requires common ground (Clark & Brennan, 1991), i.e., conversation partners must not only know what the other person says but what the other person means.

In museums today there are a lot of ways to provide visitors with information during the visit but little is done to help visitors *retain* this information after the visit and allow for later reflection. Often this "support" is in the domain of the museum shop, where exhibition catalogues and postcards are common commodities to help visitors remember exhibits. Even if mobile guides are being offered, the information is often not available outside of the museum. This is even true for digital data, which is mobile itself, and could simply be transferred electronically to the visitors (e.g. by eMail,

a personalized webpage, or USB/CD-storage devices). Some visitors try to solve the problem by taking photographs of the exhibits and even their labels to remember themselves of the exhibits and discuss them with others (see the cover of this dissertation). However, this strongly depends on visitors personal resources (a good camera) and the permission of the museum to take photographs in the exhibition[22].

## Bookmarking in Exhibitions

However, there is an interesting way to alleviate these problems — bookmarking. While bookmarking of webpages has been around for years (cf. Filippini-Fantoni & Bowen, 2007), it can easily be transferred to the physical world of museums. There are different ways to realize bookmarking in museums, e.g., RFID cards (e.g., Hsi, 2008), KIOSK systems, or visitors cellphones (cf. Filippini-Fantoni & Bowen, 2007, 2008). Visitors can mark exhibits or exhibit information as interesting for future reference outside the museum. This bookmarked information can be printed out (e.g., Petrosains; see Wikipedia, 2009b), sent home via eMail (e.g., Tate Modern; Proctor & Tellis, 2003; Filippini-Fantoni & Bowen, 2008), or made available on a personal museum webpage (e.g., Exploratorium; see, e.g., Fleck et al., 2002; Hsi, 2003).

Proponents of bookmarking expect that this kind of personalization (Filippini-Fantoni & Bowen, 2007) alleviates the problems preventing post-visit engagement by letting the information transcend the museum walls. Bookmarking can serve as an "aide-memoir" (Barry, 2006) and help visitors to deal with the vast amount of information they encounter during their visit. If visitors bookmark only information they found interesting, they have an immediate point of contact for later engagement. In contrast to a catalogue, they do not have to find the interesting information again but are able to access it separately from the information on museum websites or in catalogues. Consequently, visitors can have reinforcing experiences by confronting themselves with images of the exhibits and the textual information they considered interesting

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22   Museums vary in this regard: some museums allow photography, others forbid the use of flash or tripods, others want monetary "compensation", and some completely forbid it (including, ironically, the "Museum of Photography" in Berlin). Frequent reasons are conservatory issues (flash damages the exhibits), copyright issues, fear of competition to the museum shop, or protecting the mood and atmosphere of the museum (personal communication with museum staff).

after the visit, in a setting that is more amenable to factual learning (quieter, less time restrictions), and can use it to integrate it into their personal learning infrastructure (e.g., diaries, notebooks, computer files). This could very well support interest development. Collins et al. (2009) also argue that the organization of these bookmarks and subsequent exploration "scaffolds the exploration process by building on the established interests to the visitor" (p. 30). Visitors can easily continue their exploration with additional information if additional online content and teaching materials are provided (Hsi & Fait, 2005). The bookmarks should also be helpful for knowledge communication after the visit. Visitors can show the exhibit images and information to communication partners and use them as objects for indicative gestures for grounding references (for grounding, cf. Clark & Brennan, 1991). This should establish referential identity of the communication object and facilitate knowledge communication, which, consequently, should improve learning. Bookmarks could also support the visit itself by letting visitors focus on the exhibits at hand or the presentation of a tour guide — because they can be sure that they will always be able to find out more information on the interesting exhibits after the visit (see, for example, Collins et al., 2009). It also allows visitors to focus "more on discovery and the aesthetic experience while in the museum and to leave the more traditional didactic aspects for later" (Filippini-Fantoni & Bowen, 2007).

Furthermore, theoretical considerations often include more structure than a simple list of interesting elements. Peterson and Levene (2003) argue for a "trail model of navigational learning" that allows to edit trails. Walker (2006, 2007) also argues for structure in his "learning trails", focussing on narrative and construction, not simple data capture. This is done by letting visitors, often school children, construct trails for others to follow (Walker, K., 2008), which has theoretical links to "learning by design". Kevin Walker (2008) also argues that the thematic or narrative coherence is more important than the spatial one, which he links to the way good museums structure their exhibitions ("present individual objects within a structure that links them together to form a larger picture", p. 120). However, given the often interest-driven behavior of visitors

(compare Rounds, 2004), it is questionable whether these coherent trails would also be useful for visitors outside of school excursions.

Barry (2006) has made the largest claims for the effects of bookmarking by proposing that bookmarks can lead to a "virtuous circle": A visit to the physical museum leads to interaction with the gallery or mobile devices. Information is sent home to the visitor which leads him or her to visit the website; this, in turn, leads to a further visit to the physical museum, where the circle repeats itself. This not only creates "continuity between pre-, post-, and actual visit experiences" (Barry, 2006), thus leading to "a stronger relationship between the institution and the visitor" (Filippini-Fantoni & Bowen, 2008), but is increasingly expected by the visitors in an information-on-demand culture (Barry, 2006; see also Filippini-Fantoni & Bowen, 2007).

Given these expected advantages, it is no wonder that bookmarking has been adopted by some of the world's leading museums (Filippini-Fantoni & Bowen, 2007). These museums include, for example, the Tate Modern, London (as "eMail information home"; see Proctor & Tellis, 2003; Filippini-Fantoni & Bowen, 2008), the Natural History Museum, England; the Vienna Museum of Technology (Hsi & Fait, 2005); the Tech Museum in San Jose, CA (Hsi & Fait, 2005); the Science Museum, London (Barry, 2006); and Bletchley Park, England (Collins et al., 2009). While museum studies show that visitors think exhibit bookmarking is a desirable feature (Hsi & Fait, 2005; Hsi, 2002; Semper & Spasojevic, 2002), actual usage numbers show that visitors act differently. Assessment of the usage of bookmarking systems is surprisingly difficult, since "most systems are not set up to track what users do and when they do it; they do not necessarily collect useful information such as number of unique visitors, first time versus repeat visitors, the number of bookmarked items, etc." (Filippini-Fantoni & Bowen, 2007).

However, Filippini and Bowen (2007) have analyzed different bookmarking systems by looking at usage statistics and evaluation results and came to the conclusion that "despite its great potential … there is still very little evidence that bookmarking actually works in the terms envisaged by its promoters". Their evaluation goes beyond

the "competencies, time and money" most museums have. Bookmarking rates are variable depending on the system used, with online applications and kiosk-based solutions performing lower than handheld devices (which vary between 10–43%). Click-through rates, i.e., "percentage of users that follow up and go on-line to access the bookmarked information" (Filippini & Bowen, 2007), are also disappointing. Only Tate Modern reached 44% (which equals 19% of the total number of PDA users) — all other projects analyzed by Filippini and Bowen (2007) were well below 10%. Therefore, Filippini and Bowen (2008) conclude that there is little evidence for the virtuous circle proposed by Barry (2006). Reasons for not using the bookmarking feature from different projects often include "lack of time", "lack of interest", and "too much information". Given these findings it seems that "for most visitors, the experience starts and finishes in the museum and there is no need or curiosity to extend it beyond its walls" (Filippini and Bowen, 2007).

Other reasons for low usage are the lack of understanding and lack of visibility: Visitors often do not understand the feature since it is a novel concept in this setting ("The relatively novel concept of book-marking within this context was also an issue", Barry, 2006). Visitors are prone to misunderstand bookmarking as something that is only available in the museum (comparable to bookmarks stored in a particular browser on a particular computer before webservices like del.icio.us were available). The term "email Information home", for example, chosen for the Tate Guide to prevent such misunderstandings, since it provided a better mental model for the system than bookmarking. The bookmarking function must also be easy to find and to use. According to Barry (2006), "informal evaluation suggests that this lower uptake could be due to the bookmarking's not being obvious, as it was situated on a second level of the menu.". Similar conclusions were made by Filippini and Bowen (2007) regarding the Getty online bookmarking system on the secondary pages of the museums website. A further issue could be the quality of information — while museums excel in authentic artifacts, bookmarking brings museum in direct competition with the Internet and all its information resources (e.g., it is hard to imagine that a traveling exhibition regard-

ing Star Wars had better information material on Star Wars than is available on the countless Fan Sites on the Internet).

While Filippini and Bowen (2007) show the problems of bookmarking, they also warn about seeing the results as too negative. Problems of "visibility, transparency and simplicity" can be addressed ("resulting in improved take-up rates"), but lack of interest has to be accepted. Given the free-choice informal setting of museums, Filippini and Bowen (2007) argue that one should see the results in comparison with success rates of other educational campaigns, where they become quite significant. The low percentage nevertheless equals high absolute numbers, given the large amount of visitors (e.g., Tech Museum: 300.000 RFID tickets were used and 50.000 visitors accessed information online) and the fact that there are indicators for continuity between pre- and post-visit experience with some visitors (3.2% of visitors used their tag in more than one visit; Filippini & Bowen, 2007). Consequently, Filippini and Bowen (2007) argue that bookmarking is more suitable for committed visitors and specialized target groups like art lovers, researchers, students and teachers, and second time visitors. For this small but important core group of visitors, bookmarking is extremely valuable. However, the research of Filippini and Bowen (2007) reaches its limits whether visitors learn and remember more through the process of creating and accessing bookmarks. Most of the studies they analyzed did not address these issues, "mainly because of the difficulties inherent in measuring learning over an extended period of time (during the visit and after the visit) and in different locations (in the museum, at home, in the classroom, etc.).". I am addressing this question as the third question of this dissertation thesis: Does bookmarking lead to higher engagement with the exhibition topic, interest, and knowledge exchange after the visit? Given the risk of overwhelming visitors with too many functions, I will use only a simple bookmarking function: Visitors can bookmark information on the mobile device if they find the exhibit interesting and are able to access the bookmarked exhibits on a personal website after the visit. Formulated as a hypothesis, I propose that bookmarking does lead to higher engagement with the exhibition topic, interest, and knowledge exchange after the visit.

# Research Questions and Hypotheses

Based on the theoretical considerations and the assumption that interest of visitors can and should be supported, I will address the following research questions in this dissertation thesis:

## 1. What Makes an Exhibit Interesting?

*Specifically:* Which factors determine that an exhibit is interest for a visitor if the person-object relationship of interest is taken into account? This question will predominantly be addressed in Study 2.

*Hypothesis 1.1:* Interactive exhibits are more often named as most interesting than expected by chance.

*Hypothesis 1.2:* Exceptionally large exhibits are more often named as most interesting than expected by chance.

*Hypothesis 1.3:* Subjective factors in the visitor-exhibit relationship determine what makes an exhibit most interesting for a particular visitor, although no specific hypotheses can be made regarding the factors (exploratory analysis).

## 2. (How) Can Interest Be Supported During the Museum Visit?

*Specifically:* If mobile media can provide additional information or immediate access to available information on the spot when the visitor is interested in an exhibit, is this used by the visitor in the hot moment when he or she experiences a state of interest, and does this lead to longer duration of visit, higher interest and learning?

*Hypothesis 2.1:* Providing additional information on mobile devices does support interest in terms of longer visit duration, higher interest and learning.

*Hypothesis 2.2:* Facilitating access to in the exhibition available information in front of the exhibit does support interest in terms of longer visit duration, higher interest and learning.

## 3. (How) Can Interest Be Supported After the Museum Visit?

*Specifically:* If visitors have the opportunity to bookmark exhibits as interesting, what are the consequences of this feature on interest, post-visit engagement with the topic of the exhibition, and knowledge exchange?

*Hypothesis 3:* Bookmarking leads to higher engagement with the exhibition topic, interest, and knowledge exchange after the visit.

# Overview of the Analysis Strategy

I have conducted two studies to address these three questions. The first study was conducted in a laboratory exhibition, i.e., an authentic exhibition that was erected in the foyer of the Knowledge Media Research Center. The second study was conducted in a real museum as a field study. Both settings have their advantages and disadvantages, but together they were useful to shed some light on these three questions from different perspectives. Although the three questions will be the thread through this thesis, I will present and discuss both studies with respects to their answers to the three questions separately before addressing the three questions again in the General Discussion section from page 174 on.

# Challenges of Setting and Media

The setting and the media used provided some difficulties for research:

## Research in Museums

While museums do conduct research of their own (see definition on page 9 or Reussner, 2009), research in museums is difficult for non-museum staff. A free-choice informal setting is only partly compatible with laboratory experiments psychologists often conduct. Experiments are rarely possible and influences on an existing museum setting are limited. This is reflected in the two studies of this dissertation: In the first study, using a laboratory exhibition ensured high control and an experiment could be conducted. The second study was 'only' a field study where existing conditions had to be accepted and integrated into the design. However, ecological validity was much higher and closer to the original situation than in any laboratory exhibition, let alone laboratory experiments with student participants sitting in front of a computer screen with a virtual exhibition and pretending to visit a physical museum.

## Research with Mobile Media

Mobile media is a relatively new research area with yet unstandardized practice regarding "research frameworks, methods and tools" (Vavoula & Sharples, 2008, p. 1). Vavoula and Sharples (2008) see six challenges in evaluating mobile learning, four of which are relevant in this context: capturing and analyzing learning in context and across contexts, measuring mobile learning processes and outcomes, considering the wider organizational and socio-cultural context of learning, and assessing in-/formality. Consequently, this dissertation can only provide first insights into the question of supporting interest with mobile devices.

# Empirical Part

## Study 1: Laboratory Exhibition

## Method

### Design

In the first study the above-mentioned questions were addressed using a 2-by-2 between-subjects design (see Table 3). The first factor was whether participants had access to additional information on their mobile device or not (see "Mobile Device and Program Used" on page 61). The second factor was concerned with whether participants could bookmark interesting exhibits and exhibit information and have them available on a personal page of the exhibition website or not (see "Exhibition Website" on page 63). Participants were randomly assigned to one of the four conditions.

|  |  | bookmarking | |
| --- | --- | --- | --- |
|  |  | yes | no |
| **additional information** | yes | a | b |
|  | no | c | d |

*Table 3:* Design of Study 1 — Laboratory Exhibition

The information available on the mobile device depends on the experimental condition of the visitor. In the additional information conditions (a and b), a touch on the exhibit image on the PDA provides the visitor with a menu of possible choices: bookmark the exhibit (coloring it in yellow on the exhibition wall image); see further information about "background information", "chances and risks", or "societal consequences"; visit the Wikipedia entry about Nanotechnology (http://de.wikipedia.org/wiki/Nanotechnologie) as a starting point for further research (using the Mediawiki

layout "küken" which was viewable on the PDA); or back to previous screen (see Figure 2). Accessing further information provided the visitor with the information requested which could also be bookmarked separately. In the non-additional-information conditions (c and d) a touch of the exhibit image on the PDA only marked this exhibit, coloring it yellow on the display.

The bookmark and non-bookmark conditions both had the same program and functions, depending only on whether they also had access to additional information or
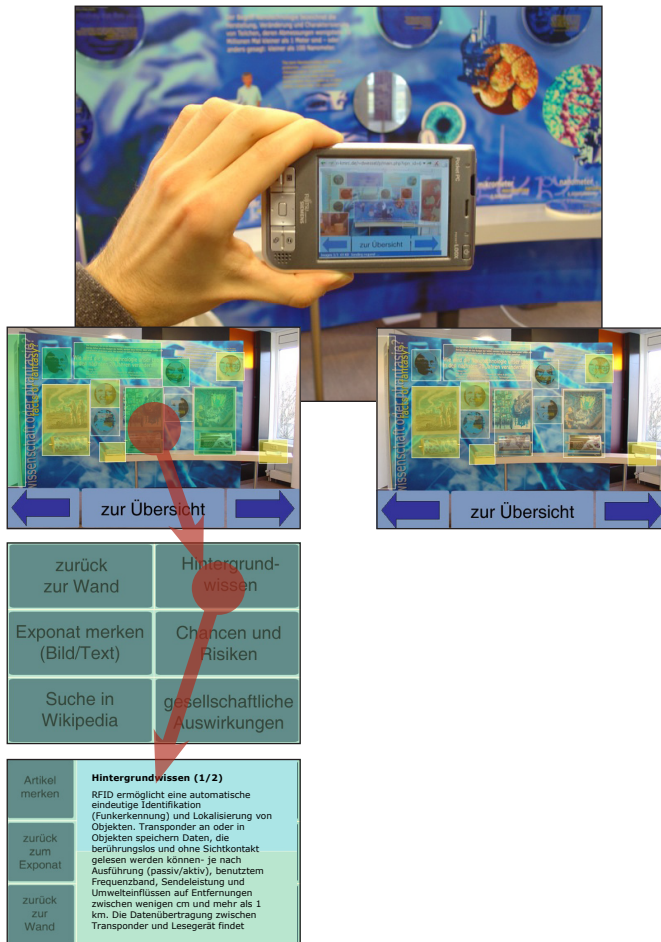


*left:* condition with additional information; *right:* condition without additional information

*Figure 2:* Mobile device and program used in Study 1

not. This condition was realized by telling visitors before the visit that the aim of this function was to find out which exhibits are interesting. After the visit, half the participants (a and c) were told that this information was also available to them on a personal page on the exhibition website, while the other half did not get this information nor a personal page with this information (b and d).

In this study, the effects of additional information had priority — giving the information about bookmarking after the visit allowed comparing the behavior of the visitors during the visit of both additional information groups (a and b) with the behavior of both non-additional information groups (c and d), resulting in higher power.

In this study, the focus is on the support of interest during the visit by allowing access to additional information or not, and the effects of bookmarking on post-visit engagement. Due to the homogeneity of the exhibition in terms of topic (nanotechnology) and media (much text, a few exhibits), the question of what makes an exhibit interesting for a visitor (Question 1) is not addressed in this study. Interesting exhibits will be described, but an analysis of underlying factors of an interesting visitor-exhibit relationship will be done in study 2 only.

## Participants

Participants were 62 students of the University of Tuebingen which were recruited via flyers, notices and a mailing list where interested students could register to be informed about future experiments. Students received €12,- or two hours study participation credit to take part in the study.

## Settings and Instruments

Given that the experiment was conducted with an authentic exhibition, I will first describe the exhibition itself, then the mobile device and program used, followed by the website of the exhibition that was available to the visitors after the visit, and finally the dependent measures.

*Laboratory Exhibition: Nanodialogue*

To research interest in an informal free-choice setting, laboratory experiments did not seem suitable: In a setting where movement of the participants is part of the central characteristics and the main reason for the use of mobile learning, virtual representations are too different to be used as adequate research environment. Consequently, an authentic exhibition[23] was used and placed in the lobby of the Knowledge Media Research Center. This exhibition, called "Nanodialogue", was a small travel exhibition previously shown in the "Deutsches Museum München" and (in localized versions) in other European cities. It was designed by the Fondazione IDIS-Città della Scienza (Italy) in the context of the "science and society" debate (Amodio, 2007) and aimed to provide information and raise awareness regarding nanotechnology, create a dialogue between researchers, citizens and relevant social actors, and to improve the quality and legitimacy of decisions by the public regarding these issues (Amodio, 2007). It was also designed to stimulate interest and curiosity, which made it especially suited to research these questions. The target audience were adults with higher educational background. Consequently, the focus was on providing information and "hands-on" content was rare. The exhibition itself consisted of four rounded walls which were placed in a circle (see Figure 3). Two of the walls provided textual information, one textual information with a few exhibits, and the fourth wall consisted of showcases containing exhibits (e.g., coated surfaces, cleaner with nano-particles, an electron microscope).

The exhibition was evaluated with more than 700 visitors (Amodio, 2007). Self-reports of visitors indicated that the knowledge about nanotechnology was low: 55% had a fairly low or very low understanding, and only 14% had a very or fairly high understanding of nanotechnology. Visitors mostly agreed that the visit had increased their understanding of nanotechnology: 38% strongly agreed, 50% agreed, 5% tended to disagree, and 2% strongly disagreed (Amodio, 2007).

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23   Although some museum curators might speak of the used exhibition disdainfully as an "industry exhibition" because it was created by the European Union, its look and feel was that of a real albeit small exhibition.
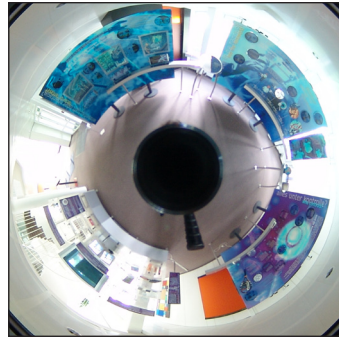
(the exhibition in the foyer of the KMRC, a 360° Image of the exhibition
and the four exhibition walls)

*Figure 3:* Exhibition Nanodialogue

## Mobile Device and Program Used

*Mobile Device:* As a tool to provide additional information and allow bookmarking of exhibits and information, visitors were provided with Fujitsu-Siemens Pocket Loox 720 PDAs (see Figure 2 on page 58). These small devices (12.2 x 7.2 x1.52 cm) can easily

be worn around the neck with lanyards, making them easy to carry[24]. The display is about 7.4 x 5.5 cm (3.6″ diagonal), which is roughly equivalent to current smartphones (e.g., iPhone). Automatic standby and automatic reduction of screen brightness were disabled.

*Program Used:* The actual program to display the information and allow bookmarking was written by me. It is essentially a webpage that is displayed on the PDA using the Opera Mobile Browser. The device was connected to the Internet, specifically a server of the institute, via wireless LAN. Javascript, PHP and SQL were used to create the interface and to personalize the information display. Due to the small size of the exhibition (four walls), a visual interface with exhibit wall representation was chosen. Pictures (image maps) of the exhibition walls were displayed on the device, and the exhibits could be selected by simply touching the images of the exhibits on the PDA (see Figure 2 on page 58). Visual interfaces are easy to understand, and are consequently used in many museum tours. A visual interface "allows visitors to quickly and easily select objects that interest them" (Proctor, 2005, p. 11, citing Woodruff, Aoki & Thorton, 2001). Manual selection also gives visitors control over the technology, which is important for their well-being (Norman, 1993) and, in comparison to automatic display of information, it allows for using visitor selections as indicators of interest (cf. Mitchell, 1993).

The advantages of using PDAs and a website program were that it closely resembles current mobile guides in museums in handling and appearance, was easy to program, and allowed easy creation of logfiles. Storing visitor actions on a server also allowed real-time monitoring of visitor activity. The experimenter could watch visitors' actions on a computer in another room that displayed the same content as was selected by the visitor on the device. Additionally, four surveillance cameras (each one covering one of the four walls) also allowed monitoring of the visitor in the exhibition without disturbing him or her (see Figure 4).

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24 One exciting idea was to use a PDA Armholder which would strap the PDA to the arm in the same position as a wristwatch. However, pilot tests indicated that this was much too uncomfortable — it is one thing to raise a lightweight watch for two seconds and read the time, but quite another to raise a 170 g PDA for several minutes reading text on it. For more information see http://www.ipsych.org/creative-projects/tinkering/pda-arm-holder/.
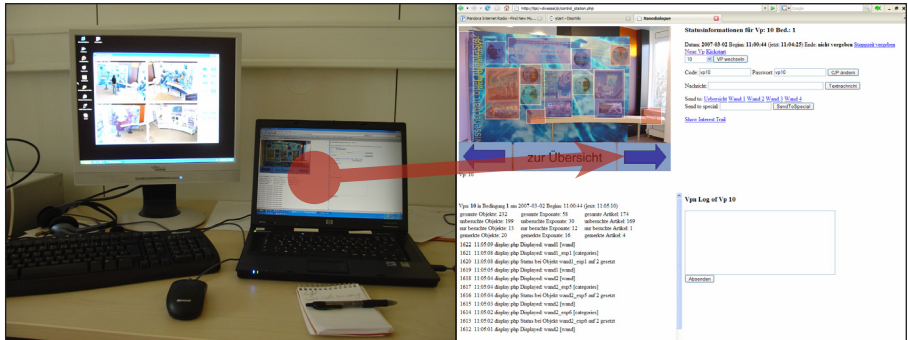
*left:* Monitor with the images of four surveillance cameras
and the control station; *right:* control station

*Figure 4:* Monitoring of the study participants in the exhibition in Study 1

Disadvantages were that the browser could not be secured against user errors, and constant wireless network access was needed for the device[25]. However, a status message was transmitted every 3 seconds by the device, showing on the experimenter's screen that the device was working. If the message failed to appear the experimenter could intervene and restore the device to its working function. In conclusion, the device was not "fool-proof" and unsuitable as a commercial stand-alone version, but very well suited for conducting experiments with it: It appeared to be a typical mobile guide for the visitors but allowed detailed logging of user actions for the experimenter. While a website "program" might sound untypical, it should be noted that providing information via web browsers on mobile devices is neither uncommon nor unexpected. For a detailed description of the program see http://www.ipsych.org/creative-projects/computer-programs/electronic-guidebook-program-1-js-php-sql/.

*Exhibition Website*

To allow visitors to access images of exhibits and the accompanying information, I created a website that contained all the information of the exhibition, pictures of every exhibit, and the additional information that was provided on the PDA to the additional-information groups. In addition, participants in the bookmark condition had

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25   During the course of the study, only one appointment with a participant had to be cancelled due to unexpected server downtime.

a list of bookmarked exhibits and information available. The website used DokuWiki (http://www.dokuwiki.org/dokuwi, a wiki engine made for small companies and single users, which is text-file based, fast, reliable, and has a lot of useful plugins) with the monobook layout template, giving it an appearance similar to Wikipedia (see Figure 5). Visitors had to log in to see the website, allowing logfile analysis of its usage: Logins and all page accesses were logged.
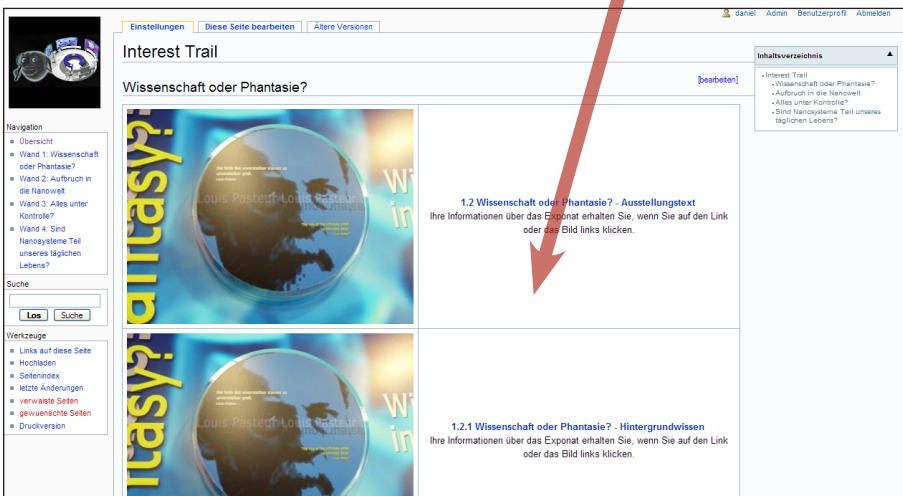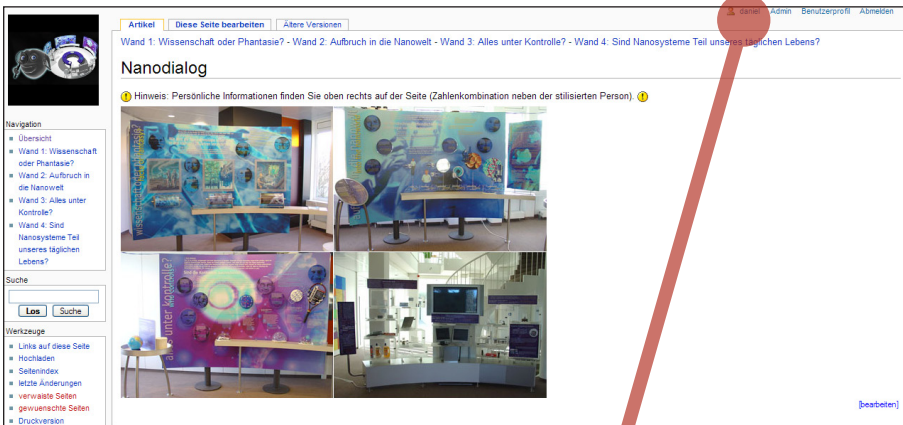


*top:* Homepage; *bottom:* a click on the profile name shows the bookmarked exhibit information (bookmark conditions only)

*Figure 5:* Exhibition Website in Study 1

## Dependent Measures

Participants answered three tests: a pretest one week prior to the visit; a posttest immediately after the visit; and a follow-up test, three weeks after the visit. All three tests were conducted using an online electronic questionnaire, the pre- and followup-test on the participants computer, the posttest on a computer at the institute. The complete list of the questions is detailed in the Appendix A from page 203 on.

*Pretest measures:* Participants were asked whether they had already seen the exhibition (due to its prior showing at the "Deutsches Museum München"), the number of museum visits per year, including the reason of the visit and the types of museums visited, interest in nanotechnology and paired comparison (see "reoccurring measures" below), and for free comments.

*Posttest measures:* Immediately after the visit, participants were asked about interest and elaboration (deep learning strategies, situational interest scale for the exhibition and for the topic, strength of engagement with the exhibition, interest in nanotechnology and paired comparison (see "reoccurring measures" below), whether something raised their interest in the exhibition), knowledge (self-reported knowledge prior and after the visit, free recall, multiple choice knowledge test regarding nanotechnology by Mayr, 2009), evaluation of the device (including novelty effect, media literacy, satisfaction with and evaluation of the device, willingness to use the device during future visits, price they would be willing to pay to rent the device, comparison with other kinds of guides, wish list of desired features, remarks about the device, experience with mobile guides), media usage (internet access and usage, knowledge about and usage of Wikipedia, confidence in Wikipedia), evaluation of the exhibition (curator-visitor distance, previous visits of the exhibition, visit of similar exhibitions), conditions of the visit (voluntariness of the visit, preparation of the visit, external time pressure), socio-demographic variables (age, gender, educational level), and remarks regarding the questionnaire.

*Follow-up test measures:* Three weeks after the visit, participants were asked for their engagement in the topic, usage of the exhibition website, knowledge exchange with

others, evaluation of the exhibition, interest in nanotechnology and paired comparison (see "reoccurring measures" below), knowledge test (free recall), presumed goals of the study, and for remarks regarding the study or the questionnaire.

*Logfiles:* PDA usage and Website usage produced logfiles with visitor ID, date, time, and kind of information accessed.

*Reoccurring measures:* To compare interest over the three measurements, two measures were repeated in each test. Participants were asked for their interest in nanotechnology on a scale from 1 to 10. This one-item measure was used for a simple comparison of their interest in the topic of the exhibition at the three times. However, as this kind of measurement might produce tendency to be interested in anything (see page 25), paired comparison was also used (before the one-item measure): participants are confronted with all possible binary combinations of items and have to choose the item they like more in each comparison. They cannot select both, thus forcing them to choose and to give clear preferences for individual items. To cover a wide range of topics while keeping the amount of comparisons low[26], the ten divisions of the "Outline of Knowledge" in the *Propædia* were used (the first of three parts of the 15th edition of *Encyclopædia Britannica*, Adler, 1974). These divisions are: "Matter and Energy", "The Earth", "Life on Earth", "Human Life", "Human Society", "Art", "Technology", "Religion", "The History of Mankind", and "The Branches of Knowledge". Each division (with the names of its major subjects for clarification) was compared with all other divisions. Thus it was possible to determine few but exhaustive domains of interest. Influences on interest should lead to changes in two divisions: in "Matter and Energy" (due to the major subjects of Physics and Chemistry) and in "Technology". The measure might be too abstract to be influenced by a single confrontation with an exhibition about nanotechnology, although quite differentiated ratings were possible using a 6-point scale, with the two items at the end points. A rating would consequently result in either one, two, or three points for one item and (always) zero points for the other, with a maximum number of points of 27 (3 points in each of the 9 ratings)

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26   Ten items for pairwise comparisons result in 45 comparisons per test (amount of items * (amount of items - 1)) / 2.

and a minimum number of zero (the other item is always favored).

Consequently, the following measures of supported interest are available:

*Self-reported interest:* Visitors should report higher interest in the topics of the exhibition after they have seen it.

*Usage of additional information:* Visitors should use the available information on the mobile device if the information suits their interests.

*Learning:* Multiple-choice and free-recall test are used, and visitors with higher interest should show higher learning. However, measuring learning with multiple choice and free recall in museums was criticized (see page 17), so self-reports and visit duration are also included as indicators of learning.

*Engagement:* Supported interest should lead to higher engagement with the exhibits.

*Visit duration:* Time on task (here: visit duration) can also be used as an indicator of interest and of learning.

*Subsequent actions after the visit:* Supported interest might lead visitors to discuss the visit with other people, e.g., fellow visitors or persons who have not been in the exhibition. They might also read related books, listen more closely to related news reports or watch related TV programs (e.g. Donald, 1991). They might also review information, e.g., visit the webpage of the exhibition or revisit the exhibition.

## Procedure

The study was conducted between March and May 2007. Study participants received a link to the pretest online questionnaire one week before their scheduled visit. They also received information about the study, i.e., that they would be visiting a small exhibition and that their visit would be recorded. On the day of their visit, participants were randomized into one of the four conditions and received a PDA whose program offered the functions corresponding to the condition they were in (see "Design" on page 57 and "Mobile Device and Program Used" on page 61). The use of the device was explained to them, and participants had the opportunity to test it outside the exhibition at one of the pictures in the lobby which was similarly represented on the device as the later exhibits in the exhibition. When participants were ready and showed that

they could use the device, they were free to explore the exhibition at their own leisure. Appointments were scheduled such that only one visitor was in the exhibition at the same time. After they were finished with the exhibition, visitors returned the device and filled out the posttest questionnaire in a separate room. Then visitors were thanked and received their compensation. They were also handed a small, museum ticket-like card that contained their personal login information for the exhibition website. Participants were free to visit the website after they left. Three weeks later, they received an eMail with the link to the follow-up questionnaire.

# Results

## General Results and Preconditions for Further Analysis

### Sample

In total, 64 study subjects participated in the study, visited the exhibition, and filled out the pre- and posttest. Two participants had to be excluded due to technical (server-side) problems, leaving a sample of 62 participants. In the follow-up test three weeks after the visit, the number of participants dropped to 52. The average age was 25.32 years ($SD = 4.64$) with 17 male (27.42%) and 45 female (72.58%) participants. While there are significantly more women than men participating ($\chi^2(1, n = 62) = 12.645$, $p < .001$), neither the distribution to the conditions ($\chi^2(3, n = 62) = 7.460$, $p = .059$, although cell frequencies were too low), nor to the factors (additional information vs. no additional information: $\chi^2(1, n = 62) = 2.026$, $p = .155$; bookmark vs. non-bookmark: $\chi^2(1, n = 62) = 0.729$, $p = .393$) are significant. Participants were highly educated, as expected an experiment conducted at a university: All had at least a diploma from German secondary school qualifying for university admission, and 14 had a degree from a university or from a university of applied sciences. Consequently, the sample fit the target audience of the exhibition but was very homogeneous.

Almost all (59 of 62; the remaining three are missing values) participants had visited a museum during the last year, with 4.0 visits on average ($SD = 2.52$). They often

visited museum while on vacation ($t(61) = 5.344$, $p < .001$, one sample $t$ test against scale midpoint of 4) or when interested in a particular exhibition topic ($t(61) = 4.854$, $p < .001$) — however, they rarely visited museums of natural science or technology ($t(61) = -5.216$, $p < .001$). Their prior interest in nanotechnology was rather low ($M = 4.26$, $SD = 2.30$, on a 10-point scale ranging from "not at all" to "absolutely") with no statistically significant differences across the four groups. The average of subjective knowledge prior to the visit (measured in the post-test to give participants a better idea what they could have known) was between "very little" and "little" ($M = 2.24$, $SD = 0.99$). However, groups did differ in statistically significant ways, $F(3, 30.942) = 3.74$, $p = .021$ (Welch Robust Test of Equality of Means), with Tamhane post-hoc test showing group c (no additional information but bookmarking, $M = 1.69$, $SD = 0.704$) as having significantly less knowledge than group d (no additional information and no bookmarking, $M = 2.73$, $SD = 1.1$, $p = .027$). However, numerical differences were low ("very little" compared to "little"). Descriptively similar differences that did not reach significance can be found for prior interest and amount of museum visits per year (c: $M = 3.5$, $SD = 2.31$; d: $M = 5.13$, $SD = 2.75$). While the conditions seem comparable and randomization seems to have been successful, group d (no additional information, no bookmarking) tended to be more interested, knowledgeable, and museum experienced. However, given the minimal absolute differences this effect can probably be neglected.

Regarding the conditions of the visit, participants liked visiting the exhibition, had much to do, visited the exhibition on their own free choice, did not prepare themselves well for the visit and were under no time pressure when visiting the exhibition. There also was a tendency that they would not have visited the exhibition without participating in the study (see Table 4). They perceived their visit as self-determined, meaningful, reasonable and entertaining.

On a 10-point scale, visitors indicated that they would also recommend the exhibition to others ($M = 7.58$, $SD = 2.20$, $t(51) = 6.810$, $p < .001$; see Figure 6) but were divided whether they would want to visit it again (bimodal distribution with $M = 5.42$, $SD$

|  | M | SD | t Test |
|---|---|---|---|
| **Condition of the visit** | | | |
| I liked visiting the exhibition | 5.55 | 1.00 | $t(61) = 12.157, p < .001$ |
| I have much to do at the moment | 4.69 | 1.21 | $t(61) = 4.517, p < .001$ |
| I am here out of my free choice | 6.15 | 1.29 | $t(61) = 13.082, p < .001$ |
| I have prepared myself well for this visit | 1.48 | 0.86 | $t(61) = -22.944, p < .001$ |
| I am currently under time pressure | 2.53 | 1.38 | $t(61) = -8.401, p < .001$ |
| I would have visited the exhibition without this study participation | 3.60 | 1.70 | $t(61) = -1.864, p = .067$ |
| **Perception of the visit** | | | |
| self-determined vs. other-determined | 3.21 | 2.01 | $t(61) = -8.975, p < .001$ |
| meaningful vs. without meaning | 4.05 | 1.45 | $t(61) = -7.864, p < .001$ |
| reasonable vs. senseless | 2.92 | 1.30 | $t(61) = -15.668, p < .001$ |
| boring vs. entertaining | 7.06 | 1.92 | $t(61) = 6.404, p < .001$ |

Conditions of the visit: 7-point Likert scale from 1 (not at all) to 7 (absolutely). *t* Test against the scale midpoint of 4.

Perception of the visit: 10-point semantic differential, points are given in table (left 1, right 10). *t* Test against the scale midpoint of 5.5.

*Table 4:* Conditions and perception of the visit in Study 1

= 2.61; see Figure 7). Taken together, the study sample consists of young students (a majority of them are female). They are museum experienced (but not especially regarding science and technology museums), with low interest in and prior knowledge of the topic. While they had much to do in general, they took the time for the visit and regarded it as a free choice visit they liked and found meaningful, but would probably not have visited the exhibition without participating in the study.
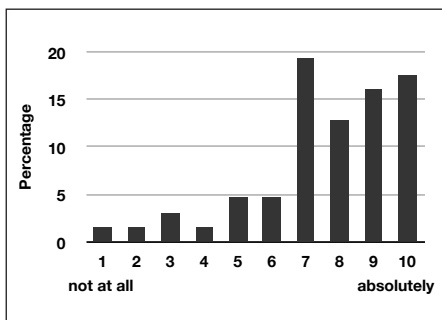


*Figure 6:* Recommendation of the exhibition to others
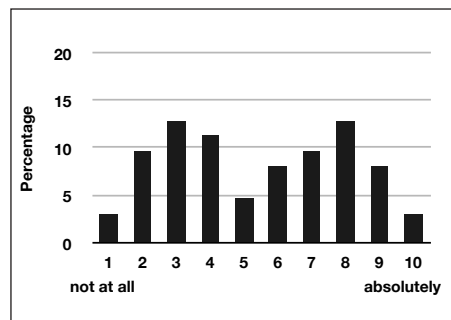


*Figure 7:* Willingness to visit the exhibition for a second time

## Manipulation Check

*Did the exhibition elicit interest?* All (62/62) participants stated in the posttest that they found something of interest in the exhibition. The logfiles of the device showed that the additional information groups had marked 30.48 ($SD$ = 23.71) "objects" of interest: 9.77 ($SD$ = 7.4) exhibits and 20.71 ($SD$ = 19.53) additional information texts. The groups without additional information had marked 25.87 ($SD$ = 10.87) exhibits as interesting. Whether additional information had been available or not, there is no difference in the number of objects found interesting by the participants, $t(42.078) = 0.985$, $p = .330$. The groups with additional information marked significantly less exhibits as interesting ($t(60) = -6.813$, $p < .001$) and concentrated on the additional information texts. But in total, all groups found the visit equally interesting in regard to the number of "objects" marked interesting, albeit with different foci.

*Did the additional information conditions use the device?* As a museum visit takes place in an informal setting, participants were free to use the device as they liked. In the additional information conditions, the average number of accessed additional information was 73.84 out of 174 ($SD$ = 41.83). Usage varied between 11 and 166 additional information texts accessed. The distribution of usage is approximately normal, with a skewness of 0.661 ($SD$ = 0.42, z = 1.57, $p = .058$) and a kurtosis of -0.184 ($SD$ = 0.82, z = -0.22, $p = .587$), Kolmogorov-Smirnov $D(31) = 0.104$, $p = .2$; Shapiro-Wilk $D(31) = 0.95$, $p = .156$.

*Evaluation of the device:* The device was rated as new (additional information: $M = 6.06$, $SD = 1.39$, $t(30) = 8.276$, $p < .001$; no additional information: $M = 5.77$, $SD = 1.56$, $t(30) = 6.314$, $p < .001$; one-sample $t$ Test against 7-point scale middle of 4; only 3 participants owned a PDA or Smartphone). However, the device was considered to be very easy to use (in the additional information conditions: $M = 8.65$, $SD = 1.43$, on a scale from 1 to 10, $t$ Test against 5.5: $t(31) = 12.271$, $p < .001$; in the conditions without additional information: $M = 9.2$, $SD = 0.98$, $t(31) = 20.98$, $p < .001$). Visitors also used the device for the intended purpose and not for "playing around with it" ($M = 8.63$, $SD = 1.50$, $t(61) = 16.472$, $p < .001$, one-sample $t$ Test against 10-point scale middle of 5.5). Evaluation

of the device regarding hardware, software, interface, weight, handling, readability, quality of information, usefulness of information, and disturbance free integration in the visit, was good for participants with additional information (combined scale with Cronbach's α of .758: $M = 3.98$, $SD = 0.42$, $t(30) = 12.82$, $p < .001$, one sample $t$ Test against 5-point scale middle of 3).

*Usefulness of the device for the additional information groups:* The groups who had access to additional information on the PDA would like to use use the device during a normal museum visit ($M = 7.45$, $SD = 2.16$, $t(30) = 5.036$, $p < .001$, one-sample $t$ Test against 10-point scale middle of 5.5).

In comparison with other possible companions, the device is preferred to flyers, brochures, catalogues, visits without any guide, and other electronic guides, rated similar to guided tours by museum guides and audioguides, but it is rated lower than a knowledgeable human companion (see Table 5).

In summary, interest did occur in the exhibition for all participants and the device was well used and accepted.

|  | M | SD | t Test |
|---|---|---|---|
| flyers vs. device | 7.26 | 2.59 | $t(30) = 3.773$, $p = .001$ |
| brochures vs. device | 6.94 | 2.41 | $t(30) = 3.32$, $p = .002$ |
| catalogues vs. device | 6.81 | 2.37 | $t(30) = 3.066$, $p = .005$ |
| visits without any guide vs. device | 7.45 | 2.52 | $t(30) = 4.321$, $p < .001$ |
| other electronic guides vs. device | 6.55 | 2.26 | $t(30) = 2.579$, $p = .015$ |
| guided tours by museum guides vs. device | 5.68 | 2.82 | $t(30) = 0.350$, $p = .729$ |
| audioguides vs. device | 6.23 | 3.02 | $t(30) = 1.339$, $p = .191$ |
| knowledgeable human companion vs. device | 3.29 | 2.47 | $t(30) = -4.99$, $p < .001$ |

10-point semantic differential, endpoints are given in table (left 1, right 10). $t$ Test against the scale middle of 5.5.

*Table 5:* Comparison of other types of visitor information
and the device used in Study 1

# Question 1: What Makes an Exhibit Interesting?

The first question is addressed in detail in Study 2, although the following results of Study 1 are relevant for this question in a wider context.

*Most interesting exhibit categories:* The exhibition "Nanodialogue" consisted predominantly of text. Of a total number of 58 exhibits, 34 "exhibits" (58.62%) were textual information on the exhibition wall, often combined with a few images. A wall with 19 physical exhibits (24.14%) and 3 additional physical exhibits (5.17%) made actual exhibits the second largest category (29.31%). Additionally, there were three exhibits that consisted of images and information printed on the outside of a rotating tube (5.17%), two stand-alone exhibits on little tables (3.45%), one (literally) "hands-on" exhibit where visitors could get the measurement of their hand in nanometer (1.72%), and a book about Nanotechnology (1.72%). Table 6 shows how often these different categories were marked as interesting. While all categories except the book were around 30%, only the rotating tubes were marked with a much higher frequency on average (48.39%).

*Frequency of exhibits marked as interesting:* Figure 8 shows the frequency with which exhibits were marked as interesting. While some exhibits were marked as interesting by over 50% of the visitors, no single exhibit was interesting for everyone, but there were a few exhibits which were interesting for very few visitors.

*Spatial Patterns:* If the average number of marked exhibits is compared across the four exhibit walls, the percentages are quite similar, with 27.79%, 31.45%, 29.61%, and

| Exhibits | Mean Percent | Mean | *n* | percentage |
|---|---|---|---|---|
| rotating tubes | 48.39 | 30.0 | 3 | 5.17 |
| stand-alone exhibits | 32.26 | 20.0 | 2 | 3.45 |
| physical exhibits | 31.02 | 19.2 | 17 | 29.31 |
| hands-on | 30.65 | 19.0 | 1 | 1.72 |
| textual information | 28.29 | 18.0 | 34 | 58.62 |
| book | 24.19 | 15.0 | 1 | 1.72 |
| Total | | | 58 | 100.00 |

*Table 6:* Exhibit Distribution
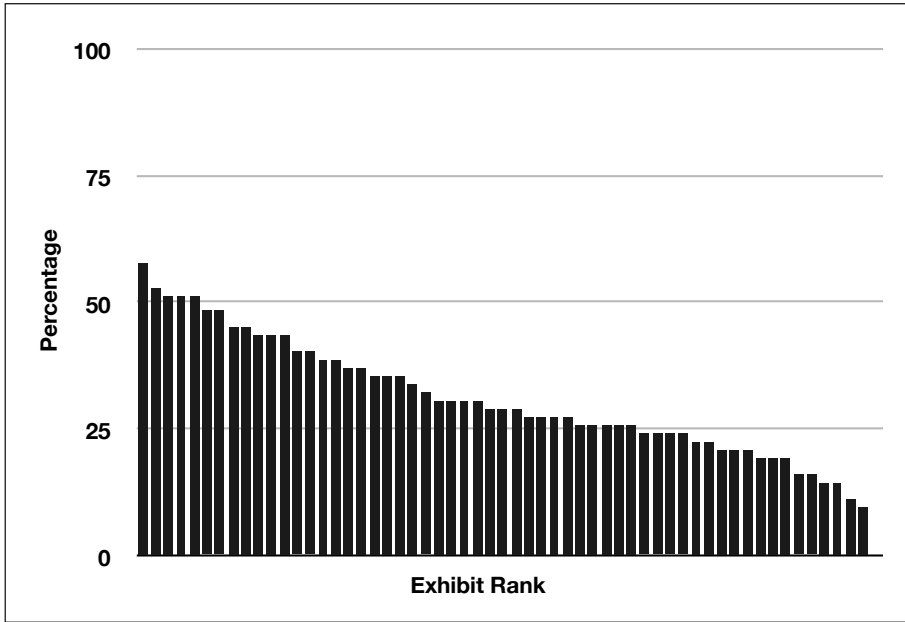
*Figure 8:* Percentage of exhibits marked as interesting by all visitors

33.11% for walls one to four, respectively. Similar distributions are found on a lower level for the average number of information texts marked as interesting by the additional information groups, with 14.23%, 10.48%, 13.13%, and 10.3% for walls one to four respectively.

Given the small sample size of 62 participants in total and the single topic of the exhibits (nanotechnology), further analysis of what makes exhibits interesting will be addressed in study 2, where a larger sample size and a more heterogeneous exhibition is available for analysis.

## Question 2: (How) Can Interest Be Supported During the Museum Visit?

*Comparison of the Groups*

To increase power, the second factor (bookmarks available after the visit or not) is neglected for question one and two. Participants in the bookmark condition were informed about the availability of the exhibits they had marked as interesting after the visit but prior to the posttest. Consequently, behavior variables of the visit are not influenced by this factor and groups a and b (additional information) and groups c and d (no additional information) can be collapsed. Regarding the answers in the posttest I propose that the groups can be similarly merged: While the information about the availability of the marked exhibits as bookmarks was available to the participants to allow questions about their evaluation of such a function in the posttest, questions related to the visit itself should not be influenced by this factor. However, it probably would have been better to either give the bookmarking information prior to the visit to assess its influence on visitor behavior during the visit or give it during the posttest after the questions about the visit had been answered by the participants. The wish to increase power in an experiment that could only be done with a few participants unnecessarily complicated the analysis.

*Interest Effects During the Museum Visit*

Does the availability of additional information have an effect on the indicators of supported interest?

*Use of additional information:* Of the total amount of 174 information texts (58 exhibits with three texts each), visitors with additional information accessed 73.84 texts of additional information ($SD = 41.83$) on average. Thus, on average, 42.44% of the available information was accessed. Regarding the exhibits itself, in 23.75% of the cases, visitors accessed only one, in 13.74% exactly two, and in 13.46% they accessed all three of the information texts that were available for each particular exhibit. This means that,
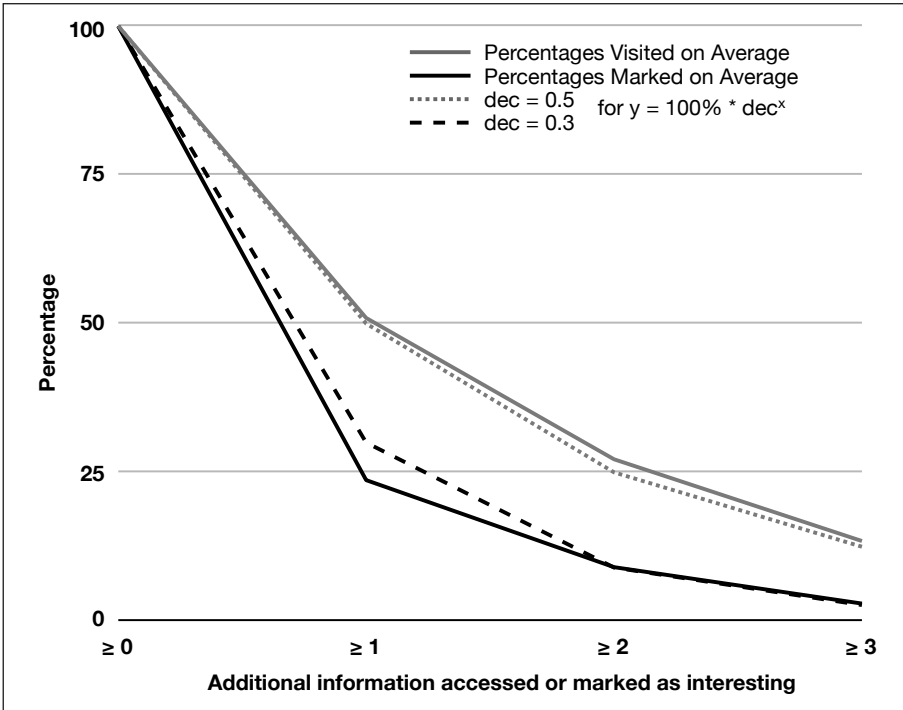
*Example:* For one or more visited information on average at an exhibit the empirical value is 50.95%. The decay function predicts as result 100% * 0.5¹ = 50%. For two or more visited information the empirical value is 27.20%, the decay function predicts 100% * 0.5² = 25%.

*Figure 9:* Amount of visited and marked additional information and exponential decay distribution

on average, at 50.95% of the exhibits[27], visitors accessed at least least one additional piece of information. The form of the cumulative distribution is interesting to note (see Figure 9): Given that in 50.95% of the cases (calculated with averages) participants accessed at least one additional piece of information, in 27.20% of the cases, they visited at least two, in 13.46% they visited all three, this behavior resembles a distribution that is similar to the half-life decay function. The amount of accessed information is the starting value (here: 100%) times 0.5 to the power of the number of information units. It becomes increasingly unlikely that visitors visit greater numbers of information texts. The distribution across the four exhibit walls is very similar to the total number of visited exhibits (see Figure 10). $\chi^2$-tests show no statistical difference — what was

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27   23.75 + 13.74 + 13.46 = 50.95
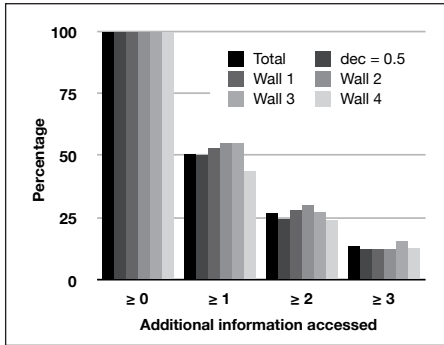
*Figure 10:* Average Percentage of Additional Information Visited per Exhibit
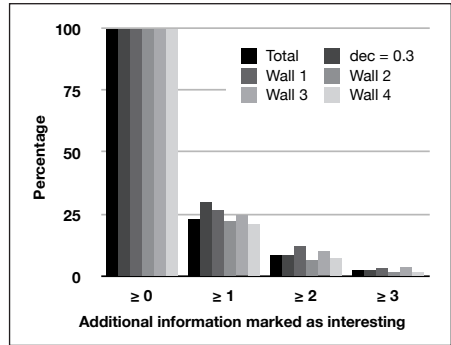


*Figure 11:* Average Percentage of Additional Information Marked as Interesting per Exhibit

found for the total exhibition was reflected at each of the four walls.

*Interest of additional information:* On average, 20.71 ($SD = 19.53$) additional information texts were marked as interesting. Usage patterns of the device show that the additional information marked as interesting by ai-visitors is partly focussed on individual exhibits. Whereas the non-ai-visitors could only mark exhibits, the ai-visitors could be more specific. On average, in 76,3% of the cases they marked none, in 14,62% one, in 6,12% two and in 2,95% all three additional pieces of information as interesting. Thus, the additional information is partly concentrated on individual exhibits, indicating a more localized interest. Given that at 23.69% of the exhibits[28], visitors marked at least one information of an exhibit as interesting, at 9.07% at least two, and at 2.95% all three, the cumulative distribution function is steeper. Here the value for the function is not 0.5 but 0.3 (see Figure 9 on page 76). It becomes increasingly unlikely that visitors mark greater numbers of information texts as interesting. As with the accessed exhibit information, the distribution across the four exhibits walls was very similar to the total amounts in marked objects (see Figure 11). $\chi^2$-tests show no statistical difference — what was found for the total exhibition was reflected at each of the four walls.

*Usage of Wikipedia:* Wikipedia was accessed by 75,76% of the additional information visitors during the visit. However, they did not like to use Wikipedia on the mobile

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28   14.62 + 6.12 + 2.95 = 23.69

|  | **M** | **SD** | **t Test** |
|---|---|---|---|
| use Wikipedia often | 4.87 | 1.43 | t(30) = 3.387, p = .002 |
| do only slightly trust it | 4.48 | 1.09 | t(30) = 2.468, p = .02 |
| think that it is free of errors | 2.55 | 1.67 | t(30) = -4.839, p < .001 |
| want to use it in a museum | 3.03 | 1.47 | t(30) = -3.661, p = .001 |
| think that a museum should rely solely on it | 5.97 | 1.40 | t(30) = 7.815, p < .001 |

Conditions of the visit: 7-point Likert scale from 1 (not at all) to 7 (absolutely). *t* Test against the scale middle of 4.

*Table 7:* Perception of Wikipedia by visitors in the "additional information" conditions

device. While the layout ("küken") made navigation on the PDA possible, visitors criticized that it was uncomfortable to use (as the Wikipedia text, unlike the additional information, was not adapted to it) and that the access was too slow. The latter was a problem of the internet connection Wikipedia required: The other additional information was in an SQL database on a local server which would rapidly provide the selected information to the one user who accessed it, but Wikipedia was on an external server on the Internet that had to be shared with many other users.

*Evaluation of Wikipedia:* When asked how often they used Wikipedia privately, "additional information" participants stated that they used Wikipedia often, but only slightly trusted it and thought that it was not free of errors. However, their private use of Wikipedia did not transfer to museum use: They neither wanted to use it in a museum nor did they think that a museum should rely solely on it (see Table 7 on page 78).

*Visit duration:* The availability of the additional information did have a very large effect on visit duration. On average, visitors with additional information stayed in the exhibition for 1 hour, 1 minute and 18 seconds ($SD$ = 00:22:13), while visitors without additional information stayed 33 minutes and 9 seconds ($SD$ = 00:11:08), which is statistically highly significant, $t(44.195) = 6.306$, $p < .001$, $\eta^2 = 0.4$). If a two-way ANOVA is calculated with bookmarks as second factor, the only statistically significant effect is the main effect for additional information ($F(ai)(1, 58) = 38.385$, $p < .001$, partial $\eta^2 = .398$), but not bookmarks ($F(bm)(1, 58) < 1$, *n.s.*), nor interaction ($F(1, 58) < 1$, *n.s.*). The visit duration of participants with additional information correlates in a statistically significant way with the amount of additional information that was accessed ($r = .663$,

$n = 31$, $p < .001$) and marked as interesting ($r = .404$, $n = 31$, $p = .024$). This indicates that the longer duration was actively used by the participants to read the additional information and mark it as interesting.

*Evaluation of the exhibition:* Visitors with additional information also rated the exhibition more positively regarding the available information ($M(ai) = 3.90$, $SD(ai) = 0.651$, $M(nai) = 3.52$, $SD(nai) = 0.68$, $t(60) = 2.295$, $p = .025$) and size ($M(ai) = 3.90$, $SD(ai) = 0.65$, $M(nai) = 3.45$, $SD(nai) = 0.77$, $t(60) = 2.498$, $p = .015$). They also agreed more strongly that the exhibit designers wanted to convey knowledge ($M(ai) = 5.90$, $SD(ai) = 0.87$, $M(nai) = 5.26$, $SD(nai) = 1.18$, $t(60) = 2.447$, $p = .017$) than visitors without additional information[29].

*Self-reported interest:* Interest in nanotechnology was assessed in the posttest with a scale of 18 items (Cronbach's α: .923) but no difference in self-reported interest between the additional information and no additional information visitors was found ($M(ai) = 4.53$, $SD(ai) = 0.67$, $M(nai) = 4.68$, $SD(nai) = 0.96$, $t(53,554) = -0.735$, $p = .466$). Similarly, a two-way ANOVA with bookmarks as second factor did not lead to statistically significant differences either ($F(\text{Interaction})(1, 58) < 1$, *n.s.*; $F(ai)(1, 58) < 1$, *n.s.*; $F(bm)(1, 58) < 1$, *n.s.*). The single-item question "Are you interested in nanotechnology?", which was asked in the pre-, post- and followup-test, did not lead to significant differences between the conditions either (see "Interest over Time" on page 89). The 18-item scale and the single-item questions (at pre, post and follow-up) did correlate highly with each other; all correlations were significant at the .01 level.

*Engagement with the exhibition:* A 9-item scale with Cronbach's α of .762 was used to assess the deeper processing of the exhibition content. There were no statistically significant differences between the depth of engagement between additional information ($M = 4.35$, $SD = 0.72$) and no additional information visitors ($M = 4.17$, $SD = 0.83$, $t(60) = 0.929$, $p = .357$). A single item asking for strength of engagement with the exhibition ranging from 1 to 10 did not result in a statistically significant difference either ($M(ai)$

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29   If a two-way ANOVA is used instead of a *t* Test to include the availability of bookmarks as a second factor, only the main effect for additional information is significant ($F(ai)(1, 58) = 5.797$, $p = .019$) but not the main effect for bookmarking ($F(bm)(1, 58) < 1$, *n.s.*), nor the interaction ($F(1, 58) < 1$, *n.s.*).

= 7.84, $SD$(ai) = 0.78, $M$(nai) = 7.74, $SD$(nai) = 1.83, $t$(40.573) = 0.272, $p$ = .787).

*Learning — Self-Reports:* No differences in self-reported learning between additional information and no additional information visitors were found regarding the estimated knowledge prior to the visit and after the visit of the exhibition. A one-way repeated measures ANOVA with additional information as between-subject factor and time (prior vs. post visit) as repeated factor showed no differences for the conditions ($F$(ai)(1, 60) = 1.117, $p$ = .295, partial $\eta^2$ = .018) and no significant interaction ($F$(IA) (1, 60) < 1, *n.s.*, partial $\eta^2$ = .014). However, there was a statistically significant effect for time ($F$(time)(1, 60) = 219.65, $p$ < .001, partial $\eta^2$ = .785). Participants thought they knew more about the topic after the visit in both conditions.

*Learning — Multiple Choice Knowledge Test:* A multiple choice knowledge test was conducted to assess knowledge about the exhibition. While a comparison of the knowledge of the additional information between the two groups (ai vs. non-ai) would make no sense, it would show whether the additional information did distract from the exhibition itself or whether both conditions had learned equally from the exhibition itself (as measured by the knowledge test). A *t* Test found no differences in the score of the multiple choice test between the two visitor groups ($t$(60) = -0.139, $p$ = .89). The additional information did not have a negative effect on the understanding of the exhibition topic.

## Question 3: (How) Can Interest Be Supported After the Museum Visit?

### Evaluation of Bookmarking

*Evaluation of the available bookmark feature by the bookmark groups:* Visitors who had bookmarks available were asked how they liked this function. They agreed that bookmarks have a value compared to a complete list of all exhibit information, make sense, and are not too much effort during their creation compared to their usefulness. However, the feature did not motivate them to engage inthe topic after the visit, nor was it used it as a "thread" to tell others about their visit (see Table 8 on page 81).

| | M | SD | t Test |
|---|---|---|---|
| **evaluation of exhibit bookmarks by the bookmark groups** | | | |
| bookmarks have a worth compared to a complete list of all exhibit information | 2.61 | 0.83 | t(27) = -2.499, p = .019 |
| are reasonable | 3.93 | 1.05 | t(27) = 4.673, p < .001 |
| are too much effort during their creation compared to their utility | 2.46 | 1.04 | t(27) = -2.737, p = .011 |
| motivate to occupy with the topic after the visit | 2.32 | 1.19 | t(27) = -3.022, p = .005 |
| used it as a "thread" to tell others about the visit | 2.25 | 1.21 | t(27) = -3.292, p = .003 |
| **evaluation of bookmarks in general by all visitors** | | | |
| would like to have them available | 3.37 | 1.09 | t(51) = 2.428, p = .019 |
| would have a look at them | 3.48 | 1.11 | t(51) = 3.12, p = .003 |
| would use them | 2.56 | 1.13 | t(51) = -2.829, p = .007 |
| think they are reasonable | 3.67 | 0.90 | t(51) = 5.384, p < .001 |
| would motivate them to further occupy themselves with the topic | 3.54 | 0.85 | t(51) = 4.563, p < .001 |
| would be a good starting point for further occupation with the topic | 3.77 | 0.85 | t(51) = 6.492, p < .001 |
| would prefer it to an exhibition catalogue | 3.37 | 1.19 | t(51) = 2.217, p = .031 |
| would not want to create it before the visit via the museum webpage | 2.17 | 1.00 | t(51) = -5.937, p < .001 |

Conditions of the visit: 5-point Likert scale from 1 (not at all) to 5 (absolutely). *t* Test against the scale middle of 3.

*Table 8:* Evaluation of Bookmarking

*Evaluation of bookmarks in general by all visitors:* Participants were also asked how they evaluated bookmarks in general. They agreed that they would like to have them available, would have a look at them, would use them, thought they make sense, would motivate them to further engage in the topic, would be a good starting point for further occupation with the topic, would prefer it to an exhibition catalogue, and that they would not want to create it on the museum webpage before the visit (see Table 8). The only difference between the two gropus (bookmarks vs. no bookmarks), was that the bookmark group valued the feature more (bookmarks: $M = 2.46$, $SD = 0.79$; no bookmarks: $M = 3.08$, $SD = 0.97$; $t(50) = -2.526$, $p = .015$).

In summary, bookmarking is "nice to have" for later in case one happens to need it, but it does not motivate visitors to engage further in the topic. While visitors think

that in general, bookmarks would motivate them to further engagement, in the study it did not have an effect, and those who had them available disagreed that bookmarks did have an motivational effect.

## Use of the Exhibition Webpage After the Museum Visit

The exhibition webpage was rarely used. According to the logfiles, only 9 of the 62 participants visited the webpage, 5 had bookmarks available on the page and 4 did not. It does not seem that there are any differences in webpage usage between those visitors with bookmarks and those without. The webpage was only accessed by those who had stated in the follow-up questionnaire that they wanted to further engage in the topic (6/9) or were not sure about it (3/9), not by those who said that they did not want to engage in it any more. On average, the 9 users of the webpage stayed for 2 minutes and 8 seconds, accessing 5.22 pages (including the main page). Although all participants had the organizational and technical prerequisites to use the webpage (all indicated they were online at least once a week, and 88.7% had private, 56.1% work, 8.1% mobile internet access), the webpage was used by only 14.5% of the visitors.

## Usage of the Bookmarks After the Museum Visit

Of the 5 visitors who had bookmarks available, 3 accessed their bookmark page. However, usage was too low for any statistical analysis.

## Reasons for Low Usage of Webpage

When asked in the follow-up test, why participants had not used the webpage, 26 said they did not have the time, 8 had forgotten the webpage, 6 were not interested, 3 said that the exhibition had satisfied their interest, 2 had inexplicably encountered technical problems, 2 had lost their login information, and one had mistaken the webpage for Wikipedia.

## Knowledge Communication After the Museum Visit

*Self-reported knowledge communication after the visit:* Visitors were asked in the follow-up test, whether they had talked to others after the visit, separately for in people they knew before the visit and those they did not, and people who also had visited the exhibition and those who had not. For each of these four groups, two-way ANOVAs were calculated with the availability of additional information and bookmarks as factors. However, no statistically significant effects of additional information, bookmarking, or interaction effects were found (see Table 9). The mean values and standard deviations show that knowledge communication was rare and even non-existeant with some communication partners, and that the variance was very small. Given these circumstances, it is not surprising that no statistically significant differences were found.

*Preparation and follow up of museum visits:* Why did participants talk so little about the exhibition? Answers to the question how visitors prepare themselves for a visit and what they do after a visit give insight why the bookmarks did not have an effect. According to visitors' answers to the way they prepare and follow up their museum

| | additional information | | no additional information | | Total | | F Test (2 way ANOVA) |
|---|---|---|---|---|---|---|---|
| | book-marks | no book-marks | book-marks | no book-marks | book-marks | no book-marks | |
| *n* | 14 | 12 | 14 | 12 | 28 | 24 | |
| previously known non-visitors | 3.57 (1.16) | 3.08 (1.44) | 3.5 (1.65) | 2.92 (1.31) | 3.54 (1.40) | 3.0 (1.35) | $F(IA)(1, 48) < 1$, *n.s.* $F(ai)(1, 48) < 1$, *n.s.* $F(bm)(1, 48) = 1.879$, $p = .177$ |
| previously known visitors | 1.57 (1.28) | 1.58 (0.99) | 1.43 (0.94) | 1.50 (1.17) | 1.50 (1.11) | 1.54 (1.06) | $F(IA)(1, 48) < 1$, *n.s.* $F(ai)(1, 48) < 1$, *n.s.* $F(bm)(1, 48) < 1$, *n.s.* |
| previously unknown non-visitors | 1.21 (0.58) | 1.75 (1.22) | 1.29 (0.83) | 1.25 (0.62) | 1.25 (0.70) | 1.50 (0.98) | $F(IA)(1, 48) = 1.502$, $p = .226$ $F(ai)(1, 48) < 1$, *n.s.* $F(bm)(1, 48) = 1.150$, $p = .289$ |
| previously unknown visitors | 1.14 (0.54) | 1.08 (0.29) | 1 (0) | 1 (0) | 1.07 (0.38) | 1.04 (0.20) | $F(IA)(1, 48) < 1$, *n.s.* $F(ai)(1, 48) = 1.713$, $p = .197$ $F(bm)(1, 48) < 1$, *n.s.* |

6-point scale: 1 = not at all, 2 = very little, 3 = little, 4 = medium, 5 = much, 6 = very much
IA = interaction, ai = additional information, bm = bookmarks

*Table 9:* Knowledge communication after the visit in Study 1

|  | M | SD | t Test |
|---|---|---|---|
| **Preparation** | | | |
| talk to their fellow visitors about the exhibition | 5.10 | 0.98 | $t(51) = 8.104, p < .001$ |
| read books | 3.17 | 1.28 | $t(51) = -4.662, p < .001$ |
| talk to other people who do not visit the exhibition | 2.96 | 1.39 | $t(51) = -5.404, p < .001$ |
| use Wikipedia | 3.00 | 1.69 | $t(51) = -4.262, p < .001$ |
| use other websites | 2.98 | 1.48 | $t(51) = -4.982, p < .001$ |
| **Visit Follow Up** | | | |
| talk to persons who were with them in the exhibition | 5.12 | 1.01 | $t(50) = 7.88, p < .001$ |
| use the museum webpage | 3.04 | 1.54 | $t(50) = -4.468, p < .001$ |
| talk with non-fellow-visitors | 3.55 | 1.53 | $t(50) = -2.109, p = .04$ |
| use the newspaper | 3.49 | 1.43 | $t(50) = -2.54, p = .014$ |
| use Wikipedia | 2.94 | 1.75 | $t(50) = -4.325, p < .001$ |
| use other websites | 2.82 | 1.48 | $t(50) = -5.68, p < .001$ |

Conditions of the visit: 7-point Likert scale from 1 (not at all) to 7 (absolutely). One-Sample $t$ Test against the scale middle of 4.

*Table 10:* Preparation and Followup of Museum Visits

visits, visitors often prepare their visits by talking to their fellow visitors about the exhibition. They rarely use books, talk to other people who do not visit the exhibition, or use Wikipedia or other websites. After the visit, they also often talk to the persons who were in the exhibition with them. But they rarely used the museum webpage, rarely talked with non-fellow-visitors, rarely used the newspaper, and rarely used Wikipedia, or other webpages. For statistical values and tests see Table 10 on page 84. Consequently, while bookmarks for knowledge exchange are most useful for discussions with people who did not visit the exhibition because they can provide common ground, this rarely happens after the visit. Given that participants were alone in the exhibition during the experiment, visitors did not have fellow-visitors either who were in the exhibition with them. They probably did know a few others who had participated as well, but this was rare.

## Engagement in the Topic After the Museum Visit

*Interest in further occupation with the topic:* In the posttest, participants were asked five questions[30] regarding their desire to engage further in the topic, which were combined into a scale (Cronbach's α = .903). No differences were found between visitors with and without additional information (information: $M = 3.95$, $SD = 0.83$; no information: $M = 4.25$, $SD = 1.30$; $t(51.084) = -1.073$, $p = .288$) , nor did a two-way ANOVA with additional information and bookmarks as factors find any statistically significant differences ($F(IA)(1, 58) = .823$, $p = .368$; $F(ai)(1, 58) = 1.086$, $p = .302$; $F(bookmarks)(1, 58) < 1$, *n.s.*). Neither the availability of additional information nor the later availability of bookmarks increased participants' interest in engaging themselves further in the topic immediately after the visit.

*Subsequent actions after the visit:* In the follow-up test, participants were asked how much they had engaged in the topic after the visit. A two-way ANOVA (additional information yes/no vs. bookmarking yes/no) showed a significant main effect for additional information ($F(1, 48) = 4.373$, $p = .042$, partial $\eta^2 = .083$) but no effect for bookmarking ($F(1, 48) < 1$, *n.s.*, nor an interaction ($F(1, 48) < 1$, *n.s.*). However, engagement in the topic was very rare in general (additional information group: $M = 3.69$, $SD = 2.81$; no additional information group: $M = 2.27$, $SD = 1.85$; on a scale ranging from 1, "not at all" to 10, "very strongly").

In summary, follow up of museum visits was rarely done by the visitors of the study, and the website was so seldomly accessed that a statistical analysis of the effects of bookmarking was not possible. However, additional information had a positive effect on subsequent actions after the visit.

## Post-hoc Analysis of Visitors

What are characteristics of visitors who want to see the exhibition again or who want to engage further in the topic? If the data are compared post hoc, the following differ-

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30  "Nanotechnologie sieht so aus, als würde mir eine weitere Beschäftigung damit Spaß machen.", "Sich mit Nanotechnologie weiter zu beschäftigen ist interessant für mich.", "Ich möchte alle Feinheiten von Nanotechnologie entdecken.", "Ich möchte mehr über Nanotechnologie erfahren.", "Ich möchte mehr über die Details von Nanotechnologie wissen."

ences are of interest. However, it should be noted that this is a post-hoc analysis which consequently may not be used to explain differences, its value is purely exploratory for further studies.

*Characteristics of visitors who want to see the exhibition again:* Post-hoc analysis regarding visitors who would want the see the exhibition again and those who would not (asked in the follow-up test, which makes more sense since high situational interest after the visit might lead to overly optimistic answers by the visitors) were conducted by constructing two groups, those above the mid-point of the scale and those below. Visitors who would want to visit the exhibition again compared to those who would not differed with respect to their answers to the questions displayed in Table 11. It is interesting that self-proclaimed return visitors have higher interest one week prior and three weeks after the visit, but that there is no difference compared to non-return visitors immediately after the visit. It seems that the high situational interest of the visitors makes it impossible to differentiate between self-proclaimed return-visitors and non-return-visitors immediately after the visit. However, a multiple-items scale regarding interest in nanotechnology differentiated between the two groups.

*Characteristics of visitors who wanted to further engage in the topic:* Post-hoc analysis of visitors who stated in the follow-up test that they would or probably would occupy themselves with the topic ($n = 27$) compared to those who would probably not ($n = 12$; the undecided, $n = 13$, were excluded), showed a large number of differences. The most important differences are displayed in Table 12. Note: $\chi^2$ tests showed that there was no difference regarding the visitors who would engage in the topic or not and the distribution with respect to the factors or the conditions. Whether visitors had additional information or bookmarking available had no influence on their intention to engage further in the topic.

Visitors who wanted to engage further in the topic three weeks after the visit had shown higher interest prior to, immediately after, and three weeks after the visit. In contrast to those visitors who did not want to engage in the topic further, their interest not only increased after the visit but remained on the this extremely high level (7.3 / 10

| Question | return visitors | | non-return visitors | | t Test |
|---|---|---|---|---|---|
| | M | SD | M | SD | |
| willingness to visit the exhibition again | 7.73 | 1.22 | 3.12 | 1.14 | $t(50) = -14.087, p < .001$ |
| Visits to science and technology museums | 3.69 | 1.32 | 2.62 | 1.24 | $t(50) = -3.038, p = .004$ |
| Interest one week prior to the visit | 5.12 | 2.22 | 3.73 | 2.24 | $t(50) = -2.243, p = .029$ |
| Interest immediately after the visit | 6.88 | 1.51 | 6.04 | 2.01 | $t(50) = -1.718, p = .092$ (ns) |
| Interest three weeks after the visit | 6.50 | 1.90 | 4.92 | 2.53 | $t(46.437) = -2.541, p = .014$ |
| connecting content of exhibition with prior knowledge | 4.73 | 1.00 | 3.88 | 1.51 | $t(50) = -2.386, p = .021$ |
| further occupation with NT looks like fun | 4.85 | 0.92 | 4.08 | 1.32 | $t(50) = -2.428, p = .019$ |
| further occupation with NT looks interesting | 4.88 | 0.99 | 4.12 | 1.53 | $t(50) = -2.149, p = .037$ |
| want to discover all subtleties of the exhibition | 5.08 | 1.29 | 4.31 | 1.35 | $t(50) = -2.098, p = .041$ |
| were very attentive in the exhibition | 5.58 | 0.90 | 4.92 | 1.29 | $t(50) = -2.114, p = .04$ |
| visit: meaningful vs. meaningless | 3.58 | 1.33 | 4.50 | 1.33 | $t(50) = 2.497, p = .016$ |
| would have visited the exhibition independent from the study | 4.12 | 1.61 | 3.04 | 1.71 | $t(50) = -2.340, p = .023$ |
| bookmarks as starting point | 3.77 | 0.95 | 3.08 | 1.09 | $t(50) = -2.437, p = .018$ |
| preferring bookmarks to catalogue | 3.73 | 1.08 | 3.04 | 1.31 | $t(50) = -2.079, p = .043$ |
| bookmarks as "thread" | 3.12 | 0.91 | 2.15 | 1.16 | $t(50) = -3.335, p = .002$ |
| Interest in Nanotechnology (18 item scale) | 4.89 | 0.64 | 4.42 | 0.94 | $t(50) = -2.101, p = .041$ |
| would visit bookmarks | 3.85 | 1.12 | 3.12 | 1.00 | $t(50) = -2.489, p = .016$ |
| would create bookmarks prior to visit | 2.50 | 1.14 | 1.85 | 0.73 | $t(42.606) = -2.461, p = .018$ |
| would enlarge bookmarks after visit | 3.31 | 1.09 | 2.69 | 1.09 | $t(50) = -2.041, p = .047$ |

For comparability, only data from visitors with complete data set (pre, post, follow-up) were used ($n = 52$).

*Table 11:* Post-hoc differences of visitors (willingness to see the exhibition again)

post, 7.22/10 follow-up) while the value of those unwilling to engage dropped down to the low pre-test values (see Figure 12).

A one-way repeated measures ANOVA with willingness to occupy (yes/no) as between-subjects factor and pre-, post, and follow-up interest in nanotechnology as within-subjects factor shows a statistically significant interaction ($F(IA)(2, 74) = 10.882, p < .001$, partial $\eta^2 = .227$), and effect for between-subject ($F(\text{occupy})(41.729) = ,$

| Question | engagement | | no engagement | | t Test |
|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | |
| further occupation with the topic[a] | 1.67 | 0.48 | 4.08 | 0.29 | $t(33.36) = -19.416, p < .001$ |
| Interest one week prior to the visit | 5.11 | 2.19 | 3.08 | 1.68 | $t(37) = 2.85, p = .007$ |
| Interest immediately after the visit | 7.30 | 1.56 | 5.08 | 1.68 | $t(37) = 3.99, p < .001$ |
| Interest three weeks after the visit | 7.22 | 0.89 | 2.75 | 1.36 | $t(37) = 12.258, p < .001$ |
| self-report of knowledge prior to visit | 2.44 | 0.93 | 1.58 | 0.67 | $t(37) = 2.875, p = .007$ |
| self-report of knowledge after the visit | 4.41 | 0.69 | 3.42 | 0.90 | $t(37) = 3.752, p = .001$ |
| total number of right answers multiple choice | 33.59 | 6.26 | 28.17 | 6.58 | $t(37) = 2.461, p = .019$ |
| right answers in multiple choice test minus wrong and "don't know" answers | 7.19 | 12.52 | -3.67 | 13.15 | $t(37) = 2.461, p = .019$ |
| bookmarked objects | 31.33 | 14.72 | 22.17 | 6.18 | $t(36.968) = 2.739, p = .009$ |
| Interest in Nanotechnology (all items) | 5.10 | 0.69 | 3.99 | 0.45 | $t(37) = 5.054, p < .001$ |
| Interest in Nanotechnology (18 item scale) | 5.19 | 0.70 | 3.82 | 0.45 | $t(37) = 6.166, p < .001$ |
| willingness of a second visit | 6.44 | 2.28 | 2.67 | 1.3027 | $t(34.346) = 6.544, p < .001$ |
| recommendation of exhibition | 8.70 | 1.30 | 5.17 | 1.9462 | $t(37) = 6.715, p < .001$ |

[a] Scale with 5 items: 1 = "yes, absolutely", 2 = "yes, probably", 3 = "don't know", 4 = "no, probably not", 5 = "no". A dichotomized version of the scale (1+2 vs. 4+5) was used to calculate the *t* Tests

For comparability. only data from visitors with a complete data set (pre. post. follow-up) were used (n = 52).

*Table 12:* Post-hoc differences of visitors (willingness of further occupation with topic)

$p < .001$, partial $\eta^2 = .530$) and within-subject ($F(time)(2, 74) = 25.920, p < .001$, partial $\eta^2 = .412$) factors. Caution is warranted regarding these results as the cell frequencies are not equal and this is a post-hoc analysis. However, given that visitors who stated that they were unsure whether they would like to get engaged with the topic after the visit or not lay between the occupiers and non-occupiers, this measure seems consistent.
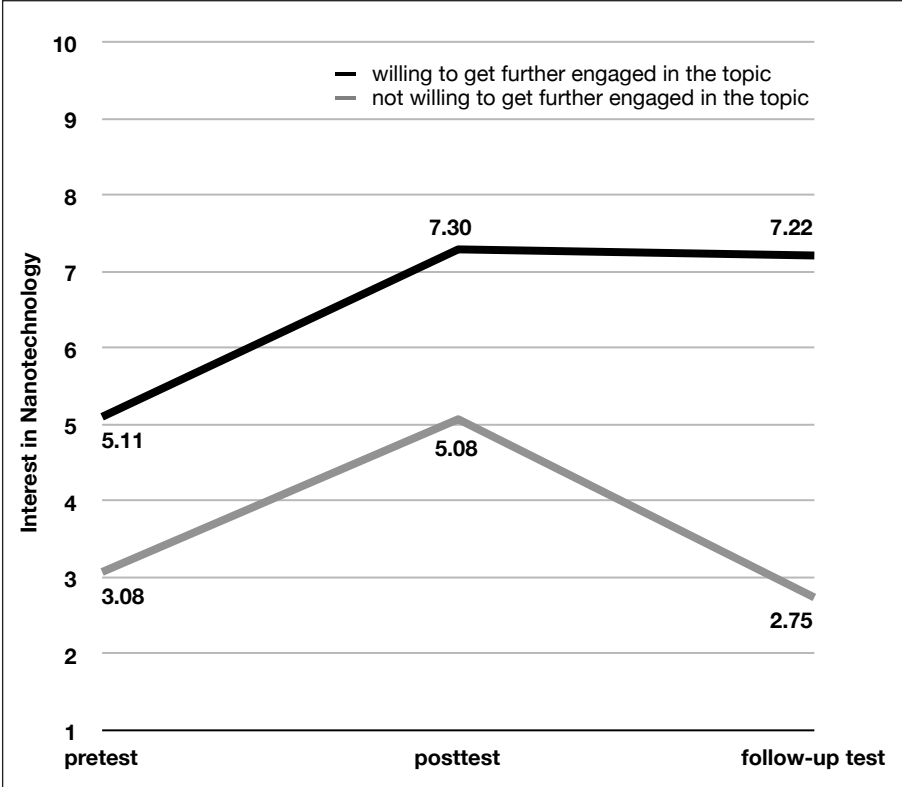
Willingness to get further engaged was a *post-hoc* factor; interest in nanotechnology on an item from 1 to 10.

*Figure 12:* Willingness to further engage in the topic

## Interest over Time

*Single-Item Question*

Interest in nanotechnology was measures in the pre-, post- and follow-up tests as a single-item question with answers ranging from 1 to 10. This allows a view of interest over time regarding the effect of the exhibition visit. Over the three sample times, a significant change of interest occurred in all visitors. For visitors with vs. without additional information, a one-way repeated measures ANOVA showed a significant main effect for time ($F$(time)(2, 100) = 30.461, $p < .001$) but neither for additional information ($F$(additional information)(1, 50) < 1, *n.s.*) nor for an interaction of the two main effects ($F$(Interaction)(2, 100) = 1.282, $p = .282$). The effect for time also shows

when bookmark vs. non-bookmark is included as a second factor ($F$(time)(2, 96) = 29.996, $p < .001$; $F$(additional information)(1, 48) < 1, *n.s.*; $F$(bookmark)(1, 48) < 1, *n.s.*; $F$(interaction)(1, 48) = 1.651, $p = .205$). Interest in nanotechnology increases from pre-test (one week prior to the visit) to the posttest (immediately after the visit). This increase, however, is not stable but drops until the follow-up test three weeks after the visit (see Figure 13). However, the follow-up values are significantly higher than the pretest values when measured with a one-way repeated-measures ANOVA with availability of information and pre- vs. followup-test ($F$(time)(1, 50) = 17.959, $p < .001$, partial $\eta^2 = .264$; $F$(additional information)(1, 50) < 1, *n.s.*; $F$(Interaction)(1, 50) < 1, *n.s.*). This effect is also found when bookmarking is included as a second factor ($F$(time)(1, 48) = 17.198, $p < .001$; $F$(additional information)(1, 48) < 1, *n.s.*; $F$(bookmark)(1, 48) < 1, *n.s.*; $F$(Interaction)(1, 48) = 2.295, $p = .136$).
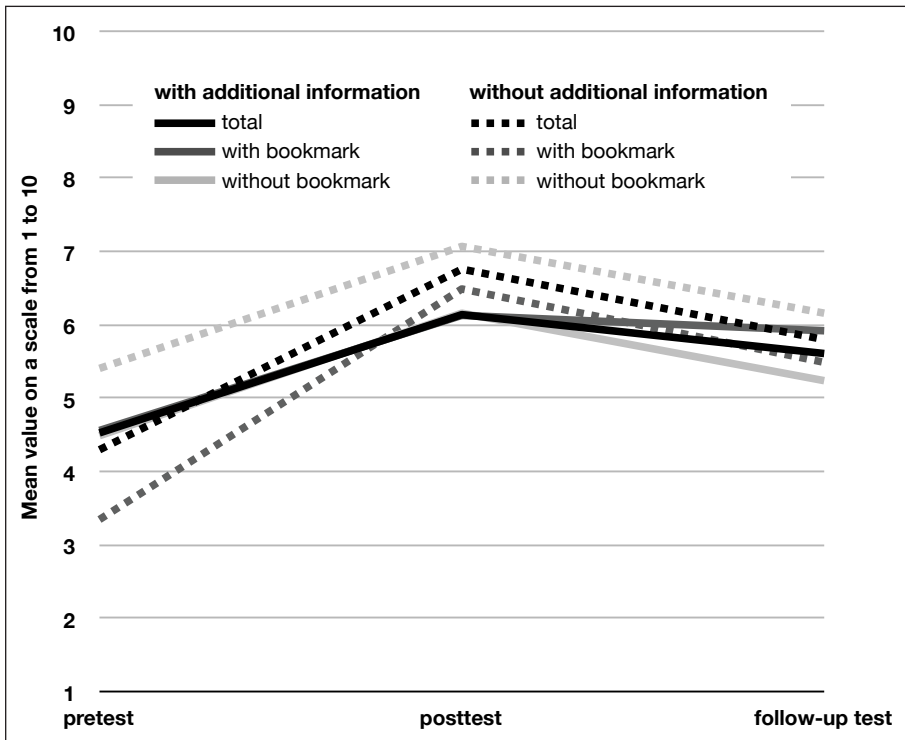


*Figure 13:* Interest in Nanotechnology over time

While gender differences are not the topic of this study, those found lend confidence to the dependent variables used: Men were more interested in nanotechnology than women over all three measurements, resulting in a statistically significant main effect for gender (and time, but no significant interaction) in a one-way repeated-measures ANOVA with interest in nanotechnology at pre-, post- and follow-up test as repeated factor ($F$(time)(2, 100) = 16.899, $p < .001$, partial $\eta^2 = .253$; $F$(IA)(2, 100) = 1.97, $p = .145$, partial $\eta^2 = .038$; $F$(gender)(1, 50) = 11.55, $p = .001$, partial $\eta^2 = .188$).

In summary, while there were effects for time, there were none for the availability of additional information nor for bookmarks. This perspective also shows that interest gains after the visit are short-lived.

## Paired Comparisons

If interest in nanotechnology has changed, it should have influence on the paired comparison ratings of "Matter and Energy" and "Technology". While values between 0 and 27 were possible, the average value varied between 2.76 (pretest "Technology") to 13.32 (pretest, "Human Society"). "Technology" and "Matter and Energy" had the lowest average values (2.76 to 4.06) and the lowest maximum ratings of individual participants (13 to 17), thus interest in these two categories compared to other domains was very low (Table 13; see also Figure 14). Of all categories, visitors were least interested in "Technology" and "Matter and Energy", no matter when they rated them. This is in accordance with the study majors the participants had: only one participant studied physics[31] and one had dropped out of physics after the first semester, while psychology, education and languages were very common.

*Matter and Energy:* A two-way repeated measures ANOVA with additional information and bookmarks as independent factors and paired comparison score of "Matter and Energy" over the three measurement times as repeated factor showed no effects, neither of time ($F$(time)(2, 92) = 2,25, $p = .111$), nor main effects ($F$(ai)(1, 46) < 1, *n.s.*; $F$(bm)(1, 46) < 1, *n.s.*), nor any interaction effects.

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31    She had the highest values in "Matter and Energy" (14-17-15 in pre-, post-, and follow-up test) but low in "Technology" (1-4-8).

| Test and Division | M | SD | Minimum | Maximum |
|---|---|---|---|---|
| Pretest Human Society | 13.32 | 5.91 | 0 | 26 |
| Posttest Human Society | 13.10 | 5.07 | 2 | 25 |
| Followup Human Society | 12.82 | 5.71 | 2 | 25 |
| Pretest The History of Mankind | 12.13 | 5.11 | 4 | 25 |
| Pretest Human Life | 11.60 | 5.18 | 1 | 23 |
| Posttest Human Life | 11.08 | 5.78 | 0 | 23 |
| Followup Human Life | 11.00 | 4.96 | 2 | 22 |
| Followup The History of Mankind | 10.74 | 6.04 | 0 | 26 |
| Posttest The History of Mankind | 10.71 | 5.98 | 1 | 27 |
| Pretest Art | 9.77 | 7.48 | 0 | 26 |
| Pretest The Branches of Knowledge | 9.02 | 5.23 | 2 | 25 |
| Posttest Art | 8.90 | 7.73 | 0 | 27 |
| Followup Art | 8.56 | 8.28 | 0 | 27 |
| Pretest Life on Earth | 8.53 | 4.53 | 1 | 22 |
| Posttest The Branches of Knowledge | 8.37 | 4.63 | 0 | 19 |
| Followup The Branches of Knowledge | 8.34 | 5.29 | 0 | 23 |
| Posttest Life on Earth | 7.58 | 4.26 | 1 | 20 |
| Followup Life on Earth | 7.54 | 4.74 | 0 | 22 |
| Pretest Religion | 5.81 | 5.59 | 0 | 22 |
| Followup Religion | 5.80 | 5.23 | 0 | 24 |
| Pretest The Earth | 5.47 | 4.73 | 0 | 23 |
| Posttest Religion | 5.40 | 5.43 | 0 | 26 |
| Posttest The Earth | 5.26 | 4.38 | 0 | 20 |
| Followup The Earth | 5.06 | 4.17 | 0 | 20 |
| Posttest Technology | 4.06 | 3.64 | 0 | 17 |
| Followup Technology | 3.92 | 3.76 | 0 | 14 |
| Followup Matter and Energy | 3.64 | 3.81 | 0 | 15 |
| Posttest Matter and Energy | 3.00 | 3.56 | 0 | 17 |
| Pretest Matter and Energy | 2.82 | 3.06 | 0 | 14 |
| Pretest Technology | 2.76 | 2.84 | 0 | 13 |

$(n_{pre/post} = 62, n_{followup} = 50)$

*Table 13:* Results of paired comparisons (all participants)
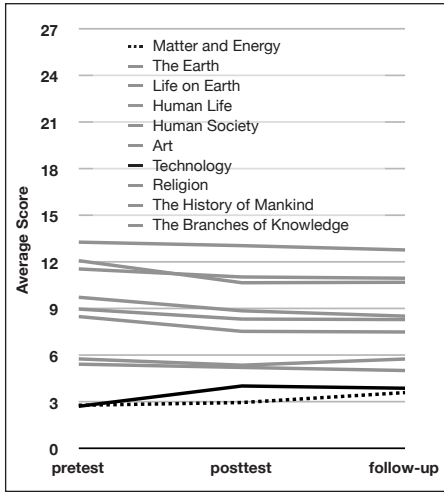
*Figure 14:* Average Paired Comparisons Scores
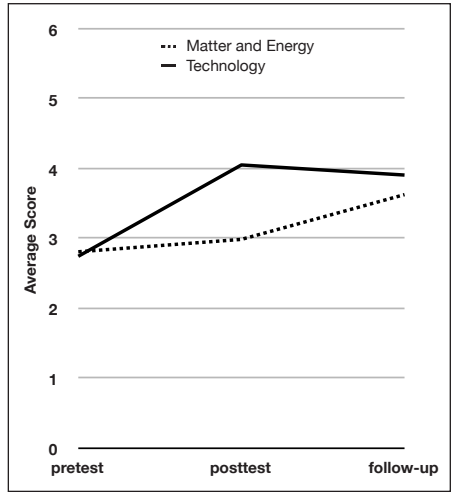
*Figure 15:* Average Paired Comparisons Scores in Technology and Matter and Energy

*Technology:* A two-way repeated measures ANOVA with additional information and bookmarks as independent factors and paired comparison score of "Technology" over the three measurement times as repeated factor showed a statistically significant main effect for time ($F(time)(2, 92) = 9.787$, $p < .001$), but neither significant effects for additional information ($F(ai)(1, 46) < 1$, *n.s.*) nor for bookmarks ($F(bm)(1, 46) < 1$, *n.s.*), nor any interaction effect (see Figure 15). In summary, while there was an effect on the paired comparison score of "Technology" but not on "Matter and Energy" over the course of the experiment, there were no differential effects due to treatments.

# Discussion

To find out how to support interest during (Question 2) and after the museum visit (Question 3), I conducted a study where participants visited a small laboratory exhibition under different conditions: Either they had the opportunity to access additional information on a PDA and mark exhibits and information as interesting, or they could only mark exhibits as interesting on the PDA. A second factor was the availability of the marked exhibits (and — depending on experimental condition — additional

information) on a webpage or not (bookmarking). The first question (what makes an exhibit interesting for a visitor) can be addressed only peripherally in the first study but is a major part of Study 2.

## General Results and Prerequisites for Further Analysis

*Study Sample:* The study sample consisted of students who were highly educated and in accordance with the target audience of the exhibition as stated by Amodio (2007). They also were museum experienced but also rather homogeneous as a group, resulting in a constrained variance. Given their study majors (only one with physics), they also had a low prior interest in and knowledge of nanotechnology, which was reflected in the single-item assessments of interest in nanotechnology and the paired comparisons, where "Energy and Matter" and "Technology" had the lowest values. Subjects generally participated well in the experiment. Although they would not have visited the exhibition without the experiment and had much to do, they took their time for the visit and engaged in its content. Although they were compensated for their participation, they regarded the visit as self-determined, enjoyed it, and found something of interest, probably similar to the semi-voluntary visit during a school trip or works outing. Their compliance was very high. Consequently, the use of a laboratory exhibition and a recruited student sample worked well, provided a high degree of experimental control, and allowed for a close analysis of the participants.

*Device:* The device was very much accepted by the participants who considered it very easy to handle, under both conditions, for only marking exhibits as interesting, and for accessing additional information and marking exhibits and information as interesting. It was used as intended by the additional information groups to access further content — participants did not play with the device or gave it "a value of its own". While the device was new to the participants, results do not seem to be due to a "novelty" factor. No negative effects of the device were found, although a pure control group without a device was not realized. The evaluation of the device was positive and the additional information on the device did not lead to lower scores in the multiple choice knowledge test.

# Question 1: What Makes an Exhibit Interesting?

As mentioned before, this first study can only give limited insight into what makes an exhibit interesting, but some important conclusions can be drawn:

*Participants did (genuinely) find something of interest:* All visitors, who were recruited and paid study participants (i.e., externally motivated at the beginning), found something of interest, as indicated by self-reports and the fact that every visitor has marked some exhibits as interesting. If the interest scores for nanotechnology are compared across the three measurements, the exhibition did increase interest, as is shown by the higher ratings immediately after the visit. In most cases, this seems to be due to situational interest, because the values decrease between posttest and follow-up test three weeks later, and because interest in "Matter and Energy" and "Technology" was generally low. Interest may also have been self-generated by the visitors: Given that they were study subjects who participated in an experiment and "had to" stay in the exhibition, they could have generated their own interest (cf. Schraw & Lehman, 2001). However, if this interest had nothing to do with the exhibits and the available information, it is doubtful whether they would have marked them as interesting.

*Interest in exhibits varies considerably:* While all participants found something of interest, their actual objects of interest varied considerably. The most popular exhibit was marked as interesting by 58% of the visitors, but percentages go down to 9.68% (and in one case zero: one information text was marked as interesting by no visitor). These differences did not seem to have anything to do with their location on the exhibition walls as the average amount of interesting exhibits was comparable for all four walls. Museum fatigue (such that, for instance, fewer exhibits are marked as interesting on the last wall) did not seem to be a problem. This was probably due to the small size of the exhibition, allowing visitors to see the entire exhibition from any point and correspondingly plan their expense of resources.

## Question 2: (How) Can Interest Be Supported During the Museum Visit?

The additional information on the mobile device had some but not all of the anticipated effects.

*Use of additional information and Wikipedia:* The additional information provided was very much used, and visitors liked its ease of use and accessibility. Wikipedia, however, was regarded critically in museums: Shown as a website on a PDA, the slow speed and the layout of the information made usage taxing, and while visitors used Wikipedia at home, this did not transfer well to the museum.

*Behavioral indicators of interest:* The availability and use of the additional information had a very strong effect on an important indicator of interest: visit duration (see page 18). With the constrained physical museum space being extended into the virtual information space of the mobile device, visitors with access to the additional information stayed roughly half an hour longer than those who did not, thus nearly doubling the visit duration (34 minutes to 61 minutes on average). The statistically significant correlation between visit duration and the amount of additional information accessed and marked as interesting, along with the ease of use of the device, are strong indicators that visitors actually did use the device to access information during that time. Consequently, it is highly unlikely that the longer visit duration is just an artifact of participants' problems with the device, their "toying around" with it, or their desire to be "good study subjects". Additional information was read and marked as interesting during that time, allowing visitors to become more engaged with specific exhibits.

*Evaluation of the exhibition:* Additional information also had a positive effect on visitors' perception of the available information in the exhibition and the subjective size of the exhibition. That is, visitors thought the exhibition to contain more information (it did, due to the device), and they thought it was larger (it was, but "only" virtually as well). Visitors also thought more often that the exhibition designers wanted to convey knowledge with the exhibition.

*Subjective indicators of interest:* Despite frequent use and the large effect on visit dura-

tion, additional information did not have an effect on subjective indicators of interest or related variables: Neither higher self-reported interest (18-item posttest scale, single items, paired comparisons), greater learning (self-reports and multiple-choice test), engagement with the exhibition (9-item posttest-scale and single item), nor interest in further engagement in the topic were found. Why is this the case?

It does not seem that the measures are too insensitive, at least those for interest, given that expected gender differences were found (men stated higher interest than women in nanotechnology), and that those who would like to engage further in the topic had higher interest, especially in the followup measurement, than those who would not. On the other hand, participants' interest in nanotechnology might have been too low to be effectively affected by the intervention.

However, perhaps the main reason for the missing effects in the subjective indicators of interest on these scales is that additional information can probably only support interest, but not raise it. It seems that the additional information was used until a subjective cut-off value was reached. Consequently, self-reported interest was similar regardless of the availability of additional information — as was the total amount of objects marked as interesting (exhibits and additional information vs. exhibits only). On the group level, there seems to be a cut-off amount of information that can be interesting in a given setting. This interpretation refers to Rounds (2004) regarding information foraging behavior in exhibitions. Visitors search for enough interesting information until they "call it a day" because the probability of finding additional interesting information is too low. Using Rounds' (2004) metaphor, the interest landscape is larger for visitors with additional information because the interest landscape of the physical exhibition has a virtual part that can also be explored by the visitors. Visitors with additional information consequently search the virtual interest landscape for interesting information too, so they stay longer in the exhibition. But their cut-off (quitting) rules are the same, and so they leave the exhibition with the same number of objects marked as interesting and the same level of interest, but after spending much more time exploring the exhibition. This cut-off level also seems to appear at

individual exhibits: The half-life decay function shows that visitors are increasingly unlikely to access additional information or (indicated by an even steeper function) to mark information as interesting — probability for access at an exhibit was reduced by a factor of 0.5 for each additional text; for being marked as interesting, the factor was 0.3. This decline can also be explained by information foraging behavior: Visitors are reluctant to invest much time in single exhibits and are quick to cut their losses if additional information does not prove interesting. They may access information about an exhibit, but if that information is not interesting, they will probably not access another piece of information. So, while visitors with additional information spend more time in the exhibition accessing the additional information, probably with a more specific interest as they explored the exhibit information more in depth when it got their interest, on average they marked the same amount of "objects" as interesting.

However, it is also possible that the interest measure just came too late. Interest might have been higher during the exhibition visit but not after the visit: If the visit is aborted when interest falls below a certain point, then both conditions would terminate the visit with the same level of interest, while their interest might have reached different heights during the exhibition or existed for longer time frames.

The multiple-choice knowledge test proved problematic because it could not discriminate meaningfully between those with additional information and those without, but only show that there was no negative impact of the device on knowledge acquisition during exhibition. Measuring knowledge has to be excluded for this question, as those with additional information cannot be compared with those who did not have the chance to obtain this information, and knowledge tests seem more suitable for formal settings but not for informal free-choice settings (see page 17). However, self-reported knowledge estimates by the participants showed an increase: Participants thought they knew more after the visit than before visiting it.

Of course, low power and the homogeneity of the study sample could also be (partly) responsible for the lack of observable effects on these measures, as could the desire of the participants to be good study subjects. Students may have felt obliged to use the

additional information on the device to be a "good study subject" and justify their compensation, leading to similar engagement with the exhibition, but to different visiting times because "using" the additional information took more time. In summary, while large effects were found regarding the behavioral indicator of interest (visit duration), this effect could not be found with subjective indicators. Given the theoretical considerations on page 35, this result gives reason to be optimistic: The effects show the importance of providing information at the "hot moment" when visitors are at an exhibition. The information is read and visitors stay longer in the exhibition. As interest for the topic drops after the visit, information must be given during the visit. The results also show that the device can only support interest — it cannot elicit it.

Given the hypotheses for Question 2 on page 54, the first study supports Hypothesis 2.1 in part — providing additional information on mobile devices does support interest by means of longer visit duration (behavioral indicator), although an effect on self-reported interest (subjective indicator) and on learning (self-reports and knowledge test) was not found in this study.

## Question 3. (How) Can Interest Be Supported After the Museum Visit?

While the organizational and technical prerequisites for a usage of the exhibition webpage and the bookmarking feature by the visitors were fulfilled, actual usage of the webpage was rare. Only nine out of 62 participants accessed the webpage, and did so for a very short amount of time only. These results are similar to the findings by Filippini and Bowen (2007) and make it impossible to perform a quantitative analysis of the effects of the bookmarks on the webpage, which were available for half the visitors. What is not used cannot show any effect, unless the knowledge that it is available (even if it is not used) influences behavior. While this is undoubtedly true for some situations, it seems unlikely in this one. This interpretation is supported by the lack of empirical effects of the availability of bookmarks on the measured variables.

Why was the webpage not used, and why did those who would have been able to not make use of their list of bookmarked exhibits (and, for those who had them available,

at their additional information)?

*Lack of use of the webpage:* Students stated in the follow-up test that they had not had the time, which corresponds to their posttest-agreement that they "had much to do". The topic was also of low dispositional interest, and they were externally motivated. Given these constraints, interest in the topic after the visit was rare. An additional problem was that the link and login to the webpage was provided on a small calling card which was used to simulate a typical museum ticket. However, this implementation made losing the ticket or forgetting it in one's wallet a likely possibility and induces a media break: The link and login information are not available where they should be (i.e., on the computer) but have to be entered manually. Sending the login information per email to reduce this media barrier would probably have been a better solution.

*Lack of use of the bookmarks:* Questionnaire answers showed that bookmarks of interesting exhibits and exhibit information are a "nice to have", but are — in themselves — not motivating. While the participants evaluated the bookmarks as useful and would like to have this function available for other museum visits, this feature does not seem to have a motivating effect for further engagement in the topic when the topic itself is not of enduring interest.

Results of *knowledge communication* after the visit point to another reason for the low use. In general, communication with other people after the visit was very low. Visitors talked only little with people of their acquaintance who had not visited the exhibition, but communication with other groups was rare to non-existent. Questions regarding participants' usual preparation and follow-up of visits show that participants talk to people who go to the exhibition with them, both before and after the visit. Given that participants were solitary visitors in the laboratory experiment to prevent confounding effects of other visitors, they did not have these fellow visitors to talk to. Because they rarely talked with non-visitors, the exhibition webpage and the bookmarks are hardly needed to establish a common ground (see page 48) — the conversations for which the bookmarks would have been especially useful simply did not occur. The possible use of bookmarks for this purpose was not made salient or pointed out either,

probably contributing to the fact that conversations with others occured so seldomly. Consequently, bookmarks cannot support knowledge communication under these circumstances.

*Effects of additional information beyond the visit:* However, the additional information during the visit did show an effect beyond the visit. While the additional information had no influence on interest in terms of further engagement in the topic, the self-reported actual engagement in the topic was higher for those with additional information than for those without. Consequently, supporting interest during the visit seems to have beneficial effects on engagement in the topic after the visit. While other explanations seem possible, e.g., memory bias due to availability heuristic (longer visit duration facilitates recall which is then attributed to engagement in the topic after the visit) or cognitive dissonance (higher investment in the visit due to longer visit duration leads to higher subjective engagement in the topic after the visit), it is more likely a *"foot-in-the-door" effect*: Giving visitors the possibility to access additional information results in the use of this information, which makes it more likely that visitors engage in the topic after the visit. If one considers that interest in the topic was very low in general, even this small effect is impressive.

*Post-hoc analysis of self-reported return visitors:* It is interesting to note that self-reported return visitors see the value of bookmarks and are more willing to use them before and after the visit. While the way to Barry's (2006) virtuous circle is still long, and strongly depends on liking of the exhibition and dispositional interest in the topic, this result gives hope that bookmarks have their use for return visitors. However, in this case results are based on post-hoc analysis and have to be treated with great caution.

*Post-hoc analysis of those who wanted to engage further in the topic:* While return visitors are interesting for museums themselves as they increase the museums income, what about those visitors who stated that they wanted to engage further in the topic? The availability of bookmarks did not influence them, but what did? For those who wanted to engage further in the topic, interest rose due to the exhibition visit and remained high until at least three weeks after the visit. Given that their interest had been higher

prior to the visit and that their increase in interest due to the visit (posttest value) is similar to the increase of those who did not want to engage in the topic further, it seems that they had a predisposition, i.e., dispositional interest, that the exhibition tackled. It made them aware that nanotechnology was something that is interesting for them, and this interest stayed with them even three weeks after the visit. Regarding the hypotheses, it could not be found that bookmarking leads to higher engagement with the exhibition topic, interest, and knowledge exchange after the visit. However, an outright rejection of the hypothesis seems unsuitable, given that due to low post-visit engagement, bookmarks had no chance to affect engagement, interest and knowledge exchange.

## Interest over Time

In general, interest started low prior to the visit, was high immediately after the visit, and dropped after the visit. Visitors who wanted to engage in the topic further showed a continued high interest three weeks after the visit, but no effects of additional information nor bookmarks per se were found. It is unclear whether the follow-up test values will finally drop to pretest values over time and how long this will take, as the study was finished three weeks after the visit. This development of interest shows that the visit of the exhibition can at least influence interest for a topic situationally: While the exhibition manages to elicit situational interest that can be used during the visit, this short term intervention usually does not lead to enduring dispositional interest, which would be too much to expect. Similarly, paired comparisons show that interest in technology was increased immediately after the exhibition visit. However, it should be noted that the mobile device could be considered a piece of technology as well. Therefore it is unclear what lead to this increase, given that all participants had a mobile device, albeit with different functions.

# Conclusion

In summary, participants used the additional information provided by the mobile device in this study, which led to a much longer visit duration, better evaluation of the exhibition, and increased self-reported post-visit engagement in the topic, although effects on other variables could not be found. Supporting interest after the visit proved to be hard in this study, as usage of the webpage and the bookmarks was low, but the "foot-in-the-door" effect of additional information gives hope. Although it was possible to use compensated student participants to analyze possible *support of interest during the visit*, students proved to be unsuited as study participants to analyze *support of interest after the visit*. Given their time constraints, their low prior interest, and the external motivation, any willingness to engage in the topic during the experiment dissipates after the visit. Consequently, higher ecological validity is needed, even if this reduces the internal validity of the experiment.

A preliminary conclusion is that support of interest must occur during the exhibition visit when visitors take their time to engage in the topic. After the visit, situational constraints and the fleeting nature of situational interest (which an exhibition can elicit even when visitors are externally motivated to visit it) prevent engagement in the topic in all but the dispositionally interested visitors. This study also shows the limits of what exhibitions can do, at least with this sample: What is of interest is a subjective matter, and it is not possible to get all visitors to engage in the topic after the visit.

# Connecting Study 1 and Study 2

## Rationale for Conducting a Second Study in a Museum

While the first study in a laboratory exhibition provides first insights into possible answers to the three questions of this thesis, it also showed the constraints of doing museum research with paid participants in a laboratory setting. Even using an authentic exhibition, the advantages of internal validity come at a cost for the much needed external (ecological) validity. For the following reasons, a second study was needed under more ecologically valid conditions:

*Variance:* The classical study participant, a young student of psychology, who is more likely to be a woman than a man and who is also well educated, is not typical for museum visitors in general. Conventional visitors are too heterogeneous to be adequately represented by relatively homogeneous student participants.

*Intrinsic Motivation:* While it was possible to elicit interest in the exhibition when the participants were actually visiting it, interest drops after the visit, resulting in a rare use of the exhibition website and — if available — bookmarks. A more ecologically valid sample should also rule out the alternative explanation that visitors self-generated their interest, e.g., by making the task more challenging or non-repetitive (Schraw & Lehman, 2001).

*Heterogeneity of the exhibition:* To answer Question 1 (What makes an exhibit interesting?), a more heterogeneous exhibition was needed to generalize across different kinds of exhibits. Visitors should rate their most interesting exhibit on a scale. The answers on these items could then be reduced to underlying factors.

*Praxis Test:* The high ecological validity was also needed because museum settings are informal and much depend on the free choice of the user. While some proponents of mobile media consider "potential" and "use" (and "beneficial consequences") as a logical sequence, I considered it important to test the solution in the field with con-

ventional visitors and not with students of psychology hardened by numerous experiments.

## Lessons Learned from Study 1

Some general improvements in the design became necessary due to the experiences from Study 1:

*Reduce media barrier for post-visit engagement:* The link to the website and the login information should be sent by email. Visitors cannot lose it and have it available when they are connected to the Internet.

*Focus on extreme groups:* While a 2x2 design was useful in theory, in practice, it costs too many study subjects and thus limited the possibilities of useful statistical analysis. For example, an exploratory factor analysis could not be computed, not only due to the small total number of visitors, but also because it would have had to be computed with the different subgroups, which then would have been only 1/4 of the total sample. In the second study, a focus on extreme groups (visitors who have everything available) and a pure control group (visitors who see the exhibition without a mobile device) promises to be more useful.

*Later follow-up tests:* Follow-up tests in Study 1 were conducted after three weeks. In the second study, this is extended to two months, giving interest more time to subside after the visit.

*No paired comparisons:* Participants of study 1 stated (verbally) that they did not like the paired comparisons: They had to make the same 45 comparisons three times (pre-, post-, and followup-test, resulting in 135 comparisons), which was taxing. Given that the results with paired comparisons compared to self-reports on a single item did not differ and that they were only useful to show the low dispositional interest in the relevant topics (Matter and Energy, Technology), they were not used in Study 2.

*No Wikipedia:* Wikipedia in Study 1 was too slow, and the design was not adequate for the mobile device. While it would have been possible to compensate for these two constraints by exporting the information into separate files and make them available

on the 2 GB storage card of the mobile device, this still would not change visitors' opinion that Wikipedia does not belong into a museum. Consequently, Wikipedia was not used again in study 2. This was also in accordance with the museum representative (see "Situational Constraint" on page 108): He was strongly against using Wikipedia in his museum due to an perceived lack of quality.

# Methodological Problems of Conducting Research in a Museum

While a study in a real museum is necessary, conducting a study in a museum has its own constraints and limitations:

*Limited influence of the researcher:* The main problem of research in museums is the limited influence of the researcher, compared to a laboratory experiment. While museums do research, and even visitor research (see Reussner, 2009), they are neither testbeds for new technology nor natural settings for psychological experiments, but are responsible for the visitors' experience to be rewarding and for keeping their standards high. Consequently, a study has to be integrated smoothly into the exhibition, which limits the treatments that can be given (e.g., providing visitors with alternative information which could threaten the museum's high standard regarding the quality of information they provide). With rare exceptions (e.g., when a museum is renovated and the exhibition is temporarily displayed in a place where the experimenter can influence what it looks like and who enters it), it is not possible to conduct an experiment according to laboratory standards (e.g., visitors come in groups, alone, with partner, etc. leading to confounding effects). Consequently, cut-backs will have to be made in the second study. On the other hand, while the controlled experiment might righteously be the golden path of modern psychology and Study 2 is as a quasi-experiment as close to a controlled experiment as possible, the latter might not be the best solution for informal settings. Whenever compared to a strict laboratory experiment, Study 2 will come off lacking — but internal validity is only one and not the main goal. To put it bluntly, I rather have data gathered in voluntary, self-selected, and confounded conditions (e.g., due to visitor compositions in the exhibition), if they are

ecologically valid, than highly internally valid data from artificial conditions that do not mirror the settings to which they are applied later. This point is emphasized here, because Study 2, as a field study, differs from most, more controlled, experiments in psychology.

*Free-choice participants in a leisure setting:* Given that participants are normal visitors who have to be asked to participate in a study, a highly selective sample of those who participate can be expected. Dropout is also likely to be high — in contrast to student participants, normal visitors are not compensated for their participation, and thus the norm of reciprocity (see Cialdini, 1995) does not apply.

*Informed participation changes visitor behavior:* Researching an exhibition might signal visitors that the exhibition is particularly interesting; otherwise, why would someone spend time to research it? It can also motivate visitors to be 'on their best behavior' and have a 'really good look at the exhibits', especially if they know that a question-naire will follow after their visit. Allen (2002) found that cueing visitors changes their behavior, e.g., visitors stayed much longer in the exhibition than visitors who are un-obtrusively tracked. While this might impede comparability with "normal" partici-pants who enter the museum when no study is taking place, this effect should equally affect all conditions if visitors are all cued before they enter the exhibition.

*No pretest:* While it would be possible to ask visitors first to answer a few questions before they enter the museum, it would lack the advantages of a pretest one week prior to the visit where visitors were not so influenced in their visit by the pretest. It is also hard and probably frustrating to stop museum visitors when they can already see the interesting exhibits.

In summary, I decided to conduct the second study under more realistic, externally valid conditions. Participants had to be visitors who came to the museum on their free choice and for various reasons, and not to participate in an experiment. However, this means doing an field study, which imposes serious limitations on what can be realized in this setting, e.g., what can be offered to the participants on the device. However, given the need for an ecologically valid sample, these costs had to be accepted.

# Study 2: Field Exhibition

## Method

### Design

In the second study, the three questions were addressed using one experimental group (EG) and one control group (CG). This design compares the extreme groups of visitors who have everything that was possible to realize in this setting (easy access to the exhibition information and bookmarks) to regular visitors who visited the museum unassisted by a mobile device.

In the experimental condition, visitors were provided with a mobile device (see page 114) that contained all the information that was available at the museum, with the exception of the media terminals. All exhibit labels and all additional information texts that were available throughout the exhibition and which could rarely be viewed at the same time as the exhibit were made available on the device. Each of this pieces of information could be marked as interesting by the visitor, which made the information available on a personal page of the exhibition website (see page 116) for post-visit usage. Visitors in the control group did not receive a mobile device but were simply asked at the entrance if they were willing to participate in a study. They visited the exhibition like any regular visitor (albeit cued about the study) but received access to the exhibition website after the visit (without any personal bookmarks).

#### Situational Constraint

It was not possible to offer additional information to the experimental group due to restrictions by the museum. Even an offer to pay a museum employee to check the veracity (or rather: quality) of the additional information was rejected due to lack of qualified personnel. Wikipedia was rejected out of hand, even as a source for additional information that could be checked. This is a hard constraint that had to be accepted. Consequently, this study can only examine the effect of immediate access to exhibit

information: With the help of a mobile device, visitors could see the exhibit information directly in front of the exhibit and did not have to search for additional information nearby. Visitors did not have to search for the relevant rotating information labels but could easily view the objects referred to on the device. This is considered vital by museum researchers (Gammon & Burch, 2008) and similar to the electronic guidebook used by the Blanton iTour (Manning & Sims, 2004), where the wall text was also available on the device (although the iTour offered additional information as well). Consequently, the barrier for accessing information is lower and more information should be accessed. Additionally, the information can be bookmarked for later usage.

## Participants

Participants were regular visitors who were not part of organized guide tours, works outings, or school visits, but visited the museum alone, with a partner, with family, or with friends, and had agreed to participate in the study before entering the exhibition. This deliberately allowed self-selection regarding participation in the study and usage of the device in the experimental condition. The aim was to assess the consequences of mobile devices with high ecological validity and not to "force" study participants into using something that they would not use during a regular visit. Consequently, not all visitors who were asked participated in the study; however, probably two thirds of the suitable visitors did participate. This self-selection might limit the interpretability of the results; however, it should affect the experimental and the control group equally. Visitors who were too busy managing their children, speaking in a foreign native language, children, adolescents under 18, and those who needed one hand to stabilize their walking by using a stick (and therefore could not use a mobile device that required both hands) were excluded under both conditions. However, the mobile device was given to adolescents if their parents had agreed that their child could participate. Despite the "about 1000" visitors per month according to the information provided by the museum (Burmester, 2008, personal communication), most of the 1000 visitors per month were not suited for the present study, i.e. the majority were school classes. Unfortunately, it was not possible to extend the study period due to a special exhibition

that was placed in the center of the museum 7 weeks after the beginning of the study. Despite these conditions, 210 visitors participated in the study. To prevent treatment diffusion due to visitors with device (experimental condition) and those without (control condition) influencing each other, days were randomized to conditions and not participants to conditions: Accordingly, all visitors on a given day were correspondingly either in the experimental or the control group. As the days were randomized, possible confounding effects of different visitor compositions on different days (e.g., weekend visitors vs. weekday visitors) should be controlled for.

## Settings and Instruments

Given that the field study was conducted in an existing museum, I will first describe the museum and its exhibits, then the mobile device and program used, the website of the exhibition that was available to the visitors after the visit, and finally the dependent measures.

### Field Exhibition: Deutsches Museum Bonn

Study 2 was conducted at the "Deutsches Museum Bonn", a technology museum exhibiting German high technology achievements (see Figures 16 and 17).

It is the smaller branch of the "Deutsches Museum München" and contains 96 exhibits[32] on two levels. The building is rather small, but it has a wide open space in the middle and a staircase connecting both levels.

Despite all exhibits being examples of German high technology, the exhibits themselves are very heterogenous, covering a wide range of different fields. For example, they range from theoretical physics (e.g. Supercollider elements) and high-tech artifacts (e.g. satellites) to everyday applications (e.g. energy-saving housing) and artifacts (e.g. styrofoam, Fischer wall plug, mp3-codec), see Figure 18.

While the range of exhibit topics is much larger than in Study 1, they are still closely related. The exhibits of Study 1 would have fitted in the Deutsches Museum Bonn (and the entire exhibition of Study 1 was shown in the larger sister museum of the

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32    All exhibits that were mentioned in the catalogue as unique exhibits were counted.

*Figure 16:* Deutsches Museum Bonn

Deutsches Museum in Munich). A small number of exhibits were interactive (12.5%), from being able to steer a small maglev train model to pressing buttons to show elements of energy saving housing, most being very simple to use. For a short description of interactive exhibits see Table 14. For the purpose of the study, movies (which did not offer interactive elements but ran in a loop) and media terminals were excluded. The media terminals contained information about 18 of the 96 exhibits of the museum. Unfortunately, the information of the terminals was locked in compiled and protected Shockwave Director files and the museum did not have the original source files. It was possible to crack these files (which was part of the agreed compensation for the museum for allowing the study) but only after the study had already begun. Consequently, this information could not be offered on the device. However, the terminals did not seem to be very popular as the were old, slow, and awkward to use. Taken together, the museum had the advantages of high ecological validity, a high number of visitors (although it turned out that most of them could not be used for the study), and a very heterogeneous but manageable content, which made it well suited
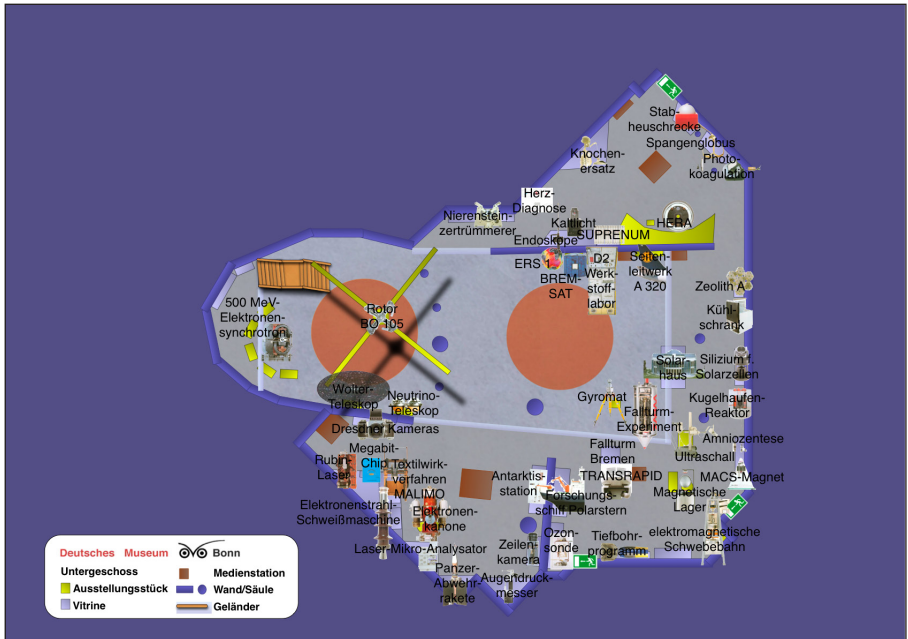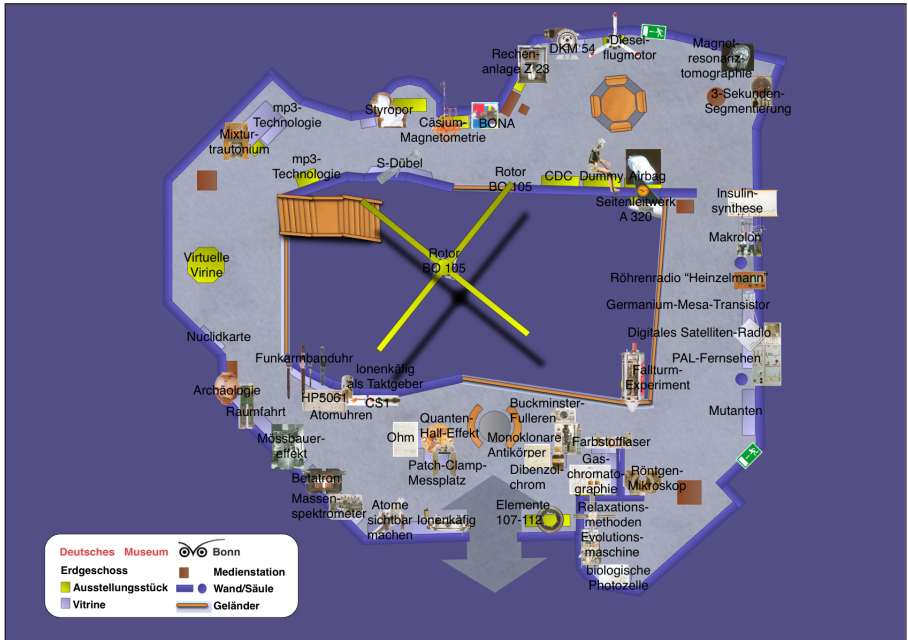
top: Ground Floor with entrance to the exhibition; bottom: Basement)

*Figure 17:* Floor plan, designed by the author
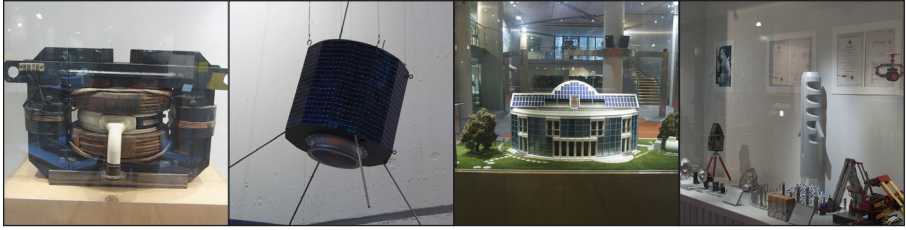
Sample exhibits from theoretical physics (e.g., supercollider element of the 6MeV-Betatron) and high-tech artifacts (e.g., satellites like the BREM-SAT), to everyday application (e.g., energy-saving housing with the "Energieautarke Solarhaus in Freiburg"), and artifacts (e.g., Fischer wall plug).

*Figure 18:* Sample exhibits of the Deutsches Museum Bonn

| Exhibit | Interactive Elements | rated as most / least interesting |
|---|---|---|
| Bona – Diskrete Mathematik und Chip Design [Bona – Discrete Mathematics and Chip Design] | Rather complex interactive about chip design | 3 / 0 |
| Das Energieautarke Solarhaus in Freiburg [The Energy-Autarkic Solar House in Freiburg] | Buttons illuminate different parts of an energy-saving house | 1/2 |
| Das Mixturtrautonium [The Mixturtrautonium] | Audio on demand of the instrument | 5 |
| Der Mössbauer-Effekt [The Mössbauer Effect] | Button starts dynamic visualization of the effect | 0 |
| Der Nierensteinzertrümmerer HM 1 [The Lithotripter HM 1] | Buttons allow the placement of a kidney stone model in the center of simulated shockwaves | 6 / 0 |
| Diagnose des plötzlichen Herztodes [Diagnosis of the Sudden Cardiac Arrest] | Exercise machine for heart diagnostic | 4 / 0 |
| Die Gaschromatographie [The Gas Chromatography] | Physical exhibit (tube that can be turned) that illustrates the principle via balls of different sizes | 0 |
| Die elektromagnetische Schwebebahn [The Maglev Train] | Small maglev train model that can be steered via buttons | 6 |
| Magnetismus [Magnetism] | Table where magnets can be moved | 12 / 0 |
| Magnetresonanz-Tomographie [Magnetic Resonance Tomography] | PC which allows skimming through 128 pictures of the human head | 1 / 0 |
| mp3-Technologie [mp3 technology] | Audio on demand | 2 / 0 |
| Immunsystem (Spiel) [Immune System Game] | Game to illustrate how the immune system works | 0 / 0 |

Note: Each exhibit consisted in part of interactive elements — there were also physical artifacts and textual and graphical information available.

*Table 14:* Interactive Exhibits in Study 2

for the study. On the other hand, it was not possible to offer additional information, so interest has to be supported by making the information of the museum immediately available in front of the exhibits, and the first topic area the visitors encounter is "Elementares" [basics], which refers to theoretical physics and is perhaps not the most elementary topic for most visitors. For more information, see the museum website at http://www.deutsches-museum.de/bonn.

## Mobile Device and Program Used

*Mobile Device:* The same Fujitsu-Siemens Pocket Loox 720 as in Study 1 were used for Study 2. They were equipped with lanyards to allow visitors easy carrying of the devices. As in Study 1, automatic standby and automatic reduction of screen brightness were disabled.

*Software:* Like in Study 1, the program was written by me, albeit with different constraints. Because WiFi was not a secure option for information delivery in the winding and not easily structured layout of the museum, all information had to be available on the device itself. It turned out that a working solution could be reached using HTML (with Frames) and JavaScript, displayed in Opera Mobile browser in fullscreen mode. Opera "fullscreen" means that the address bar was still visible and could not be hidden. According to Opera developers this is a feature, not a bug. Unfortunately, no other browser could be used on these devices with the program: Microsoft Internet Explorer could not handle the JavaScript commands used, and Minimo only ran in a version that had high demands on memory and was excruciatingly slow. HTML files were created with a script using data from a SQL-database that was the basis for the website, allowing the creation of the content within seconds. Logfiles and visitors' bookmarks were exported from the device via a *mailto* link. This link created an email that contained the logfile or information about bookmarks in the mail body. To secure the program against user error or accidents, PocketKiosk Builder was used which limited the use of programs to Opera Mobile and Mail. While it might sound strange to write a program that provides information and logs the user actions with HTML and JavaScript, it worked extremely well for the study. For detailed information about the

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program used, see http://www.ipsych.org/creative-projects/computer-programs/electronic-guidebook-program-2-js/.

*Interface:* The interface had to allow visitors to select any one of the 96 exhibits with up to 7 information texts. Unlike in Study 1, navigation via exhibit walls could not be used due to size differences, irregular form of the walls and the position of exhibits in the open-plan space (see Figure 17 on page 112). However, visual navigation was still used for ease of use and visitor control, but with floor plans in two spatial resolutions: a large overview map of the current floor and more detailed maps that showed the area with the available exhibits at their location and their names. This allows easy selection of the exhibits. While two small floor plans provided by the museum proved useful to determine the form of the rooms, they lacked information about the exhibits and their position; thus intense additional work with photos from the museum and the exhibits was necessary to design a floor plan that could actually be used for exhibit selection (see Figure 17). An overview of the interface layout is shown in Figure 19. Visitors were able to select the area, then the exhibit, and then any of the available information texts that were displayed with the title of the text. Exhibits and information texts could be marked as interesting by clicking on the "highlighter" icon. The marked text was then indicated by highlighting the title in yellow. If an exhibit or a text had
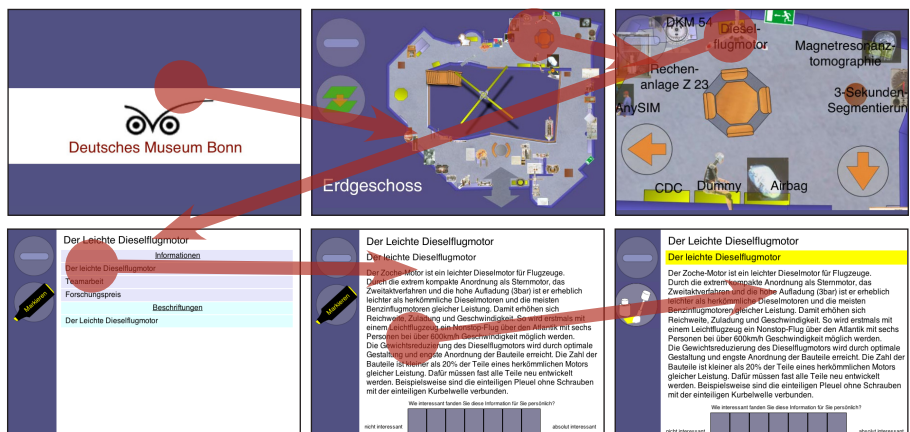


Screenshots were made on a MacBook and not on the mobile device itself, but images are identical with the exception of the navigational bar of Opera Mobile which is not shown in these images.

*Figure 19:* Study 2 Mobile Device and Program Used

already been marked as interesting, the highlighter icon changed to a "whiteout" icon that could be used to unmark the information. Each information text was followed by two questions on a 7-point scale: how personally interesting the information was, and how strongly they wanted more information about the exhibit. The program also contained a short questionnaire, which was time-delayed-activated and action-triggered. It will be described in the "Dependent Measures "section on page 121. All user actions were logged for later analysis.

The device and program used provided a workable solution for the study. However, this solution had a few limitations: the browser could not be secured against user errors or accidents (e.g., by opening a new window or by turning "grab and scroll" off) and the touchscreen allowed not only easy user action but could also receive accidental clicks when the device was put in the back-pocket of the visitor or was handled carelessly. However, PocketKiosk Builder prevented the worst possible mistakes (like opening other programs or deleting files) and visitors were instructed how to handle the device and what not to do (e.g., reloading the webpage would delete all user data). A further problem was rather structural in nature: the device was not given as an integrated part of the visit. It was given before entering the exhibition as part of a study, but not at the cash register as normal part of the visit. However, this is similar to Tate Modern where visitors are asked in the museum between floors whether they would like to use a mobile guidebook.

In summary, while this solutions was not a commercially applicable mobile platform with an accompanying CMS, it fulfilled its purpose to allow a mobile learning study in an actual museum with regular visitors under natural conditions.

### Exhibition Website

To allow visitors to engage further in the exhibits and (for the experimental group) to view their bookmarked exhibits, I created a website that contained photos of all exhibits, the corresponding labels and information texts, and the information from

the out-of print exhibition catalogue of the exhibits[33] (see Figure 20). It used an SQL database that provided the information and PHP to display it. Visitors had to log in to access the website, allowing logfile analysis of its usage: Logins and all page accesses were logged, allowing monitoring of website users and actions.

While it was not possible to use the original museum webpage, this alternative website worked very well. The content and the server was under the author's control, and logfiles could be easily accessed.

## Dependent Measures

All participants answered a paper-and-pencil questionnaire in the museum immediately after the visit (posttest, see below) and — if they chose to — online about six weeks after their visit. In the experimental condition, the mobile device furthermore created logfiles of visitor actions and, under certain circumstances, displayed a questionnaire (see below).

### Questionnaires

*Posttest:* Participants were asked about the condition and aims of their visit, their previous museum visits, the evaluation of the most interesting exhibit, the rating of the least interesting exhibit, the evaluation of the museum visit, their interest in natural science and technology, the evaluation of companions during museum visits, their self-reported knowledge, the evaluation of the museum, and their socio-demographic variables. A free-recall knowledge test about three randomly chosen exhibits was discarded after a few trials, as it was extremely unpopular: Participants either skipped this page, did not note any usable information or complained about it. Consequently, to maintain participant motivation, it was discarded, especially since the quality of the data was not too high. Participants in the experimental group were also asked about their evaluation and usage of the electronic guidebook. Sample questionnaires for both groups can be found in the appendix on page 234.

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33   Unfortunately, the catalogue was only available as a printed book since the digital files were not available any more to the museum. Digitalizing the catalogue via OCR and manual proof-reading was one of my compensations for the museum for allowing the study.

The control group received the same information and navigation structure, except for the link to "Gemerkte Informationen" [bookmarked information].

*Figure 20:* Website of the Exhibition in Study 2

The questions that visitors were asked in the posttest regarding the most interesting exhibit are of special interest. The aim of the questions was to determine the underlying structure of interest in an exhibit. However, the creation of a scale to measure the structure of interest was constrained by the possible length of such a questionnaire in the context of the field study. It was decided to keep it as short as possible to reduce strain on the side of the voluntary study participants and to allow inclusion of questions for the other topics of this study. Visitors were asked to write down the name of the exhibit that was most interesting to them and to rate it on a scale consisting of fourteen items. These items were based on interest scales that were considered suitable in this setting, i.e., factors and indicators of interest (situational and dispositional), as identified by Mitchell (1993), Chen, Darst, and Pangrazi (2001), and Hidi and Renninger (2006), as well as two museum-related items. Mitchell (1993) researched interest in secondary mathematics classrooms and constructed a 45-item questionnaire consisting of seven categories: personal interest, situational interest, meaningfulness, involvement, group work, puzzles, and computers. Meaningfulness (as "personal relevance") and group work (as "stimulated discussion") were included in the questionnaire. Chen et al. (2001) looked at interest in physical education and found five factors of situational interest: novelty, challenge, exploration intention, instant enjoyment, and attention demand. Exploration intention (as "stimulated engagement"), novelty (as "new for me"), instant enjoyment (as "immediate fun"), challenge (as "is challenging"), and attention quality (as "attracted attention") were included as questions in the questionnaire. Hidi and Renninger (2006) considered the development of interest from situational to dispositional interest. The following aspects of interest seemed suitable for inclusion in the questionnaire: positive feelings (as "entertaining" and "liking"), repeated engagement (as "repeated engagement prior to visit"), stored knowledge (as "previous knowledge"), and curiosity questions (as "had many questions"). Finally, two further questions were included as relevant to the museum setting: whether the exhibit "answered many questions" and "provided much information". The questions used are shown in Table 15. The questionnaire covered different

| ID | Item | *M* (*SD*) | MSA |
|----|------|-----------|-----|
| 1 | Das Ausstellungsstück war unterhaltsam. [The exhibit was entertaining.] | 4.67 (0.97) | .602 |
| 2 | Die Auseinandersetzung mit dem Ausstellungsstück hat mir sofort Spaß gemacht. [I immediately enjoyed engaging myself with the exhibit.] | 4.70 (1.06) | .626 |
| 3 | Das Ausstellungsstück war für mich persönlich relevant. [The exhibit was personally relevant for me.] | 4.04 (1.44) | .509 |
| 4 | Das Ausstellungsstück hat zu Diskussionen angeregt. [The exhibit stimulated discussion.] | 3.46 (1.32) | .728 |
| 5 | Das Ausstellungsstück war neu für mich. [The exhibit was new for me.] | 3.48 (1.77) | .638 |
| 6 | Das Ausstellungsstück hat meine Aufmerksamkeit angezogen. [The exhibit attracted my attention.] | 4.96 (0.88) | .731 |
| 7 | Das Ausstellungsstück war herausfordernd. [The exhibit was challenging.] | 3.78 (1.35) | .705 |
| 8 | Das Ausstellungsstück regte mich zu einer aktiven Auseinandersetzung mit dem Thema an. [The exhibit stimulated my active engagement in the topic.] | 3.99 (1.37) | .709 |
| 9 | Über das Ausstellungsstück habe ich vor dem Besuch schon viel gewusst. [I knew a lot about the exhibit prior to the visit.] | 3.58 (1.46) | .659 |
| 10 | Zu dem Ausstellungsstück hatte ich viele Fragen. [I had many questions regarding the exhibit.] | 3.26 (1.23) | .572 |
| 11 | Zu dem Ausstellungsstück wurden viele Fragen direkt vor Ort beantwortet. [Many questions regarding the exhibit were answered on the spot.] | 3.62 (1.41) | .663 |
| 12 | Zu dem Ausstellungsstück gab es in der Ausstellung viele Informationen. [There was a lot of information about the exhibit in the exhibition.] | 3.90 (1.30) | .597 |
| 13 | Mit dem Thema des Ausstellungsstücks habe ich mich schon häufig beschäftigt. [I have often engaged in the topic of the exhibit.] | 3.55 (1.49) | .604 |
| 14 | Mir gefällt das Ausstellungsstück. [I like the exhibit.] | 4.87 (0.92) | .748 |

Answers were assessed using a six-point Likert scale ranging from 1 to 6 with 'strong disagreement', 'disagreement', 'slight disagreement', 'slight agreement', 'agreement', and 'strong agreement'; middle of the scale: 3.5. MSA: Measure of sampling adequacy for Factor Analysis

*Table 15:* Questions regarding the most interesting exhibit

areas that might be relevant to why an exhibit is interesting and was short enough to be used with normal museum visitors. The answer format was a 6-point Likert scale from 1 ("strongly disagree") to 6 ("strongly agree").

*Follow-up test:* Participants were asked regarding their engagement in the exhibition topics, knowledge exchange, their evaluation of the museum, their planned further engagement in the exhibition topics, their evaluation of the website, their interest, and their pre- and post-visit activity. Participants in the experimental condition were also asked for their evaluation of the Interest Trail.

*Visit Duration*

The duration of the visit was measured by the start of the program on the mobile device in the experimental condition (checked by writing down the device number and the time the visitor entered the exhibition) and by noting distinct physical characteristics of the visitors who agreed to participate in the control condition. The latter was necessary as there were no logfiles of a mobile device to help assessing the visit duration. This strategy proved to be fairly easy, given the small number of visitors that could take part in the study — while school classes usually left the museum around mid-day, this was the time when non-school class visitors entered the museum.

*Measures on the mobile device (experimental condition only)*

*Logfiles:* The mobile device created logfiles of user actions: which information they accessed and when, and what they marked as interesting.

*Questionnaire on the PDA:* The program also contained a small, time-delayed-activated and action-triggered questionnaire. It became "armed" 15 minutes after the start of the program (counting from the first tap on the screen) and then lay dormant until a visitor next marked an exhibit as interesting. Immediately after this user action, the questionnaire was displayed once, and the visitor was asked to answer 15 questions about the exhibit. The questions were identical to those asked about the most interesting exhibit in the posttest (see Table 15 on page 120), but the aim was to ask visitors what made the exhibit interesting in exactly the hot moment when they were standing in front of it and marking it as interesting.

*Measures of the Exhibition Website*

*Logfiles:* The exhibition website required login and password, which made it possible to track user actions once they visited the website: whether they visited the site and how often, what they accessed and for how long, and whether participants in the experimental condition accessed their bookmarks or not.

Consequently, the following measures of supported interest are available:

*Visit duration:* Time on task (here: visit duration) is used as indicator of interest — interested visitors should spend more time in the exhibition.

*Self-reported interest:* Visitors should report higher interest in the topics of the exhibition after they have seen it.

*Use of additional information:* Visitors should use the available information on the mobile device if the information corresponds to their interests.

*Higher engagement:* Supported interest should lead to higher engagement with the exhibits.

*Subsequent actions after the visit:* Supported interest might lead visitors to discuss the visit with other people, e.g., fellow visitors or persons who have not been in the exhibition. They might also read related books, listen more closely to related news reports or watch related TV programs (e.g., Donald, 1991). They might also review information, e.g., visit the webpage of the exhibition or revisit the exhibition.

## Procedure

The study was conducted in March and April 2008, with a follow-up questionnaire in May, June and July. After using the first days of the study to make sure that the electronic guidebook worked as planned, research days were randomized to the two conditions. All visitors of a given day were either assigned to the experimental or the control condition due to the fact that visitors were unsupervised in the exhibition: Giving mobile devices to only a part of the visitors would lead to questions by the visitors in the control condition. This procedure was conducted to avoid treatment diffusion.

Visitors were asked at the only entrance of the exhibition (which was also the only exit) whether they would like to participate in the study, either by using a mobile device that allowed easy access to exhibit information and bookmarking of exhibits (experimental condition) or by participating in a survey after the visit (control condition),
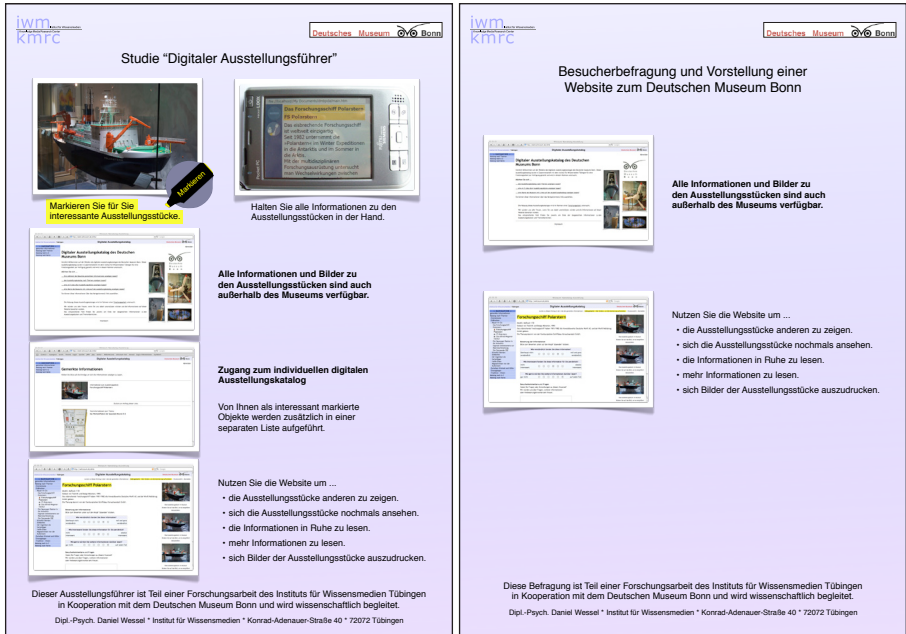
(left: experimental condition, right: control condition)

*Figure 21:* Posters used in Study 2 to show the exhibition webpage

depending on the condition of the day. In the experimental condition, visitors were shown the device, its functions, and then had the opportunity to try it out. After they had agreed that they understood the device the program was restarted (to exclude the trial from the data). The bookmarking function was also explained to them by using a poster that displayed the functions and the exhibition website (see Figure 21).

One device was offered to each visitor, no matter whether this visitor was alone or in a group; however, usually only one person in a visitor group requested a device. Consequently, data gathering was focussed on this participant. Recipients of a mobile device were requested to leave their passports or car keys as a token for the device, a procedure that all visitors except for one accepted without questioning[34]. In the control condition, visitors were only informed that a study was taking place and that, if they

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34   The only exception was a male visitor who said he did not have the time to get his passport. He tried to sway the experimenter by telling him that he was trustworthy, because he had three daughters who were in the exhibition. However, it was unclear at that time whether he had really wanted to have three daughters or ever had more than three, so he did not receive a device and consequently did not participate in the study.

wanted to participate in it, they could fill out a questionnaire at the end of their visit. They were also told about the exhibition webpage like in the experimental condition (see Figure 21 on page 123). Visitors were then free to explore the museum for as long as they wanted, like with any normal visit. On their way out, visitors in the experimental condition returned the device and received the posttest questionnaire. The visitors in the control condition who wanted to participate also received a questionnaire. Participants also received a sheet of paper on which they could note their eMail address for the exhibition website login and indicate whether they would like to participate in a short follow-up survey. They could also indicate whether they would like to receive information about the study. After filling out the questionnaire and the sheet of paper, participants were thanked and then left the exhibition. If they had given their email-address, they received an email later that day with their login information. Visitors in the experimental condition had their bookmarked exhibits available on a personal page of the website if they used this feature.

Six weeks after the visit, visitors who had left their email addresses and agreed to participate in the follow-up survey received an email with a personalized link to an online questionnaire for the follow-up test.

# Results

## General Results and Prerequisites for Further Analyses

### Sample

Despite the questionnaire being untypically long for museum studies, that is, 9 (CG) and 10 (EG) DIN A4 pages, only four participants dropped out and had to be excluded, leaving a total of 210 participants in the study (97 in the EG and 113 in the CG, but see below). Given that a paper-and-pencil questionnaire was used, a few data points are missing when participants skipped items or accidently thumbed two instead of one page. If the numbers do not add up to the total amount of participants, this is due to missing values. The museum visitors in the experimental condition were free to use

the device as they wanted, which included using the device not at all. Consequently, there was a strong self-selection regarding usage. As most visitors tried out the device immediately after receiving it, a lower bound of 5 exhibit information texts accessed was set to classify visitors of the experimental group as users. Six participants had to be excluded due to insufficient usage. It was not possible either to save the logfiles of 16 participants due to technical problems. The data of the visit were stored in a volatile storage and in some cases visitors managed to delete it, e.g., by forcing a reload of the page. Because it was not possible to determine whether they had used the device or not or to create their bookmarks on the exhibition website without the logfiles, these participants had to be excluded, reducing the number of participants in the experimental condition to 75.

Details about sample size, age, gender, educational level, condition of the museum visit, museum experience, and reason for the museum visit can be found in Table 16 on page 126.

*Age:* In the posttest, the distribution of age was approximately normal with skewness $z$-value of 0.07, $p = .472$, and kurtosis $z$-value of -0.45, $p = .674$. Age differed statistically significant in the two conditions, with the CG being 4 years older on average ($M$(EG) = 35.77, $SD$(EG) = 12.90, $M$(CG) = 39.93, $SD$(CG) = 11.20, $t$(184) = -2.334, $p = .021$). Classifying visitors into three age categories (0-17, 18-49, 50+ years) and comparing the frequency over the age groups and conditions shows that in both conditions about 80% are between 18 and 49. 16% ($n = 18$) in the control group and 12% ($n = 9$) of the experimental group were aged 50 or more. The difference was more pronounced in the 0-17 category, where the experimental group had 9.3% ($n = 7$), but the control group only 1.8% ($n = 2$). Consequently, the age difference seems to be mostly due to a greater number of young participants in the experimental group, and only partly to an absence of participants aged 50 and older in the experimental group. In the follow-up test, the distribution was still approximately normal (with skewness $z$-value of -0.43, $p = .67$, and kurtosis $z$-value of -0.83, $p = .80$). The age difference between EG and CG increased from 4.15 years to 10.8 years ($M$(EG) = 35.55, $SD$(EG) = 13.54, $M$(CG) = 46.38,

| | posttest | follow-up test |
|---|---|---|
| **Sample Size** | | |
| *n* | 188 | 42 |
| EG | 75 (39.89 %) | 20 (47.62 %) |
| CG | 113 (60.11 %) | 22 (52.38 %) |
| **Age** | | |
| mean age (SD) | 38.25 (12.05) | 41.10 (13.44) |
| range (years) | 12 – 70 | 12 – 67 |
| skewness | $z = 0.07, p = .47$ | $z = -0.43, p = .67$ |
| kurtosis | $z = -0.45, p = .67$ | $z = -0.83, p = .80$ |
| **Gender** | | |
| Male | 119 | 30 |
| Female | 66 | 11 |
| **Educational Level** | | |
| at least high-school certificate qualifying for university | 73.9 % | 78.6 % |
| student or graduate degree | 48.3 % | 52.4 % |
| **Museum Visit** | | |
| alone | 9 % | 14.3 % |
| with family | 50.5 % | 59.5 % |
| groups (w/o family) | 38.8 % | 26.2 % |
| **Museum Experience** | | |
| visited museum during the last year | 87.8 % | 85.7 % |
| visited museum of science and technology during the last year | 46.8 % | 52.4 % |
| visited this museum before | 12.8 % | 11.9 % |
| **Reasons for Museum Visit** | | |
| Interest and/or Learning | 63.8 % | 78.6 % |
| unplanned/spontaneous | 34.6 % | 42.9 % |
| entertainment | 26.6 % | 28.6 % |
| learning | 35.6 % | 38.1 % |
| interest | 43.6 % | 54.8 % |
| recommendation of others | 5.9 % | 4.8 % |
| show museum to someone else | 6.9 % | 7.1 % |
| interest in a specific exhibit | 2.7 % | ./. |
| part of an excursion | 21.8 % | 23.8 % |

*Table 16:* Sample of Study 2

$SD$(CG) = 11.28, $t(39)$ = -2.789, $p$ = .008). Age differences in the follow-up test were more pronounced.

*Gender:* Significantly more men than women took part in the study (posttest: $\chi^2(1, n = 185) = 15.184$, $p < .001$; follow-up test: $\chi^2(1, n = 41) = 8.805$, $p = .003$); however, the distribution of the two conditions did not differ significantly (posttest: $\chi^2(1, n = 185) = 1.379$, $p = .24$; follow-up test: $\chi^2(1, n = 41) = 0.067$, $p = .796$).

*Condition of the museum visit:* In posttest and follow-up test, the distribution of the condition of the museum visit under the two conditions did not differ significantly (posttest: $\chi^2(2, n = 185) = 1.142$, $p = .565$; followup-test: $\chi^2(2, n = 42) = 0.704$, $p = .703$, although 2 cells have an expected count less than 5).).

*Prior museum experience:* No significant differences could be found between the two groups regarding the prior museum experience in posttest and follow-up test. However, in the posttest, visitors who indicated "interest" as a reason for the visit were significantly more interested in science and technology, although the actual values differed only slightly ($M$(Interest) = 4.51, $SD$(Interest) = 0.69, $M$(no Interest) = 4.14, $SD$(no Interest) = 0.84, $t(182) = 3.2$, $p = .002$).

*Interest in science and technology:* On average, visitors were interested in science and technology in posttest and follow-up test. In the posttest, on a 21-item scale of interest in science and technology (Cronbach's α = .947), the mean was 4.29 ($SD = 0.80$; $t(186) = 13.607$, $p < .001$; measures of the individual items on a 6-point Likert scale ranging from 1 to 6, with items recoded such that higher values mean greater interest) with no differences between EG and CG ($M$(EG) = 4.31, $SD$(EG) = 0.78; $M$(CG) = 4.29, $SD$(CG) = 0.82, $t(185) = 0.217$, $p = .828$). However, men were found to be more interested in science and technology on the 21-item scale in a two-way ANOVA with gender and condition as independent factors ($F$(IA)(1, 180) < 1, *n.s.*; $F$(condition)(1, 180) < 1, *n.s.*; $F$(gender)(1, 180) = 29.975, $p < .001$). In the follow-up test similar results were found: Cronbach's α was .932, the mean was 4.46 ($SD = 0.66$; $t(41) = 9.341$, $p < .001$) with no differences between EG and CG ($M$(EG) = 4.43, $SD$(EG) = 0.64; $M$(CG) = 4.48, $SD$(CG) = 0.70, $t(40) = -.254$, $p = .801$).

## Participant Dropout over the Course of the Study

As the study was conducted with normal visitors who did not receive any payment for their participation, there was a considerable dropout. Figure 22 gives an overview of the dropout of the participants over the different stations: filling out the posttest questionnaire, requesting a login to the exhibition website (which meant that they left their email-address[35]), willingness to participate in the follow-up survey (as indicated
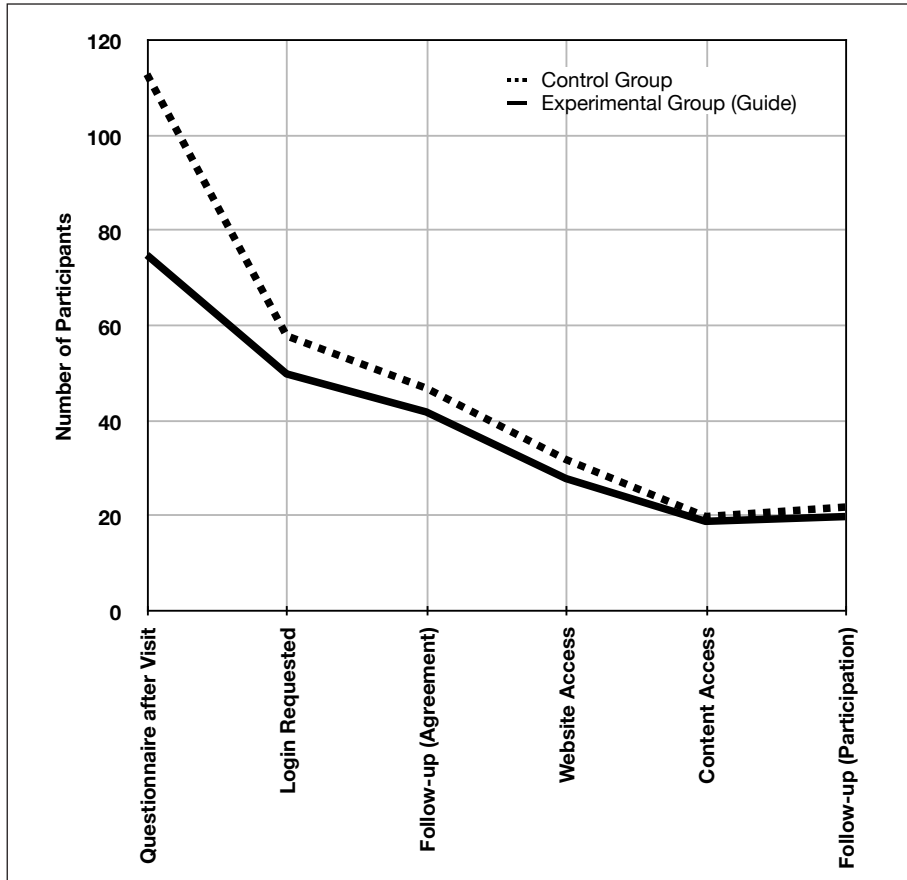


Participants that had to be excluded due to technical problems or failed manipulation check are not included in this graph.

*Figure 22:* Dropout of participants in Study 2

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35   An unforeseen problem was that all except one visitor were perfectly willing to give their passport as a token for the device in the experimental condition, but most visitors were extremely hesitant in giving out their email address, thus preventing them from visiting the exhibition website (which required a login and password) and from participation in the online follow-up test.

by marking a checkbox), accessing the exhibition website, accessing content on the exhibition website (i.e., information about exhibits), and participating in the follow-up survey.

However, while the dropout from posttest to follow-up test was significant, the characteristics of the posttest and followup sample did not seem to differ much.

In summary, the sample seems to be an ecologically valid sample of regular visitors.

## Manipulation Check

*Did the exhibition elicit interest?* When visitors were asked to indicate how much the personally most interesting exhibit scored on a scale from 1 to 10 (10 being most interesting topic in their life at the moment), the average score was 5.94 ($SD = 2.02$, $Md = 6$, $Mo = 6$). Only 5 visitors (2.7%) gave the lowest score. The personally least interesting exhibit (same scale) reached a 2.59 ($SD = 1.77$, Md = 2, Mo: 1 and 2) on average. The exhibition offered something of interest to almost all visitors, but there were also particular exhibits that were relatively uninteresting for visitors.

*Did the participants of the experimental condition use the device?* While the mobile device was used, with 49.29 exhibit information texts on average accessed on the device ($SD = 32.49$), only 61.3 % visitors marked at least one exhibit as interesting. The average value of marked exhibits of 5.83 ($SD = 24.83$) is misleading, because the median is 1 and the mode is 0. Consequently, a majority of the participants did use the device to access information, but few marked pieces of information as interesting.

*Evaluation of the device:* Participants of the experimental group reported that the device was easy to use, with 88 % agreeing to this question ($M = 4.79$, $SD = 1.12$, 6-point scale). A one-sample $t$ Test against the scale middle of 3.5 led to a statistically significant result ($t(74) = 9.962$, $p < .001$). There was no statistically significant correlation between the rating of the perceived novelty of using the device and the self-rated ability to handle the device ($r = -.122$, $n = 75$, $p = .295$). Thus, handling of the device was not related to the newness of the device itself. There was no statistically significant correlation between age and the self-rated ability to handle the device either ($r = -.144$, $n = 75$, $p = .217$). In general, the evaluation of the device was positive, as is shown in Table

17: users agreed that it was fun to use, that they liked using it in an exhibition, could discover things on their own, found the information comprehensible, found quickly what they were looking for, could orientate well on the map, and liked discovering things on the device. They disagreed that the device constrained them and that the technology controlled them. They also stated that they had looked at much information on their device and that their engagement with these information was high. There was also a tendency that the device satisfied their interest in the topics.

It should be noted that only those participants of the experimental group that had used the device to access at least five information texts were included in the analysis. However, this barrier is rather low and only six participants had to be excluded due to lack of usage.

*Self-reports:* It seems that visitors were able to estimate how many exhibits, labels, etc. they had seen in the exhibition. The correlation between the self-report of "I have seen much information on the guide" and the amount of visited exhibits on the PDA was highly significant, with $r = .386$ and $p < .001$.

|  | M | SD | t Test |
|---|---|---|---|
| fun to use | 4.33 | 1.19 | $t(74) = 6.068, p < .001$ |
| liked using it in the exhibition | 4.08 | 1.22 | $t(72) = 4.071, p < .001$ |
| could discover things on their own | 3.91 | 1.29 | $t(74) = 2.739, p < .001$ |
| found the information comprehensible | 4.53 | 1.09 | $t(74) = 8.175, p < .001$ |
| found quickly what they searched | 4.32 | 1.43 | $t(74) = 4.95, p < .001$ |
| could orientate well on the map | 4.28 | 1.39 | $t(74) = 4.857, p < .001$ |
| liked discovering things on the device | 4.01 | 1.31 | $t(74) = 3.394, p = .001$ |
| device constrained them | 2.65 | 1.29 | $t(74) = -5.688, p < .001$ |
| technology controlled them | 2.07 | 1.20 | $t(74) = -10.339, p < .001$ |
| looked at much information on the device | 4.27 | 1.23 | $t(74) = 5.381, p < .001$ |
| engagement with this information was high | 3.79 | 1.22 | $t(74) = 2.031, p = .046$ |
| device satisfied their interest to the topics | 3.76 | 1.23 | $t(74) 0 1.833, p = .071$ |

7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree). *t* Test against the scale middle of 3.5.

*Table 17:* Rating of the Mobile Device

# Question 1: What Makes an Exhibit Interesting?

In contrast to the exhibition used in Study 1, the museum used in Study 2 was well-suited to find out what makes an exhibit interesting for visitors. In the following, the analysis strategy for Question 1 is explained first, then the objective characteristics of the most interesting exhibits are analyzed. The major part of this section is to determine the subjective visitor-exhibit relation to find out what makes an exhibit interesting for particular visitors.

## Analysis Strategy for Question 1

*Data from regular visitors are used:* Visitors were asked to rate the exhibit that interested them most on 14 items (see page 120). The experimental condition also had this questionnaire on their mobile device to be asked at the hot moment when they were standing in front of the exhibit (see page 121). Unfortunately, few visitors ($n = 16$) filled out the questionnaire on the mobile device. Informal conversations about the questionnaire revealed that most visitors did not notice that the textual information had changed but clicked on the "close" icon a second time. While placing the "close" icon of the questionnaire at the same place as the one for the exhibit information made the design coherent, it was prone to this error kind of error. Consequently, the data from the mobile device could not be used for analysis. Because data from different conditions should not be mixed for an exploratory factor analysis (as combining heterogeneous groups can induce spurious correlations; see Pedhazur & Pedhazur Schmelkin, 1991), only the control condition is used to answer this question due to the larger sample and its higher usefulness in generalizing the results to other museum settings (which likely will not have a mobile device). Finding out which factors are responsible to make an exhibit interesting for a particular visitor allows us then to address this interest with mobile devices.

*Objective vs. Subjective Factors:* As mentioned in the theoretical background to this question on page 32, some museum researchers see objective factors of the exhibits as reasons why visitors are interested in them. However, a interactive perspective corre-

sponding to the subject-object relationship of interest seems to be more suitable. Given that visitors were also asked to name the exhibit they found most interesting, it is possible to analyze both perspectives. Consequently, first the objective characteristics of the most interesting exhibits for particular visitors are assessed. The focus is on two attributes: interactivity, because it is explicitly mentioned by different researchers (e.g., Ansbacher, 2003, Allen, 2004, or by those cited by Csikszentmihalyi and Hermanson, 1995), and exceptionally large size, because this is something that can hardly be realized outside of a museum (e.g., computer screens have their limitations what they can display at any given time, and even large books have their limits). In the first part of the analysis, it is examined whether interactive exhibits were mentioned more often as the most interesting ones than non-interactive exhibits, and whether the by-far largest exhibit was mentioned more often as the most interesting exhibit compared to the other exhibits. In effect, it is analyzed whether they were mentioned more often than their frequency in the museum. The second part of the analysis focused on the specific visitor-exhibit relationship across different visitors and exhibits. In order to determine whether there are subjective factors between the exhibits that underlie what makes an exhibit interesting to a particular visitor, an exploratory factor analysis (EFA) is conducted. Data on all exhibits that were mentioned as most interesting is analyzed. The goal is to move beyond a singular exhibit evaluation and find overarching similarities in the visitor-exhibit relationship between heterogeneous exhibits.

*Most Interesting Exhibit*

The distribution of the ratings of the most interesting exhibit was negatively skewed (skewness $z$-value: -2.72, $p = .003$), with a mean of 5.90 ($SD = 2.03$; $Md = 6$, $Mo = 7$) on a 10-point scale, with values ranging over the entire scale from one to ten. While a mean of 5.9 on a scale from 1 to 10 seems low, it should be considered that the scale was defined by 'of no interest' (0) to 'most interesting thing/topic at the moment' (10). The middle of the scale (5.5) does not denote 'no interest' but 'medium interest'. This indicates that most visitors found exhibits that were of medium to high interest for them.

*Objective Factors of Exhibits: Interactivity and Large Size*

The exhibit named most interesting by a visitor was in 35.7% of the cases (40 cases) an interactive exhibit, in 48.2% (54 cases) non-interactive. 6.2% did not answer this question, and 9.8% of the answers could not be clearly attributed to an exhibit. One difficulty was that the museum had two very similar and frequently (20 times) mentioned exhibits: a huge prototype of the 'Transrapid' (the name of the German maglev train) in front of the museum (the by far largest exhibit of the museum) and an interactive maglev train exhibit inside of the museum. Since 'maglev train' includes 'Transrapid' (but not vice versa), the exact terms written by the visitors were used as basis for the decision. 'Transrapid' (14/20) was related to the non-interactive prototype, while 'maglev train' (6/20) was interpreted as referring to the interactive model. The rate of interactive exhibits in the museum in total was 12.5%. A chi-square goodness-of-fit test revealed there was a significant difference in the proportion of interactive exhibits indicated as the most interesting exhibit in the current sample (42.5%) as compared with the value of 12.5% that represents the amount of interactive exhibits in the museum ($\chi^2(1, n = 94) = 77.623, p < .001$). Even if all visitors who found the maglev train or 'Transrapid' the most interesting exhibit are excluded, the result is still statistically significant ($\chi^2(1, n = 74) = 54.616, p < .001$). This means that interactive exhibits were much more likely to be considered the most interesting exhibit.

However, whether the most interesting exhibit was interactive or not did not make any statistically significant difference regarding the average rating the exhibit received on the 10-point Likert scale. When assessed with an independent-samples *t* Test, the difference between non-interactive exhibits ($M = 5.92, SD = 1.93$) and interactive exhibits ($M = 5.35, SD = 2.21$) was not significant, $t(91) = 1.334, p = .186$ (two-tailed). There was no statistically significant difference either on a self-developed scale of dispositional interest regarding natural science and technology (22 items, Cronbach's $\alpha$ = .936) between visitors who chose a non-interactive exhibit as most interesting ($M = 4.18, SD = 0.77$) and those who chose an interactive exhibit ($M = 4.22, SD = 0.77$); $t(91) = -0.230, p = .818$.

The largest exhibit ('Transrapid' prototype) was mentioned 14 times as the most interesting exhibit, far more often than expected by chance ($\chi^2$(1, $n$ = 94) = 174.966, $p <$ .001), with no differences in absolute ratings (not transrapid: $M$ = 5.63, $SD$ = 2.13; transrapid: $M$ = 5.93, $SD$ = 1.73; $t$(91) = -.492, $p$ = .624, two-tailed) or dispositional interest (not transrapid: $M$ = 4.19, $SD$ = 0.74; transrapid $M$ = 4.22, $SD$ = 0.92; $t$(91) = -.156, $p$ = .876, two-tailed).

This indicates that there is no significant difference between visitors who chose an interactive or the largest exhibit as most interesting, and visitors, who chose non-interactive exhibits or smaller exhibits as most interesting, neither in the strength of interest nor in dispositional interest.

*Least Interesting Exhibit*

A problem regarding the least interesting exhibit was that many visitors gave answers that did not apply to single exhibits but to whole content areas (e.g. 'medical technology', 'space flight', 'chemistry'). Given that 18 visitors (16.1%) did not answer the question and 35 answers (31.2%) could not be assigned, as they mentioned entire content areas (or gave 'forgotten' as answer), it is possible that visitors did not mention the least interesting exhibit they had encountered but the least interesting they could remember — which was at least interesting enough to be remembered. In contrast to the most interesting exhibit, it seems unlikely that there is a clear 'least interesting exhibit'. Results should therefore be regarded with care. Of the clearly identifiable exhibits, 6 (10%) were interactive and 53 (90%) were non-interactive. A chi-square goodness-of-fit test indicates that there is no statistically significant difference in the proportion of interactive exhibits indicated as least interesting in the current sample (6/59 = 10.2%) as compared with the value of 12.5% that represents the amount of interactive exhibits in the museum ($\chi^2$(1, $n$ = 59) = 0.293 , $p$ = .588). Whether an exhibit was rated as least interesting or not did not seem to be related to its level of interactivity.

## Overlap Between Most and Least Interesting Exhibits

While there are exhibits that are named as most interesting more often than predicted by chance, there were still impressive interpersonal differences: Many exhibits that were chosen as most interesting exhibits by some visitors were the least interesting exhibits for others, and vice versa. For example, one visitor found the energy-saving house most interesting, for two other visitors it was the least interesting. For six visitors, the interactive maglev train was most interesting, but there was a minority of one who found it least interesting. This means that on the one hand, there are exhibits that are more interesting than expected by chance, but that, on the other hand, personal differences do matter (see Table 14 for a comparison regarding the interactive exhibits). This also shows the limitations of searching for the reason why something is interesting solely in the exhibit and puts doubt to theories of museum researchers who focus on exhibits alone. Consequently, the specific visitor-exhibit interaction has to be examined to find out what makes a particular exhibit interesting for this particular visitor.

## Subjective Factors of Exhibits: Visitor-Exhibit Relation

To assess the subjective factors underlying the most interesting exhibits, an exploratory factor analysis (EFA) was conducted. The ratings of visitors on the 14-item scale regarding the exhibit each visitor personally found most interesting were used, thus assessing different exhibits and different visitors. This should lead to the underlying factors that make exhibits interesting for visitors in general, independent of the specific kind of exhibit or the particular characteristics of the visitor.

*Analysis strategy:* As a factor analytic strategy, the procedure recommended by Tabachnick and Fidell (2007) was used: First, a principal components extraction was used to estimate the factorability of the correlation matrix, the likely number of factors, and whether variables might or must be excluded from the subsequent analyses. Then different EFAs with different numbers of factors and extraction techniques were used exploratorily to find a solution with the greatest scientific utility, consistency, and meaning, which can then be used for interpretation. All participants with missing values

in the scale were excluded (11 of 113) because estimation of missing data can 'create' factors (Tabachnick & Fidell, 2007).

*Assumptions:* There are several assumptions that must be fulfilled to calculate an EFA. The main issue here is the small sample size of 101 participants. The general recommendation for EFA are large samples, although there is much debate about what 'large' means (see Tabachnick and Fidell, 2007). A major problem is that correlations fluctuate more from sample to sample for small samples (Tinsley & Tinsley, 1987), which can lead to rogue or splinter factors (Froman, 2001). Unfortunately, it was not possible to increase the sample size. Some statisticians might regard the sample size as too small or as (barely) sufficient, although rules of thumb for sample size have been criticized (cf. Pedhazur & Pedhazur Schmelkin, 1991; Tabachnick & Fidell, 2007; and Tinsley & Tinsley, 1987). The recommendation of Tinsley and Tinsley (1987) of 5-10 participants per item seemed suitable, which places the present sample size of 101 well within these bounds (14*5=70 to 14*10 = 140). To examine further whether the present sample size is sufficient for this EFA, the factor loadings and the simplicity of the received factor structure was assessed (cf. Field, 2005). This shows empirically if the present data set can be used for an exploratory factor analysis.

Regarding the factorability of the correlation matrix (see Table 18), Bartlett's Test of Sphericity is highly significant ($\chi^2(91) = 414.508$, $p < .001$), the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) is .654, thus sufficiently high for a good EFA (Tabachnick & Fidell, 2007) but only mediocre according to Kaiser (1974). All measures of sampling adequacy (MSA) are above the required minimum of .5, with the values varying between .509 and .748 (see Table 15 on page 120). An EFA is possible with respect to these criteria, but the results might not be as distinct and reliable as desired. Multicollinearity was also sufficient with 17/91 correlations exceeding a value of ±.3 (43/91 are statistically significant). All but one ('had many questions') squared multiple correlations were larger than .3, mostly low values in the anti-image correlation matrix (86/91 correlations between -.3 and .3), and the determinant is neither zero nor one. Probably due to the small sample size, these values are not as good as desired,

| ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|----|---|---|---|---|---|---|---|---|---|----|----|----|----|----|
| 1 | .535 | **.661** | .081 | .031 | -.107 | .160 | .190 | .132 | .157 | -.105 | .157 | .259 | .037 | **.432** |
| 2 | **.661** | .616 | .288 | .182 | -.131 | .254 | .199 | **.333** | .164 | -.094 | .238 | **.362** | .048 | **.358** |
| 3 | .081 | .288 | .321 | .111 | -.129 | .096 | -.057 | .030 | .264 | .000 | .002 | -.067 | **.354** | -.116 |
| 4 | .031 | .182 | .111 | .360 | .218 | .238 | **.444** | **.453** | -.170 | .013 | .253 | .149 | -.175 | .098 |
| 5 | -.107 | -.131 | -.129 | .218 | .453 | .192 | .166 | .220 | **-.544** | **.384** | .184 | .147 | -.249 | -.023 |
| 6 | .160 | .254 | .096 | .238 | .192 | .356 | **.304** | **.503** | -.106 | -.027 | .060 | -.012 | .025 | **.337** |
| 7 | .190 | .199 | -.057 | **.444** | .166 | **.304** | .410 | **.507** | -.133 | .203 | .198 | .210 | -.164 | .210 |
| 8 | .132 | **.333** | .030 | **.453** | .220 | **.503** | **.507** | .523 | -.067 | .031 | .199 | .184 | -.071 | **.377** |
| 9 | .157 | .164 | .264 | -.170 | **-.544** | -.106 | -.133 | -.067 | .489 | -.234 | -.100 | .015 | **.520** | .027 |
| 10 | -.105 | -.094 | .000 | .013 | **.384** | -.027 | .203 | .031 | -.234 | .259 | .189 | .116 | -.024 | -.138 |
| 11 | .157 | .238 | .002 | .253 | .184 | .06 | .198 | .199 | -.100 | .189 | .401 | **.589** | .019 | .077 |
| 12 | .259 | **.362** | -.067 | .149 | .147 | -.012 | .210 | .184 | .015 | .116 | **.589** | .465 | .039 | .164 |
| 13 | .037 | .048 | **.354** | -.175 | -.249 | .025 | -.164 | -.071 | **.520** | -.024 | .019 | .039 | .382 | -.035 |
| 14 | **.432** | **.358** | -.116 | .098 | -.023 | **.337** | .210 | **.377** | .027 | -.138 | .077 | .164 | -.035 | .356 |

Correlations > .3 in **bold**, Principal Diagonal (grey): Squared Multiple Correlations (SMCs) (initial communality estimates), Items:

1   Das Ausstellungsstück war unterhaltsam. [The exhibit was entertaining.]
2   Die Auseinandersetzung mit dem Ausstellungsstück hat mir sofort Spaß gemacht. [I immediately enjoyed engaging myself with the exhibit.]
3   Das Ausstellungsstück war für mich persönlich relevant. [The exhibit was personally relevant for me.]
4   Das Ausstellungsstück hat zu Diskussionen angeregt. [The exhibit stimulated discussion.]
5   Das Ausstellungsstück war neu für mich. [The exhibit was new for me.]
6   Das Ausstellungsstück hat meine Aufmerksamkeit angezogen. [The exhibit attracted my attention.]
7   Das Ausstellungsstück war herausfordernd. [The exhibit was challenging.]
8   Das Ausstellungsstück regte mich zu einer aktiven Auseinandersetzung mit dem Thema an. [The exhibit stimulated my active engagement in the topic.]
9   Über das Ausstellungsstück habe ich vor dem Besuch schon viel gewusst. [I knew a lot about the exhibit prior to the visit.]
10  Zu dem Ausstellungsstück hatte ich viele Fragen. [I had many questions regarding the exhibit.]
11  Zu dem Ausstellungsstück wurden viele Fragen direkt vor Ort beantwortet. [Many questions regarding the exhibit were answered on the spot.]
12  Zu dem Ausstellungsstück gab es in der Ausstellung viele Informationen. [There was a lot of information about the exhibit in the exhibition.]
13  Mit dem Thema des Ausstellungsstücks habe ich mich schon häufig beschäftigt. [I have often engaged in the topic of the exhibit.]
14  Mir gefällt das Ausstellungsstück. [I like the exhibit.]

*Table 18:* Inter-item correlations of the items used

but they are sufficient for an EFA.

Regarding normality, one problem is that five variables are negatively skewed and six show statistically significant non-normal kurtosis, which can lead to a degraded solution for descriptive use and prohibits statistical inference (Tabachnick & Fidell, 2007). The sample may be analyzed, but the results might not be generalizable unless

replicated with another sample. Consequently, this analysis might give first insights into the issue and be a stepping stone for further research.

To assess linearity, spot-checks of the three most negatively skewed variables and the three least skewed variables (no variables were positively skewed) were made which showed departure from linearity in some cases, but no evidence of true curvilinearity. Multicollinearity and Singularity do not seem to be an issue with the data, since squared multiple correlations are all much smaller than one (the largest being .616), the determinant of the correlation matrix is .012 (i.e., greater than the minimum of .00001 recommended by Field, 2005), the largest correlation is .661 (much smaller than .9, the maximum recommended by Field, 2005). Tolerance values are greater than .10 and corresponding VIF are smaller than 10.

Since two variables ('had many questions' and 'was personally relevant for me') had low squared multiple correlations (.259 and .321, respectively), they were regarded as possible outliers among the variables in the major analyses. Tabachnick and Fidell (2007) would recommend ignoring these variables and either deleting them for further use or adding similar variables.

*Number of factors:* To assess the number of factors, a principal component analysis was computed. First, the eigenvalues were compared with the results of a parallel analysis (using the program by O'Connor, 2000). While the results of parallel analysis indicate a four-factor solution (see Figure 23), the randomly generated eigenvalues for factor three and four were marginally below the found eigenvalues. The Minimum Average Partial correlation (MAP) test indicates two components (using a program by O'Connor, 2000). However, according to Tabachnick and Fidell (2007), MAP does not work well when some components have only a few variables that load on them. A subjective scree test indicates either two or four factors (cf. Kline, 1994, p. 75). Therefore it was decided to assess a different number of factors (between two and four) and evaluate the factor loadings under the aspect of parsimony and interpretability. If the four-factor solution has high loadings, over-extraction seems unlikely (cf. Preacher & MacCallum, 2003). While four factors seem to be a lot for 14 items, it is still below the
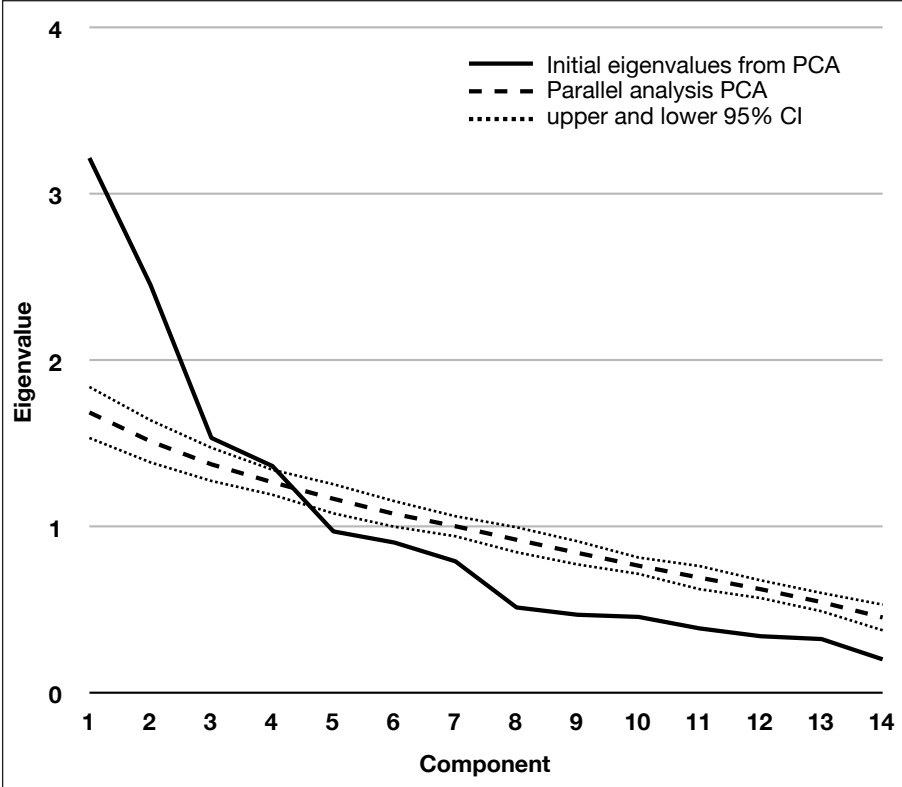
Parallel Analysis: Actual eigenvalues (from preliminary PCA) displayed as line, random eigenvalues, calculated with a program by O'Connor (2000) with Ncases = 101, Nvars = 14, Ndatasets = 100 (PCA), as interrupted line, 95%-CIs shown as dotted line.

*Figure 23:* Parallel analysis and subjective scree test

20:1 ratio of subjects to factors recommended by Kline (1994).

*Extraction method:* The descriptive principal axis factoring (PAF) extraction method was used, as it might not be possible to generalize the findings due to the non-normal distributions of the items. However, the results from inferential maximum likelihood factoring (ML) were also assessed to estimate factor loadings for a population that maximizes the likelihood of sampling the observed correlation matrix (see Tabach-nick & Fidell, 2007), because 'one test of the stability of a FA solution is that it appears regardless of which extraction technique is employed' (Tabachnick & Fidell, 2007). In this study, using maximum likelihood resulted in similarly meaningful factor load-ings and would thus lead to the same identified factors, which speaks for the stability

of the EFA solution.

*Factor Rotation:* Following the advice of several authors (e.g. Field, 2005; Pedhazur and Pedhazur Schmelkin, 1991; Tabachnick and Fidell, 2007), an oblique rotation (direct oblimin) was used first to assess the correlation between the factors in order to find a simple structure that is interpretable. If the correlation is low (i.e., lower than .3; see Pallant, 2007) and the results are similar, an orthogonal rotation method (varimax) can be used due to its simplicity. In this study, the correlations between the extracted factors using direct oblimin rotation were below .3. The results turned out to be similar, regardless whether varimax or direct oblimin was used, so it was decided to use the varimax rotation for simplicity.

*Results of the Exploratory Factor Analysis:* Of the different numbers of factors, only the two-factor solution and the four-factor solution were considered interpretable. The two-factor solution is shown in Table 19.

The factors could (speculatively) be named "situational interest" and "dispositional interest", due to their dependence on situational (Factor 1) and more enduring aspects of interest (e.g., prior knowledge; Factor 2). Though parsimonious, the two factor solution also had eight very low communalities (i.e., smaller than .3). This indicates that these items do not fit well with the other items in the factors (Tabachnick and Fidell, 2007). The goodness-of-fit test of the maximum likelihood extraction also showed a statistically significant result ($\chi^2(64) = 165.51$ , $p < .001$), indicating poor fit. In contrast, the four-factor solution (see Table 20 on page 142) showed only two communalities lower than .3, which were the same ones which had very low squared multiple correlations (i.e., are possible outliers among the variables) and should be used with care or excluded (Tabachnick & Fidell, 2007). Furthermore, the solution also had high loadings, so over-extraction seemed unlikely. Therefore it was decided to use the four-factor solution.

The four factors identified could be named *Attraction Power* (Factor 1; after a concept that is used in the museum literature and refers to the ability of exhibits to attract attention, consisting of 'stimulated active engagement', 'attracted attention', 'was chal-

| Item | Factor 1 | Factor 2 | Communalities |
|---|---|---|---|
| Die Auseinandersetzung mit dem Ausstellungsstück hat mir sofort Spaß gemacht. [I immediately enjoyed engaging myself with the exhibit.] | **.686** | **.411** | .639 |
| Das Ausstellungsstück regte mich zu einer aktiven Auseinandersetzung mit dem Thema an. [The exhibit stimulated my active engagement in the topic.] | **.670** | -.157 | .474 |
| Das Ausstellungsstück war herausfordernd. [The exhibit was challenging.] | **.557** | -.245 | .371 |
| Das Ausstellungsstück war unterhaltsam. [The exhibit was entertaining.] | **.519** | **.362** | .400 |
| Mir gefällt das Ausstellungsstück. [I like the exhibit.] | **.490** | .130 | .257 |
| Das Ausstellungsstück hat meine Aufmerksamkeit angezogen. [The exhibit attracted my attention.] | **.468** | -.072 | .224 |
| Das Ausstellungsstück hat zu Diskussionen angeregt. [The exhibit stimulated discussion.] | **.464** | -.249 | .278 |
| Zu dem Ausstellungsstück gab es in der Ausstellung viele Informationen. [There were much information about the exhibit in the exhibition.] | **.430** | -.002 | .185 |
| Zu dem Ausstellungsstück wurden viele Fragen direkt vor Ort beantwortet. [Many questions regarding the exhibit were answered on the spot.] | **.402** | -.113 | .174 |
| Über das Ausstellungsstück habe ich vor dem Besuch schon viel gewusst. [I knew much about the exhibit prior to the visit.] | -.064 | **.737** | .547 |
| Das Ausstellungsstück war neu für mich. [The exhibit was new for me.] | .192 | **-.654** | .465 |
| Mit dem Thema des Ausstellungsstücks habe ich mich schon häufig beschäftigt. [I have often engaged in the topic of the exhibit.] | -.066 | **.468** | .224 |
| Zu dem Ausstellungsstück hatte ich viele Fragen. [I had many questions regarding the exhibit.] | .050 | **-.341** | .119 |
| Das Ausstellungsstück war für mich persönlich relevant. [The exhibit was personally relevant for me.] | .083 | **.314** | .106 |
| **Proportion of Variance** | .184 | .135 | .319 |
| **Proportion of Covariance** | .577 | .423 | |

**bold:** meaningful loadings; communalities after extraction; Principal Axis Factoring with Varimax Rotation

*Table 19:* Two-factor solution of exploratory factor analysis

lenging', 'stimulated discussion', and 'was new to me'), *Instant Enjoyment* (Factor 2; 'was entertaining', 'immediately enjoying', and 'like the exhibit'), *Familiarity* (Factor 3; 'knew much about exhibit prior to visit', 'often occupied myself with topic of exhibit', 'personally relevant', and 'not new for me'), and *Information Value* (Factor 4; 'much information about exhibit', 'many questions about exhibit answered on the spot', and

| Item | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Comm. |
|---|---|---|---|---|---|
| Das Ausstellungsstück regte mich zu einer aktiven Auseinandersetzung mit dem Thema an. [The exhibit stimulated my active engagement in the topic.] | **.802** | .170 | .009 | .087 | .681 |
| Das Ausstellungsstück hat meine Aufmerksamkeit angezogen. [The exhibit attracted my attention.] | **.595** | .168 | .015 | -.081 | .389 |
| Das Ausstellungsstück war herausfordernd. [The exhibit was challenging.] | **.561** | .109 | -.120 | .196 | .380 |
| Das Ausstellungsstück hat zu Diskussionen angeregt. [The exhibit stimulated discussion.] | **.542** | -.007 | -.063 | .182 | .331 |
| Das Ausstellungsstück war unterhaltsam. [The exhibit was entertaining.] | .079 | **.746** | .061 | .160 | .592 |
| Die Auseinandersetzung mit dem Ausstellungsstück hat mir sofort Spaß gemacht. [I immediately enjoyed engaging myself with the exhibit.] | .258 | **.675** | .213 | .247 | .628 |
| Mir gefällt das Ausstellungsstück. [I like the exhibit.] | .300 | **.542** | -.079 | -.027 | .390 |
| Über das Ausstellungsstück habe ich vor dem Besuch schon viel gewusst. [I knew much about the exhibit prior to the visit.] | -.191 | .219 | **.721** | -.109 | .617 |
| Mit dem Thema des Ausstellungsstücks habe ich mich schon häufig beschäftigt. [I have often engaged in the topic of the exhibit.] | -.088 | -.036 | **.679** | .043 | .473 |
| Das Ausstellungsstück war für mich persönlich relevant. [The exhibit was personally relevant for me.] | .112 | -.004 | **.485** | .011 | .248 |
| Das Ausstellungsstück war neu für mich. [The exhibit was new for me.] | **.321** | -.287 | **-.433** | .278 | .451 |
| Zu dem Ausstellungsstück gab es in der Ausstellung viele Informationen. [There were much information about the exhibit in the exhibition.] | .048 | .254 | .007 | **.745** | .623 |
| Zu dem Ausstellungsstück wurden viele Fragen direkt vor Ort beantwortet. [Many questions regarding the exhibit were answered on the spot.] | .15 | .072 | .000 | **.708** | .529 |
| Zu dem Ausstellungsstück hatte ich viele Fragen. [I had many questions regarding the exhibit.] | .109 | -.287 | -.137 | **.309** | .208 |
| **Proportion of Variance** | .140 | .118 | .107 | .101 | .466 |
| **Proportion of Covariance** | .300 | .254 | .229 | .217 | |

**bold:** meaningful loadings; communalities (Comm.) after extraction; Principal Axis Factoring with Varimax Rotation

*Table 20:* Four-factor solution of exploratory factor analysis

'had many questions regarding exhibit').

If the factor loadings and the simplicity of the obtained factor structure are taken into consideration, the sample size seems to have been sufficient for this EFA. Application of the EFA led to a small number of factors that describe the subjective visitor-exhibit relationship that determines interest in the exhibit by a visitor.

## Question 2: (How) Can Interest Be Supported During the Museum Visit?

Does the immediate availability of information have an effect on the indicators of supported interest?

*Usage of available information:* On average, visitors accessed 49.29 entries on the PDA ($SD = 32.49$). Visitors in the EG were asked about their level of engagement (amount and strength) with the exhibits, the exhibit labels, the information in the exhibition, exhibition movies, media terminals, and the information on the PDA. Visitors reported the highest engagement with exhibits, followed by labels, information in the exhibition, the device itself, then media terminals and finally the movies (see Table 21). A repeated-measures ANOVA with contrasts shows a significant difference between the exhibits and the other information sources (which were less often attended to), but not between the different information sources themselves. No significant differences were found for strength of engagement. While visitors accessed the information, few marked information as interesting. Accessing information on the PDA was secondary

|  | looked at | intensive engagement |
|---|---|---|
| exhibits | 4.87 (0.89) | 4.04 (1.05) |
| labels | 4.49 (1.13) | 4.04 (1.05) |
| exhibit information texts | 4.39 (1.20) | 3.84 (1.21) |
| media terminals | 3.15 (1.44) | 3.08 (1.34) |
| movies | 2.93 (1.42) | ./. |
| mobile device information | 4.27 (1.23) | 3.79 (1.22) |

Mean and standard deviation (in brackets), data on a 6-point Likert scale with 1 = strong disagreement and 6 = strong agreement. Engagement with movies was not asked. The identical values for engagement regarding exhibits and labels are not a copy-and-paste error but the actual data.

*Table 21:* Engagement Differences in Study 2

to the exhibits, but comparable to the other information sources in the museum.

*Usage over time:* Figure 24 shows the aggregated usage of all users of the device over time. The figure indicates that visitors do not 'test' the device at the beginning and subsequently put it away, but that they do use the device during the whole visit. As expected, map usage is higher in the first few percentages of the visit. The increase of map usage at the end of the visit is probably an artifact because the screen to save the
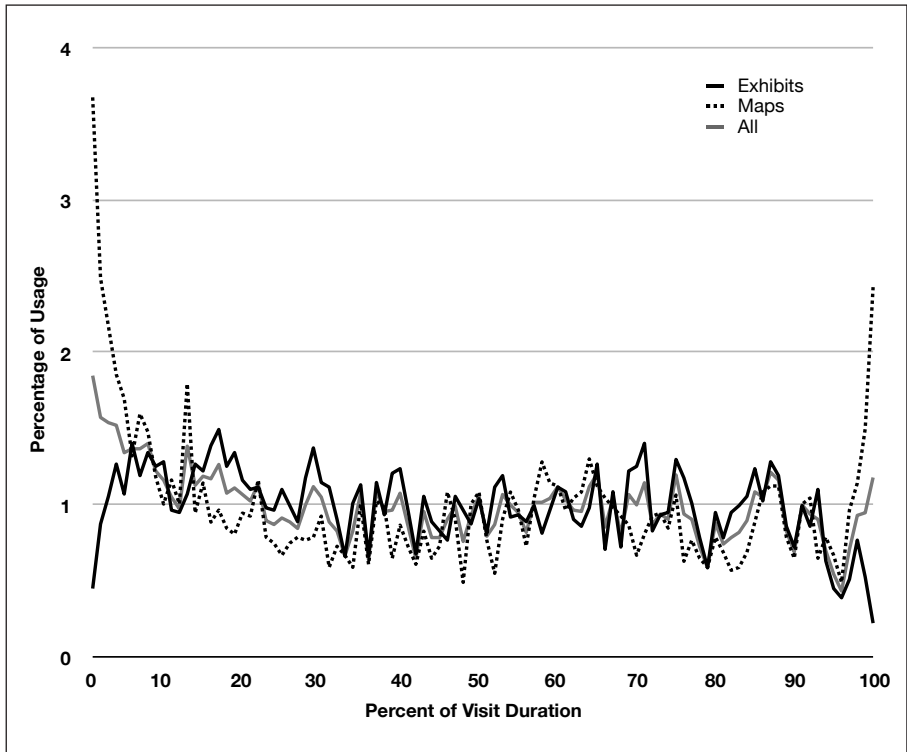


Due to individual differences in visit duration and PDA usage of the visitors, the individual data were transformed to percentages. While the absolute duration of the visit is different for each visitor, the x axis shows the visit duration in percentages of the individual visitors visit duration aggregated over all visitors. Percentage of Usage shows the usage of the device relative to the total usage aggregated over all visitors. Given that both axes are percentages, a straight, horizontal line with the value 1 would mean that the device was used on average equally over the whole visit. Values above 1 indicate usage peaks, values below 1 usage valleys. Given that the values fluctuate around 1, the device was used on average during the entire visit. There is no indication of participants testing the device during the first minutes (percentages of the visit) and subsequent discarding it.

Given that percentages are used, only the relative usage can be seen in this figure. For absolute usage values see the main text. The values of "all" (exhibit information, map navigation, start screen) is between exhibit and map because the average usage is displayed here.

*Figure 24:* Device usage over time

user data could only be accessed from the first map.

*Visit duration:* On average, the EG spend 99.75 ($SD$ = 41.49) minutes in the exhibition, the control group 80.94 ($SD$ = 25.45), i.e. the EG spent significantly more time in the exhibition ($t(91.545)$ = 3.280, $p$ = .001, $\eta^2$ = .059). This effect seems to be independent of interest in science and technology. If the 21-item scale is used as a covariate, a one-way ANCOVA still shows the significant effect for condition ($F$(condition)(1, 168) = 13.531, $p$ < .001, partial $\eta^2$ = .075), but no statistically significant effect for the covariate ($F$(covariate)(1, 168) = 1.950, $p$ = .164). The statistically significant difference in visit duration between the experimental and the control group also occurs when interest in science and technology (mean of 21-item scale) is used as second factor (dichotomized by splitting the participants into two groups, depending on their values compared to the mid-point of the scale: smaller or equal than 3.5 became the low interest group, higher than 3.5 the high interest group. A two-way ANOVA with visit duration in minutes as the dependent variable showed a significant main effect for condition ($F$(condition)(1, 167) = 4.681, $p$ = .032, partial $\eta^2$ = .027), and no effect for interest ($F$(interest)(1, 167) < 1, *n.s.*) nor a significant interaction ($F$(IA)(1, 167) < 1, *n.s.*). However, due to violated equality of error variance, a more strict $\alpha$ level of .01 has to be used. It appears that the effect of the condition dissipates once dispositional interest is treated as a second factor. Duration of the visit is correlated with the amount of information accessed ($r$ = .311, $n$ = 64, $p$ = .013) and the amount of marked information ($r$ = .458, $n$ = 64, $p$ < .001) on the device in the experimental group. This indicates that the longer duration was actively used by the participants to read the available information and mark it as interesting. Whether the visitor was alone, with family, or in another group did not make a significant difference in visit duration when assessed using a two-way ANOVA with visit constellation (alone, family, other group) and condition (experimental vs. control) as factors ($F$(IA)(2, 163) < 1, *n.s.*; $F$(constellation)(2, 163) < 1, *n.s.*, $F$(condition)(1, 163) = 14.079, $p$ < .001). Experimental condition yields a significant effect, but not the constellation of the visit. However, as Figure 25 shows, descriptive differences between single visitors and the other two constellations in the
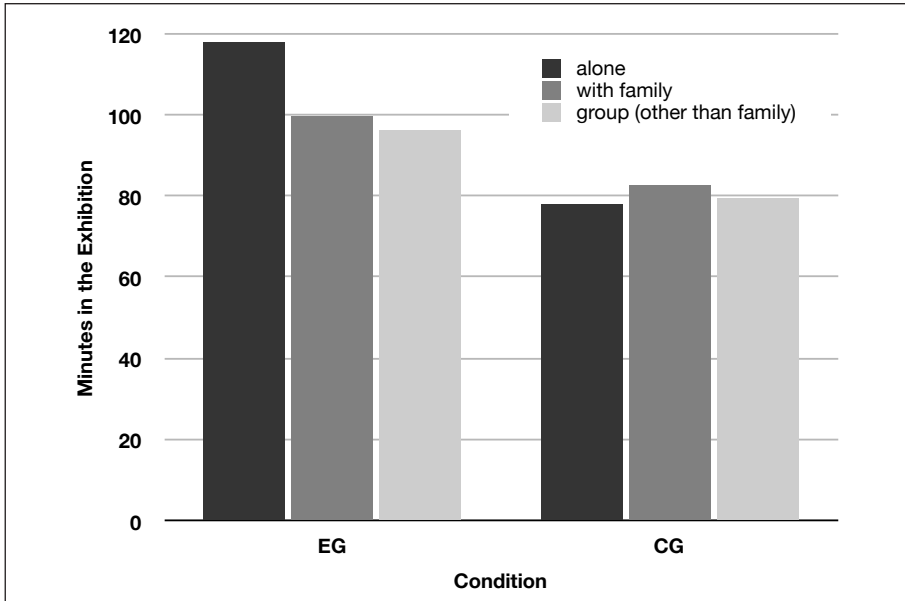
Differences in the duration of the exhibition visit depending on the condition and the constellation of the visitor: alone, with family, or in a group without family members.

Note: Cell frequencies were very low for single visitors (EG: 7, CG: 9), so statistics have to be interpreted with care. The high numerical difference between solitary visitors and visitors who were not alone of 18 minutes was not statistically significant, due to very high standard deviations and probably low cell frequencies.

*Figure 25:* Average time spent at exhibition in Study 2
for solitary, family, and other group visitors

experimental group are large: On average, visitors who were alone and had a mobile device stayed about 18 minutes longer than those who were in a group, either family or non-family. The number of single visitors in the study was very low (EG: 7, CG: 9), so, besides the very large standard deviations ($SD$(EG, Alone) = 63.03, $SD$(EG, family) = 34.19, $SD$(EG, other group) = 42.55), this might be a reason for the lack of empirical difference.

*Self-reported interest:* No differences were found between the groups regarding their satisfaction of interest. On average, both groups slightly agreed that the exhibition satisfied their interest ($M$(EG) = 3.43, $SD$(EG) = 1.23, $M$(CG) = 3.64, $SD$(CG) = 1.23, $t$(186) = -1.107, $p$ = .27, on a six-point Likert scale).

*Learning — Self Reports:* A repeated-measures ANOVA of visitors' self-reports of their

own knowledge about the exhibition topics showed a significant increase of the pre- vs. the post-visit estimate ($F$(time)(1, 186) = 89.245, $p$ = < .001, partial $\eta^2$ = .324), with no main effect for group ($F$(condition)(1, 186) < 1) or interaction effect ($F$(IA)(1, 186) < 1, *n.s.*). Both self-estimates were asked after the visit, as a museum visit is a highly individual experience and the museum visitor has to see what is available to accurately assess his or her knowledge about it.

*Engagement with the exhibition:* A scale was constructed based on 14 items (each a 6-point Likert scale) that were related to the strength of engagement with the exhibition (Cronbach's $\alpha$ = .754). No statistically significant differences in strength of engagement with the exhibition were found between the groups ($M$(EG) = 3.90, $SD$(EG) = 0.59, $M$(CG) = 3.90, $SD$(CG) = 0.56, $t$(186) = -0.014, $p$ = .988).

*Interest in further occupation with the topic:* Immediately after the visit, the EG stated a higher desire to engage in the exhibition topic ($M$(EG) = 3.73, $SD$(EG) = 1.24, $M$(CG) = 3.39, $SD$(CG) = 1.06, $t$(183) = 1.979, $p$ = .049). The difference was between "slightly disagree" (CG) and "slightly agree" (EG).

*Evaluation of the exhibition:* There was a tendency of the experimental group to rate the media use of the museum as better than the control group ($M$(EG) = 3.72, $SD$(EG) = 0.84725, $M$(CG) = 3.473, $SD$(CG) = 0.92155, $t$(184) = 1.852, $p$ = .066).

In sum, we found a strong effect in the behavioral indicator of interest: visit duration, but besides a higher self-reported interest in further engagement in the topic there were differences on subjective self-reports of interest.

## Question 3. (How) Can Interest Be Supported After the Museum Visit?

For this question, the follow-up data are used. Only those visitors are included in the experimental condition who have actually used the device (lower bound of usage: at least 5 exhibition texts accessed).

### Usage of the Bookmarking Facility of the Device

*Use:* On average, visitors marked 5.83 ($SD$ = 24.83) information texts as interesting.

As mentioned previously, this average of marked entries is misleading, because the median is 1 and the mode is 0. In total, 38.7% marked no exhibits as interesting, 21.3% only one, 32% between 2 and 10, 4% between 11 and 20, and another 4% more than 20. If an untypical motivated visitor (who marked 211 exhibits as interesting) is excluded as an outlier, the mean drops to 3.05 and the standard deviation to 6.36. If a visitor had no exhibits bookmarked, it could mean that this visitor marked and unmarked exhibits; however, for all practical reasons it is the same as if this visitor had never bookmarked an exhibit — no information survives the visit.

*Reasons for usage:* Participants were asked whether they had bookmarked information for later reflection, to show the information to others, to have a starting point for later engagement in the topic, or to try out the device, each on a 6-point Likert scale. One-Sample *t* Tests against the scale middle of 3.5 showed that the visitors who had used the device to bookmark information texts were indifferent with the first three questions and agreed to the fourth reason (see Table 22): There were no statistically significant differences for using them for further reflection, for showing them to others, nor for using them starting point for further engagement, but they agreed to using the bookmarks to try out the device. In percentages, 65.5% indicated they wanted to use it as reflection, 43.7% to show others, 61.3 as starting point, and 88.3% to try out the device (valid percentages).

Consequently, it seemed that those who used the bookmarking function most likely did so to try out the device.

| Using the bookmark feature ... | *M* | *SD* | *t* Test |
|---|---|---|---|
| for further reflection | 3.84 | 1.59 | t(31) = 1.224, p = .23 |
| for showing them to others | 3.47 | 1.46 | t(31) = -0.121, p = .904 |
| as starting point for further engagement | 3.77 | 1.45 | t(30) = 1.05, p = .302 |
| to try out the device | 4.56 | 1.40 | t(33) = 4.420, p < .001 |

6-point Likert scale from 1 (strongly disagree) to 6 (strongly agree). *t* Test against the scale middle of 3.5.

*Table 22:* Reasons for using bookmarks in Study 2

## Evaluation of Bookmarking

*Evaluation of the available bookmarks by the experimental group:* Visitors of the experimental group agreed that the bookmarking function made sense and liked having it available. However, they also disagreed that they used it to tell others about their visit (see Table 23).

*Evaluation of bookmarks in general by visitors of the experimental group:* Visitors of the experimental group agreed that bookmarking in general would make sense, would be looked at by them, would be a good starting point for further engagement in the topic, and a tendency that they would like to have them available after the visit. They disagreed that it would not have additional value compared to a complete listing of the exhibits, that they would not use it, and that it would be too much effort to create

| Bookmarks | M | SD | t Test |
|---|---|---|---|
| **Experimental Group (available Bookmarks)** | | | |
| made sense | 3.82 | 0.81 | $t(16) = 4.197, p = .001$ |
| liked having them available | 3.94 | 0.66 | $t(16) = 5.892, p < .001$ |
| used it to tell others about the visit | 2.06 | 1.31 | $t(17) = -3.071, p = .007$ |
| **Experimental Group (Bookmarks in general)** | | | |
| would make sense | 3.94 | 0.66 | $t(16) = 5.892, p < .001$ |
| would look at them | 3.82 | 1.02 | $t(16) = 3.347, p = .004$ |
| would be a good starting point for further occupation with the topic | 3.88 | 0.72 | $t(15) = 4.869, p < .001$ |
| would like to have them available after the visit | 3.53 | 1.13 | $t(16) = 1.941, p = .07$ |
| would not have additional worth compared to a complete listing of the exhibits | 2.35 | 0. 93 | $t(16) = -2.864, p = .011$ |
| would not use them | 2.29 | 1.26 | $t(16) = -2.304, p = .035$ |
| would be too much effort to create it during the visit | 2.41 | 1.06 | $t(16) = -2.279, p = .037$ |
| **Control Group (Bookmarks in general)** | | | |
| would make sense | 3.73 | 1.08 | $t(21) = 3.167, p = .005$ |
| would look at them after the visit | 3.48 | 1.25 | $t(20) = 1.746, p = .096$ |
| would not have additional worth compared to a complete listing of the exhibits | 2.43 | 1.36 | $t(20) = -1.922, p = .069$ |

5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). *t* Test against the scale middle of 3.

*Table 23:* Evaluation of bookmarking in Study 2

| | M | SD | t Test |
|---|---|---|---|
| liked having it available | 3.65 | 1.08 | $t(39) = 3.823, p < .001$ |
| looked at it | 3.68 | 1.27 | $t(39) = 3.365, p = .002$ |
| did not use it | 2.41 | 1.38 | $t(40) = -2.72, p = .01$ |
| made sense | 4.00 | 0.82 | $t(39) = 7.746, p < .001$ |
| used it to tell others about the visit | 2.10 | 1.30 | $t(39) = -4.389, p < .001$ |
| motivating to engage in the topic after the visit | 2.90 | 1.17 | $t(39) = -0.539, p = .593$ |
| was a good starting point for further engagement in the topic | 2.82 | 1.20 | $t(39) = -0.926, p = .36$ |

5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). *t* Test against the scale middle of 3.

*Table 24:* Exhibition website evaluations in Study 2

it during the visit (see Table 23).

*Hypothetical evaluation of bookmarks by the control group:* Visitors who had no opportunity to try out the bookmarks thought they would make sense and had a tendency to agree that they would look at them after the visit. They also had a tendency to disagree that it would not have an additional value compared with a complete list of all exhibits. Otherwise, they were undecided regarding the bookmarks (see Table 23).

## Evaluation of the Exhibition Website

Visitors were asked how they evaluated the exhibition website (see Table 24). In general, they liked having it available, looked at it, disagreed that they did not use it, agreed that it made sense, but disagreed that they used it to tell others about the visit. They were undecided regarding the motivation to engage in the topic after the visit and whether it was a good starting point for further engagement in the topic.

However, there were differences in the evaluation of the exhibition website for the experimental and the control group (see Table 25). Visitors in the experimental group liked the website more, agreed more that they had had a look at the website and used it. There was also a tendency that the experimental group agreed more that the exhibition webpage was a good starting point for further engagement in the topic.

|                                                    | EG          | CG          | *t* Test                      |
|----------------------------------------------------|-------------|-------------|-------------------------------|
| liked the website                                  | 4.16 (0.77) | 3.19 (1.12) | $t(38) = 3.149, p = .003$     |
| had a look at the website                          | 4.16 (0.77) | 3.24 (1.48) | $t(30.585) = 2.503, p = .018$ |
| used the website                                   | 1.95 (1.19) | 2.86 (1.42) | $t(39) = -2.207, p = .033$    |
| webpage was a good starting point for further engagement in the topic | 3.16 (1.07) | 2.52 (1.25) | $t(38) = 1.716, p = .094$ |

5-point Likert scale from 1 (not at all) to 5 (absolutely). *M* and (*SD*). *t* Test against the scale middle of 3.

*Table 25:* Comparison between experimental and control group regarding the website

### Usage of the Exhibition Webpage After the Museum Visit

Table 26 shows the usage of the exhibition website by the experimental and control group. Minimums and maximums have been included to illustrate the heterogeneity of usage. No differences were found in the number of participants of each condition who visited the website ($\chi^2(1, n = 188) = 1.686, p = .194$). Website visitors from the experimental and the control condition did not differ regarding page access ($M(\text{EG}) = 10.14, SD(\text{EG}) = 20.323; M(\text{CG}) = 8.56, SD(\text{CG}) = 11.001; t(58) = 0.381, p = .705$), or frequencies of content page access ($M(\text{EG}) = 4.9643, SD(\text{EG}) = 14.98513, M(\text{CG}) = 4.2188, SD(\text{CG}) = 7.42157, t(58) = 0.249, p = .804$). Regarding page visits, it is important to note that not all page visits are content related. Visitors also viewed non-content related information and had to access overview pages to get to content information.

### Usage of the Bookmarks After the Museum Visit

Table 26 also shows that bookmarks were accessed by 24 of the 75 participants of the experimental group (32%), but if the number of participants is considered who actually visited the website (28), it was used by 85.71% of the website visitors who had them available and visited the webpage. Of the website visitors of the experimental group, 12 (42.9% of the website visitors or 16% of the total number of participants in the experimental condition) used the bookmarks page to access different pages of the website. On average, 0.64 pages were thus accessed ($SD = 0.91$). On average, the ones who used the bookmarks page this way accessed 1.5 pages this way ($SD = 0.79$, min = 1, max = 3).

| Usage | Experimental Group | | Control Group | |
|---|---|---|---|---|
| | **Absolute** | **Percentage** | **Absolute** | **Percentage** |
| Website access | 28 / 75 | 37.3 | 32 / 113 | 28.3 |
| Access of content pages | 19 / 75 | 25.3 | 20 / 113 | 17.7 |
| Access of bookmark page | 24 / 75 | 32.0 | n/a | n/a |
| **Amount of Usage** | **M (SD)** | **Min – Max** | **M (SD)** | **Min – Max** |
| Time on website in minutes | 00:04.47 (00:10:04) | 00:00:13 - 00:49:09 | 00:05:02 (00:07:53) | 00:00:09 - 00:40:23 |
| Number of independent logins | 1.14 (0.59) | 1 – 4 | 1.31 (0.78) | 1 – 4 |
| **Page Access (averages using only visitors of the website as basis)** | | | | |
| total number of pages | 10.14 (20.32) | 1 – 110 | 8.56 (11.00) | 1 – 48 |
| total number of content pages | 4.96 (14.99) | 0 – 80 | 4.22 (7.42) | 0 – 35 |
| main page | 1.61 (0.99) | 1 – 5 | 1.5 (1.11) | 1 – 6 |
| imprint | 0.21 (0.50) | 0 – 2 | 0.19 (0.59) | 0 – 3 |
| label information | 1.11 (3.84) | 0 – 20 | 0.94 (1.85) | 0 – 7 |
| information tablets | 1.5 (3.77) | 0 – 20 | 1.25 (3.27) | 0 – 18 |
| exhibition catalogue pages | 2.36 (7.54) | 0 – 40 | 2.03 (3.15) | 0 – 14 |
| museum map | 0.57 (1.43) | 0 – 7 | 0.47 (1.14) | 0 – 6 |
| **Bookmarks Page Access (visitors of website averages, not total averages)** | | | | |
| bookmarks page | 1.21 (0.83) | 0 – 3 | n/a | n/a |
| page access via bookmarks page | 0.64 (0.91) | 0 – 3 | n/a | n/a |

*Table 26: Exhibition website usage in Study 2*

*Engagement in the Topic After the Visit and Knowledge Communication*

*Subsequent actions after the visit:* When asked how much the visitors had engaged in the topics of the museum on a scale from 1 to 10, the experimental and control condition did not differ significantly ($M$(EG) = 3.9, $SD$(EG) = 1.89; $M$(CG) = 3.77, $SD$(CG) = 2.07; $t$(40) = 0.207, $p$ = .837).

*Self-reported knowledge communication after the visit:* Only a tendency of the EG to talk more about the visit compared to the control group was found ($M$(EG) = 2.45, $SD$(EG) = 0.85; $M$(CG) = 2.01, $SD$(CG) = 0.74; $t$(39) = 1.752, $p$ = .088).

*Preparation and follow-up of museum visits:* Visitors indicated their usual preparation and follow up of museum visits on a 7-point scale, from 1, "never", to 7, "always". Items included the website of the museum or exhibition, books about the topic, talking to persons who also visit the exhibition with them, talking to people who did not visit the exhibition, reading newspaper articles, using Wikipedia, and using other websites. For the preparation, compared with the midpoint of the scale (4, "sometimes"), visitors indicated that they rarely read books about the topic ($M$ = 2.88, $SD$ = 1.20, $t$(39) = -5.918, $p$ < .001) or talk to people who do not want to visit the exhibition ($M$ = 2.6, $SD$ = 1.17, $t$(39) = -7.553, $p$ < .001). However, there is a tendency to talk to people who will visit the exhibition with them ($M$ = 4.38, $SD$ = 1.33, $t$(39) = 1.778, $p$ = .083). Regarding the follow up of a visit, visitors indicated that they rarely read books about the topic ($M$ = 3.0, $SD$ = 1.25, $t$(37) = -4.924, $p$ < .001) or talk to people who did not visit the exhibition ($M$ = 2.84, $SD$ = 1.46, $t$(37) = -4.883, $p$ < .001). A tendency was found that visitors rarely read newspaper articles about it ($M$ = 3.47, $SD$ = 1.66, $t$(37) = -1.959, $p$ = .058) or visit other websites than the museum website ($M$ = 3.39, $SD$ = 1.86, $t$(30) = -1.839, $p$ = .076).

*Interest in the Topic Six Weeks After the Museum Visit*

*Interest in the topics of the museum:* On a 10-point scale asking for the interest in the topics of the museum, no differences were found between the experimental group and the control group ($M$(EG) = 7.1, $SD$(EG) = 1.92; $M$(CG) = 6.36, $SD$(CG) = 2.06; $t$(40) = 1.196, $p$ = .239).

*Willingness to visit the museum again:* No difference in the willingness to visit the museum again was found between the experimental group and the control group on a 10-point scale ($M$(EG) = 6.00, $SD$(EG) = 3.32; $M$(CG) = 5.59, $SD$(CG) = 3.03; $t$(40) = 0.417, $p$ = .679).

*Recommendation of the museum to others:* Experimental and control group did not differ regarding how readily they would recommend the museum to others ($M$(EG) = 7.05, $SD$(EG) = 2.67; $M$(EG) = 6.32, $SD$(EG) = 3.12; $t$(40) = 0.813, $p$ = .421, on a 10-point scale).

*Further interest in the topics of the museum:* The difference between the experimental and the control condition of the posttest could not be replicated six weeks after the visit ($M$(EG) = 2.7, $SD$(EG) = 0.87; $M$(CG) = 2.64, $SD$(CG) = 1.00; $t$(40) = 0.219, $p$ = .828, on a 5-point scale with 1 meaning "yes, in any case" and 5 meaning "no, in no case"). It should be noted that there was a very strong selection effect in the follow-up test, and recalculating the differences between EG and CG immediately after the visit with only the participants of the follow-up test showed no significant differences either ($t$(39) = 0.223, $p$ = .824).

### Post-hoc Analysis of Visitors

What are noteworthy characteristics of visitors who wanted to see the exhibition again (Table 27) or who wanted to engage further in the topic (Table 28)? If the data are compared post-hoc, the following differences are of interest. However, it should be noted that this is purely exploratory.

*Characteristics of visitors who wanted to see the exhibition again:* Visitors who wanted to see the exhibition again enjoyed the visit more, rated the museum more favorable, engaged more in the exhibition topics, talked more to persons who had not visited the museum and to people in general about the visit, would more likely recommend the museum to others, wanted to engage further in the topics, and were more interested in the exhibition topics. There are, however, no differences regarding their dispositional interest, their subjective knowledge before or after the visit, or the frequency of museum visits. The values and statistics are displayed in Table 27.

*Characteristics of visitors who wanted to engage further in the topic:* Visitors who wanted

to engage further in the topic enjoyed the visit more, rated the museum more favorable, talked more to persons who did not visit the museum and to others in general about the visit, would like to visit the museum again and recommend it to others, and naturally had a higher interest in the topics. There were, however, no differences in dispositional interest, subjective knowledge before or after the visit nor in engagement in the topics after the visit. The values and statistics are displayed in Table 28.

| Question | return visitors | | non-return visitors | | t Test |
|---|---|---|---|---|---|
| | M | SD | M | SD | |
| **statistically significant differences regarding** | | | | | |
| enjoyment of the visit | 4.16 | 0.32 | 3.75 | 0.45 | t(40) = 3.442, p = .001 |
| rating of the museum | 3.71 | 0.49 | 3.26 | 0.69 | t(38) = 2.395, p = .022 |
| engagement in the exhibit topics | 4.61 | 1.64 | 2.89 | 1.94 | t(40) = 3.099, p = .004 |
| conversation with people who had not visited the museum | 3.73 | 1.03 | 2.37 | 0.90 | t(39) = 4.468, p < .001 |
| conversations with people in general about the visit (average of scale) | 2.58 | 0.82 | 1.79 | 0.58 | t(39) = 3.505, p = .001 |
| recommendation of the museum to others | 8.74 | 1.29 | 4.16 | 2.24 | t(27.462) = 7.895, p = .001 |
| intention to engage further in the topics (here, higher values mean less interest) | 2.09 | 0.60 | 3.37 | 0.76 | t(33.788) = -5.979, p < .001 |
| interest in exhibition topics | 7.30 | 1.52 | 6.00 | 2.31 | t(30.049) = 2.113, p = .043 |
| **no statistically significant differences regarding** | | | | | |
| dispositional interest | 4.41 | 0.57 | 4.51 | 0.77 | t(40) = -.469, p = .641, n.s. |
| subjective knowledge prior to the visit | 4.09 | 0.95 | 4.26 | 1.45 | t(29.976) = -.456, p = .652, n.s. |
| subjective knowledge after the visit | 4.83 | 0.65 | 4.63 | 1.26 | t(25.813) = .611, p = .547, n.s. |
| museum visits during the last year | 3.28 | 2.82 | 5.26 | 6.88 | t(40) = -1.261, p = .215, n.s. |

*Table 27:* Post-hoc differences of visitors (willingness to see the exhibition again)

| Question | further occupy | | non-further-occupy | | t Test |
|---|---|---|---|---|---|
| | M | SD | M | SD | |
| **statistically significant differences regarding** | | | | | |
| enjoyment of the visit | 4.20 | 0.31 | 3.68 | 0.38 | $t(29) = 4.115$, $p < .001$ |
| rating of the museum | 3.86 | 0.65 | 3.22 | 0.67 | $t(28) = 2.422$, $p = .022$ |
| willingness to visit the museum again | 7.91 | 2.51 | 2.60 | 1.08 | $t(29) = 6.371$, $p < .001$ |
| conversation with people who had not visited the museum | 3.55 | 1.05 | 2.30 | 1.16 | $t(28) = 2.971$, $p = .006$ |
| conversations with people in general about the visit (average of scale) | 2.41 | 0.78 | 1.78 | 0.72 | $t(28) = 2.163$, $p = .039$ |
| recommendation of the museum to others | 8.33 | 1.98 | 3.60 | 2.17 | $t(29) = 6.03$, $p < .001$ |
| interest in exhibition topics | 7.38 | 1.63 | 5.10 | 2.73 | $t(29) = 2.92$, $p = .007$ |
| **no statistically significant differences regarding** | | | | | |
| dispositional interest | 4.50 | 0.60 | 4.47 | 0.74 | $t(29) = .144$, $p = .886$, *n.s.* |
| subjective knowledge prior to the visit | 4.29 | 0.85 | 4.10 | 1.52 | $t(29) = .439$, $p = .664$, *n.s.* |
| subjective knowledge after the visit | 4.90 | 0.70 | 4.50 | 1.27 | $t(29) = 1.151$, $p = .259$, *n.s.* |
| engagement in the topic after the visit | 4.29 | 1.88 | 3.10 | 2.03 | $t(29) = 1.605$, $p = .119$, *n.s.* |
| museum visits during the last year | 3.67 | 2.78 | 7.15 | 9.10 | $t(9.806) = -1.184$, $p = .264$, *n.s.* |

*Table 28:* Post-hoc differences of visitors (willingness to further engage in the topic)

# Discussion

## General Results and Prerequisites for Further Analysis

### Study Sample

Given that this study was conducted in a normal museum with voluntary visitors who were not paid for taking part, the participation rate was very good. This is probably an effect of the setting — visitors of science and technology museums are probably more likely to participate in a scientific study (especially when technology is used) than visitors of other kinds of museums. However, there was a strong self-selection among visitors for participation and over the course of the study. A high dropout occurred from those who participated in the study, those who used the device in the experimental group, those who wanted a login for the website, those who visited the website, and those who took part in the follow-up test. However, this self-selection and subsequent dropout is actually a natural (self-)selection in a free-choice setting like a museum. This is perhaps somewhat pronounced due to the unforeseen objections of many visitors to give their email address to an unknown person, no matter whether this person is working in cooperation with the museum and a university, or not, which prevented participation in any post-visit part of the study. Here, the study echos a remark made by Allen (2002): "These limitations were not entirely predictable ahead of time, as they depended in part on the specific choices visitors would make about where to stop in the exhibition. Counting frequencies in a free-choice environment is inevitably susceptible to such disappointment." — something I can only concur with. However, it can be assumed that this dropout happened similarly under both conditions, although the control condition had it easier to decline further participation (like filling out the questionnaire), as they could simply slip past the experimenter on their way out. The participants' under the experimental condition had to return the device and were probably under the influence of the norm of reciprocity (see Cialdini, 1995), due to the fact that they had received a mobile device for the course of their visit free of charge. Given that the groups are comparable on socio-demographic variables

(despite a slight age difference), it seems that this dropout affected both conditions equally in the important aspects. The age difference does not seem to have occurred due to technophobic senior citizens who expected difficulties in handling the device and selectively did not participate as much in the experimental group (although the percentage was lower), but probably due to a greater number of very young participants in the experimental condition. The dropout from posttest to the follow-up test did not seem to have biased the sample — the visitors are still similar regarding the main biographical variables (age, gender, education, museum experience, reason for visit, interest in science and technology) and their distributions to the conditions. An interesting aspect is that none of the visitors who came to see a specific exhibit took part in the follow-up questionnaire. It seems that they had found what they came for and had no further interest in the study.

*Excluded participants:* In the experimental group, 6 participants had to be excluded due to lack of usage and 16 further participants because no data was available from the devices due to technical problems. While this might bias the sample of the experimental group, there can be no effect of a treatment without usage and, like the dropout, it shows that in a free-choice setting, one can make offers but not enforce usage. It is unfortunately a constraint of the field setting and given the technical success rate of 83.5% of the device (81/91), this is not bad for a self-made mobile guide.

*Cueing:* All visitors were informed about the study prior to the visit. This was of practical necessity in the experimental condition and was also done in the control condition to ensure comparability, as cueing can influence visitor behavior. It can be expected that cueing effects occurred in both conditions, and if no differential effects occurred, the effects due to the conditions should hold for an uncued audience.

*Missing Data and Data Quality:* Given that a paper and pencil questionnaire was used, some questions were not answered when participants accidentally or purposefully skipped items or pages. However, these instances were few, and the data seem to be internally consistent, for example, regarding the self-report of the amount of information accessed on the device and the logfile results or the typical gender effect for

interest in science and technology topics. Thus, despite its length, visitors were able to handle the questionnaire.

*Characteristics of the sample:* The present sample was well-educated and museum experienced with a wide variance in age, interest, reasons for the visit, visit constellations, and prior knowledge. It looks like a "typical" sample of museum visitors, thus having a high external validity for other science and technology museums. They were not influenced by any payment either but participated voluntarily.

## Other Factors

*Suitability of the museum:* The museum itself, despite constraints regarding the treatments that were allowed (see page 108), was well suited for the study. It consisted of heterogeneous exhibits that led to almost all visitors finding something of interest. The heterogeneity of the exhibits and the heterogeneity of the study sample allowed an analysis of what is interesting for visitors — not only objective factors, but also factors related to the visitor-exhibit relationship. A problem of the museum might be that it shows German high-technology achievements and that its primary aim is not to convey knowledge about the scientific and technical principles behind them, but be more of an advertisement for German ingenuity. However, information was provided about the exhibits and the principles behind them, although perhaps not in such detail as one would expect in a science and technology museum.

*Suitability of the mobile device:* The device was regarded as well designed and easy to use. It did not seem to be easier or harder to handle than mobile devices in general, so the results should be applicable to novices and experts alike. However, self-selection must be taken into account — visitors who were very insecure regarding their abilities would probably not have taken part in the study. However, even senior citizen used the device (the oldest user was 70 years old), and there was no statistically significant correlation between age and ability to handle the device, so this issue does not seem to be relevant for this study. A constraint is that the device was not tightly integrated into the museum visit. It was not given at the cashier as normal part of the visit (like, for example, at the Mercedes Benz Museum), but was offered after the cashier but

before the exhibition itself. This is similar to the Tate Modern, where the device is offered even later (between the floors), but might hinder generalizability. In groups, usually only one visitor took a device and became the interpreter for the group. Given that visitors were not followed during their visit, no evidence can be given as to what happens during the visit. Logfiles show that the device was used, but not by whom. It can only be expected that the visitor who took it used it the whole time. However, because the questionnaire was explicitly given to the visitor who used the device, this should not be a problem for the quality of the data, but results might turn out different in a museum where every visitor automatically gets a device.

*Website of the Exhibition:* The exhibition website worked fine and delivered the required logfiles. However, it cannot be said for sure if the person who used the device and filled out the questionnaire also used the login received per email or whether this person gave this information to someone else.

*Follow-up Questionnaire:* The follow-up questionnaire was done online and the login information was sent to the email address of the person who filled out the questionnaire, but one cannot be sure that this person also filled out the questionnaire. As far as the experimenter can estimate, the participants understood the purpose of the study and that they had to answer the questionnaire by themselves.

In summary, there was a natural self-selection and dropout in the sample which might limit the generalizability of the results, but which also shows that the museum setting cannot satisfy all users. Some do not come to the museum to learn more about the exhibits, and a tool that can support but not elicit interest cannot affect that. Despite some (natural) constraints of the field setting, the data bases is fine to address the three questions of this dissertation thesis.

# Question 1: What Makes an Exhibit Interesting?

The heterogeneity of exhibits and of the study sample allowed an analysis of what is interesting for visitors in this museum, not only regarding the objective characteristics of the exhibits, but also the subjective visitor-exhibit relationship. The focus was on the part of the sample that visited the museum unassisted by a mobile device to maximize generalizability. The approach was exploratory, although statements from museum experts led to expect effects of interactivity and large size as possible objective characteristics of what makes an exhibit interesting.

*Objective characteristics of exhibits:* Statistical analysis showed that interactive exhibits and the by-far-largest exhibit were mentioned more often as the most interesting exhibit than expected by chance. A possible explanation would be that visitors who are not interested in science and technology choose these exhibits as most interesting due to their salient surface characteristics: They could at least play around with the interactive exhibits, and the largest one was also the one that could be remembered best. However, there were no differences in the average rating of the strength of their interest (i.e., the interestingness) or the dispositional interest in science and technology of the visitors that named interactive and non-interactive exhibits as most interesting. The same effect was found for the by-far-largest exhibit. Given these results, it does not seem to have been a embarrassment choice to name interactive and the by-far-largest exhibits as most interesting. Consequently, interactivity and exceptionally large size do seem to "make" an exhibit interesting, supporting the opinions of museum experts regarding interactivity and large size (e.g., for interactivity: Ansbacher, 2003; Allen, 2004; for large size: curators cited by Csikszentmihalyi & Hermanson, 1995). However, the absolute number of the interactive exhibits probably has to be included in these considerations: In this museum, interactive exhibits were rare and thus noticeable (12.5%), so this effect probably will not hold true in a more interactive museum (or in this case, rather: science center) with a higher percentage of interactive exhibits where interactivity loses its salience. Similarly, large size per se will probably not show an effect if it is not distinct compared to the other exhibits in the museum.

The by-far-largest exhibit in the Museum stood out due to its size, as there was no other exhibit that was only half its size (and was also featured prominently on the museum website). But how can these effects be explained? The subjective visitor-exhibit-interaction can be used to explain this effect.

*Subjective factors of the visitor-exhibit relationship:* The ability to explain the effect of interactive exhibits and those of exceptional size is not the only reason to look closely at the visitor-exhibit relationship. Interest is commonly defined as a person-object relationship, and it seems unlikely that objective criteria of the exhibit are solely responsible for visitors interest. Data from the present study support this: There is a large overlap between exhibits that were mentioned as most interesting and those that were mentioned as least interesting. In other words, what is the most interesting exhibit for some visitors is the least interesting exhibit for others. Consequently, it makes sense to look for a common underlying structure of what makes exhibits interesting for a particular visitor and thus go beyond simple exhibit characteristics.

When visitors' answers to the 14 interest-related items were analyzed with an exploratory factor analysis, a four-factor solution with the factors "Attraction Power", "Instant Enjoyment", "Familiarity", and "Information Value" was identified. It is important to note that these factors are situated in the interaction between the exhibit and the visitor, e.g., the attraction power of a specific exhibit for a specific visitor. It is not located solely in either the visitor or in the exhibit itself. To be regarded as (most) interesting exhibit, exhibits must attract visitors' attention ("Hey, what's this ...?"), be instantly enjoyable ("Hey, this is fun ..."), connect to prior knowledge ("Seems familiar ..."), or provide information ("Ah, this is why ..."). As expected by their low squared multiple correlation, the items "had many questions" and "was personally relevant for me" did not fit the solutions well. For further studies, these two outliers among variables should be defined more clearly and complemented by additional items. It is possible that at least the personal relevance item was too unspecific, because it did not say for what it was relevant. For work? For leisure? Better results could probably be obtained if the item were more clearly specified.

These four factors have been supported as relevant for interest by other research studies and also encompass the criteria of museum curators (see page 32) and of museum researchers (see page 33):

*Attraction Power* is a familiar concept in museums (hence, the name was chosen for this combination of items). It relates to characteristics like "pleasing displays with bright colors" and "exhibits of large size" mentioned by museum professionals. It is a consequence of a specific presentation style which was proposed by Valdecasas et al. (2006) and of juxtaposition (proposed by Borowske, 2005). Csikszentmihalyi and Hermanson (1995) mention it as the catch component of interest: "the museum must capture the visitors' curiosity" (see also Mitchell, 1993). It also fits the early considerations of James (1890) that interest depends on attention, and that without this attention, there can be no interest. Insofar, it is no wonder that catching visitors' attention is found as the first factor underlying the visitor-exhibit relationship of what makes an exhibit interesting.

*Instant Enjoyment* relates to characteristics like "pleasing displays with bright colors", exhibits that "evoke awe or thrill of fear without actual danger" and are "mysterious" (if the visitor wants to find out more). Ansbacher's (2003) proposition that (meaningful) interactivity, e.g., something "to actually see and do at the exhibit" determines interesting exhibits also fits here. It mirrors the hold component of (situational) interest proposed by Csikszentmihalyi and Hermanson (1995): Once an exhibit has elicited visitors' attention, it must hold this attention for some time. The interaction must become "intrinsically rewarding" quickly (Csikszentmihalyi & Hermanson, 1995). The engagement of "sustained interest in order for learning to take place" (Csikszentmihalyi & Hermanson, 1995) works best if something is instantly enjoyable without any barriers that might put off visitors. In a setting where so many exhibition objects have a high attraction power and can easily catch visitors' attention, barriers for further participation must be almost non-existent; otherwise, the visitor wanders off. This result also fits Allen's (2004) concept of "immediate apprehendability" very well. Rounds' (2004) interest landscape model can also be applied here. His attention rule

of avoiding to make large down payments (i.e., avoid exhibits that take longer time to find out if they are interesting or not) and quitting rule of cutting losses when an exhibit does not prove to be interesting after a certain amount of time would predict that visitors quickly leave exhibits that do not prove to be instantly enjoyable.

*Familiarity* is implicitly contained when connections to visitors' lives are made and necessary when violations of visitors' preconceptions are used to present exhibits. Possible examples are showing a detail of a known object like a photo of a magnified fly leg (Valdecasas et al., 2006) or using juxtaposition of two known objects that do not fit from the visitors' point of view (Borowske, 2005). Rounds' (2000) proposition of "simple and general" ideas as interesting exhibits requires that the idea must be understood by the visitor and, consequently, connect to prior knowledge of the visitor. Theoretically, familiarity might seem strange at first. In a setting where visitors can explore and see new things, why isn't novelty a factor in itself? Why must exhibits be familiar (in a moderate way, when the factor loading is considered)? Silvia's (2005) theory of interest as an emotion, which he explained by using appraisal theory, can be used to explain this issue. To be interesting, something has to be new, but the person must also be able to cope with this newness. What Silvia (2005) showed for complex art (that visitors spend longest viewing highly complex pictures when they felt they were highly competent to understand it) can be transferred to exhibits of science of technology: Visitors might like new objects, but they must also feel able to deal with them, so the exhibits have to be at least somewhat familiar. Despite the low fit of personal relevance, these items show that the personal relevance must be made clear for the visitor, something that echoes Csikszentmihalyi and Hermanson's (1995) consideration that "the link between the museum and the visitor's life needs to be made clear" and a "deeper sense of meaning [is] necessary". This is also related to familiarity, as familiar exhibits have it easier to be personally relevant to the visitor. However, it must also go beyond showing visitors what they already know, as the next factor shows.

*Information Value* suits the museum context as a place for life-long learning: Visitors

found those exhibits most interesting that provided much information and answered questions on the spot. Visitors expect that they are given information, as can be seen with this sample when interest or learning as reasons for the visit are considered. However, as the previous factor shows, they must be able to handle the information and not be overwhelmed by it. Information value is also a consequence of Rounds' (2000) proposition that an interesting scientific idea has to be "simple and general", because it allows the visitor to apply an existing concept to new contexts. It is also a consequence of a specific presentation style (Valdecasas et al., 2006) that shows a familiar object in a different perspective (e.g., photo of a fly magnified).

These four factors can also be used to explain why interactive and the by-far-largest exhibit are mentioned as most interesting exhibits more frequently than expected by chance: *Interactive exhibits* seem particularly likely to *attract attention* (due to social navigation and visitors mimicking the behavior of other visitors; cf. Gammon, 1999a, 1999b; as they are often dynamic, movement, which attracts attention, may play a role as well) and to be *instantly enjoyable* (the interactive exhibits were very simple to use by pressing a few buttons leading to instant success; cf. Gammon, 1999a, 1999b). They were also the exhibits that were probably more *familiar* to visitors but allowed to see the topic in a different context. Due to the inherent dynamic, they also *give information* that goes beyond mere static (textual or graphical) representations. But the large number of non-interactive exhibits rated as most interesting also show the subjectivity of what attracts attention, what is regarded as instantly enjoyable, of familiarity, and of information. Similarly, the *largest exhibit* was also likely to *attract attention* easily; it is impressive by its size (*instant enjoyment*); it is also commonly known in Germany and featured prominently on the webpage of the museum (*familiarity*), although rarely seen in its (nearly) original size (*information value*). Consequently, it is not interactivity or large size per se but the consequences of these objective attributes of exhibits on the visitor-exhibit relationship that determine that exhibits with these two attributes are considered most interesting by many visitors. I propose that they are only confounded variables. In the setting of the second study, the interactive exhibits and the exception-

ally large exhibit can more easily fulfill the four factors of what makes an exhibit interesting — they attract attention, are instantly enjoyable, are familiar, and have information value. However, in a different setting where they are not distinctly noticeable due to their rarity (meaning they would not attract attention) or the interactive exhibits are more complicated to use (no longer instantly enjoyable), they probably would not be mentioned as often as most interesting.

It should also be taken into account that this four-factor solution can only explain 46.7% of the variance, leaving room for other factors that determine which exhibit is considered the most interesting. Future research should probably include more items that are related to more emotional factors of interest and perhaps address the "aura" of an exhibit. Given that the results were obtained by an exploratory factor analysis, they must be replicated with another sample to see if the findings of this exploratory factor analysis hold true for different samples and in different settings. However, this is perfectly legitimate, as the use of an exploratory factor analysis is purely exploratory: Its aim is to guide future hypotheses and give information about underlying patterns in a given data set (cf. Field, 2005, Chapter 15). While the sample size was sufficient for an exploratory factor analysis, it was at the lower bound of what is statistically permissible. A larger sample would also offer further interesting uses, for example, it would also be possible to differentiate between men and women to see if the underlying factor structure is the same for both genders. Regarding the Hypothesis 1, this study supports all three sub-hypotheses: Interactive exhibits (H1.1) and exhibits of exceptional size (H1.2) are mentioned far more often as most interesting than their frequency would lead one to expect. Furthermore, subjective factors underlying the most interesting exhibits could be found (H1.3).

## Question 2: (How) Can Interest Be Supported During the Museum Visit?

Visitors of the experimental group were provided with mobile devices that allowed easy access to the information that was available for the exhibits in the museum and also allowed bookmarking of interesting exhibits. The control group visited the mu-

seum unassisted, i.e., without a mobile device. It was expected that the device could support visitors' interest (during the visit) by facilitating access to the available information immediately in front of the exhibit.

The users of the device accessed much information on the mobile device, on average 50 information texts. While exhibits were generally preferred, users accepted the device and engaged with it, comparable in amount and intensity to labels or other exhibit information. Given that the device was second to the exhibits (like any other information source), it was not a competition for the unique selling point of museum: the authentic exhibits. Users did not engage with the device at the costs of the exhibits. The fear that the device might not be useful for its users because it offered no additional information was also unfounded.

Regarding the effects of the device on interest, there was a statistically significant difference with a moderate effect on one important behavioral indicator of interest: visit duration. Users of the device spent about 18 minutes more in the exhibition than the control group who visited the museum unassisted. Furthermore, in the experimental condition, visit duration also correlated with the amount of information accessed and bookmarked, indicating that visitors actually used the time in the exhibition to access and bookmark more information. This effect seems to be independent of interest in science and technology: When used as a covariate or when dichotomized and used as a second factor, the strength of the condition reduces but is still significant. On the other hand, subjective indicators on self-report scales like interest, learning, and engagement with the exhibition showed no differences.

Why was there no difference in the self-reported measures of interest but a significant difference in the behavioral measure of visit duration? A possible explanation would be that the users fiddled around with the device which led them to stay longer in the exhibition. However, it seems difficult to explain an average difference of 18 minutes and an average of 50 information texts accessed this way. Users also evaluated the device positively, almost all found it easy to use, and the use of digital media at the museum was rated more favorably by the experimental condition, so technical difficulties

also seem unlikely. However, the difference between the behavioral and self-reported indicators of interest can be explained with Rounds' (2004) application of the theory of information foraging to museums: The interest landscape was easier to explore with the device — information could be accessed immediately in front of the exhibit without having to look for the information tablets first and leaving the interesting exhibit behind. The device influenced the interest landscape of the museum by making the available information more easily available and thus facilitated movement across the landscape, even when it is not enlarged virtually by additional information. Visitors had the same quitting rules and, consequently, the same scores on the scales, although the experimental group could explore the interest landscape more easily virtually and thus stayed longer until museum fatigue set in and they terminated the visit.

An interesting result for further analysis was that the effect of the device for its users was still measurable when the constellation of the visit was included in the statistical analysis. While no statistically significant differences could be found between users who were solitary visitors, with their family, or in other groups, the absolute average difference of 18 minutes between the solitary visitors and the two other groups is remarkable. It is unknown whether the effect would be statistically significant if the number of solitary visitors were equal to those of the other groups (there were only 7 in the EG and 9 in the CG). If so, then the device might function as a companion for at least some solitary visitors, who, even without fellow visitors, can spend the time at the museum at their own leisure, explore the interest landscape more extensively and, consequently, stay longer. This effect was not statistically significant in this study; however it may be an interesting question for further studies.

It is important to note that due to self-selection (which is possible, and natural, in a free-choice setting), the results apply only to the users of the device. However, only a few (6/81, i.e., 7.4%) of the participants in the experimental group had to be excluded due to low usage (accessing less than 5 pieces of information on the device). Including only those participants into the analysis who showed the favorable behavior might appear like data manipulation. However, it is actually a natural self-selection in a free-

choice setting, not a way to manipulate data — a free-choice setting cannot enforce usage, only offer it. It also would have been interesting to analyze the effect of the device on all visitors by automatically giving the device to a visitor when he or she enters the museum. This was not possible because the setting could not be influenced this strongly and it would run counter to the nature of the free-choice setting. However, while accurate visitor numbers are not available, the majority of the visitors who were suitable for the study (no school classes, no excursion groups) took part in the study in the experimental group. Regarding the hypotheses, Hypothesis 2.2 could be partially supported by this study: Facilitating access to existing information in front of the exhibit does support interest by means of longer visit duration (behavioral indicator of interest), although no effect on subjective indicators (self-reported higher interest and learning) could be found.

## Question 3: (How) Can Interest Be Supported After the Museum Visit?

Visitors in the experimental group also bookmark information as interesting and have these bookmarks available on a personal page of the exhibition website. The control group only had access to the exhibition website, without a personalized list of bookmarks. It was expected that providing bookmarks would facilitate post-visit engagement, e.g., by aiding memory, reflection, being a starting point for further engagement in the topic, and facilitating the creation of common ground with others for knowledge communication.

The analyzes conducted to answer the third question depend on the follow-up test responses of the visitors. Due to the strong self-selection and the large dropout, these values might differ from the population at large.

*Use of bookmarking in the exhibition:* While visitors accessed 50 information texts on average, they marked only a few of them as interesting, and 40% did not use this feature at all. While the average is 5 marked information texts, the median of 1 and the mode of 0 point to few (heavy) users and many non-users of this feature. Furthermore, when asked why they bookmarked the information, users of the device neither agreed

nor disagreed regarding the use of bookmarking for further reflection, showing the information to others, or using it as a starting point for further reflection. However, 88.3% agreed that they had used the bookmarking feature to try out the device, which was also statistically significant. It seems that visitors had not bought into the system. Some visitor comments suggest that they could use the device easily but did not understand the benefits of bookmarking for later use. This is similar to the results of Filippini-Fantoni and Bowen (e.g., 2007, 2008) and illustrates the need for a more thorough explanation of the device beyond its immediate handling. Another problem was probably that the device was not truly part of the museum but clearly identified as part of a study in the museum. This might have prevented visitors to invest their resources in a "temporary" installation. Here, a more professional system, perhaps beyond the museum, would be desirable, giving visitors confidence that bookmarking is well worth the effort and establishing it as a tool for post-visit engagement.

*Use of the exhibition website:* Only 37.3% of the experimental group and 28.3% of the control group visited the exhibition website of this study. On average, visitors spend about 5 minutes on the website, accessing 4-5 pages containing exhibit information. There were no statistically significant differences in use between the groups. While this may sound low, it is actually high compared with the figures by Filippini-Fantoni and Bowen (2007).

*Use of bookmarks on the exhibition website:* The bookmarks on the website were accessed by 32% of the experimental group. While this may sound low, it should be noted that these are 85.71% of those in the experimental condition who visited the website at all, so, considering only the users of the exhibition website these numbers are not small. In absolute numbers, this page was used by 12 visitors between 0 and 3 times (0.64 times on average) to access a content page directly from the exhibit bookmarks list. Taken the total amount of visitors in the experimental condition, it means that 16% used the bookmarks page in the intended way.

*Evaluation of the bookmarks:* Despite the low use, participants generally regarded bookmarks as favorable. The experimental group, who had had the opportunity to try

bookmarking (often without actually using them), agreed that they wanted to have them available and agreed that in general, they would look at them, use them, considered them a good starting point for further engagement, and that they had an additional value compared to a complete catalogue. There was also a tendency to agree that it was not too much effort to create them during the visit in general. However, they did not use the bookmarks of the museum with the purpose of showing them to others. What is striking is that bookmarks in general are seen more favorable than the bookmarks they had during their visit — looking at them, using them, having an additional value, being a good starting point for further engagement — these ratings are in contrast to the actual use of the bookmarks they were able to create. It seems that bookmarks are basically a good idea, but that it is not that easy to get situations where visitors actually do create and use them. They appear to be a nice to have, if it is done without effort, to have something for later — only that, most of the time, that "later" never comes. The control group, on the other hand, had a tendency to agree that they would look at the bookmarks and that they had an additional value compared to a complete listing of all exhibits. So, in total, visitors are favorable regarding bookmarks, although they are not convinced that they would use them for further engagement in the topic or show them to others: They are undecided in general or when they were not able to try them out, but disagree that they would show them to others when they have used it. It appears that the idea to use bookmarks of exhibits as way to facilitate common ground (see page 48) is not met with approval by the visitors. *Evaluation of the website in general:* Similar results were found for the website in general, although the availability of bookmarks seems to be related to a more favorable rating of the exhibition website: The experimental group rated the exhibition website more favorably regarding wanting it to be available after the visit, looking at it, and using it. However, while both groups equally thought the exhibition website was reasonable, both groups also disagreed that they would use it to tell others about the visit. It seems that an exhibition website (and, consequently, bookmarks that are available on it) are not suited to tell others about the visit. A possible reason is that it is rarely avail-

able when people tell others about their museum visit, something that is rare anyway (compare the amount of knowledge communication after the visit). It would be interesting to see if and how this will change when mobile internet is more common and access of this information on the visitors' mobile phones will be made very easy.

*Self-reports:* Given the low use, it is not surprising that no statistically significant differences in engagement with the topic could be found six weeks after the visit, in terms of interest in the topics of the museum, willingness to visit the museum again, and recommendation of the museum to others. The difference between the experimental group and the control group regarding further interest in the topics of the museum also vanished six weeks after the visit, compared to the posttest. While there was a tendency for the experimental group to talk more about the visit, it is lower than expected.

While the results seem disappointing, it should be noted that most visitors neither prepare nor follow up their visit. Visitors only had a tendency to talk to those persons who also visited the museum with them before the visit (it is unclear whether it is a conversation about the content or just for organizing the visit) and showed no statistically significant agreement to any follow-up activity, not even talking to other persons who also visited the museum with them. If a follow-up of the visit is not done (and at least it is rare with this sample), bookmarks are without effect: They cannot support what is not done. Perhaps stronger personalization could lead to higher post-visit activity. Using photos of the visitor as at the Exploratorium (Fleck at al., 2002) might lead more visitors to access the website. Of course, whether they actually engage in the information or only look at their pictures is a question that has to be critically analyzed.

*Post-hoc comparisons:* Post-hoc comparisons of those who would want to see the exhibition again and engage further in the topics of the exhibition found that these visitors had enjoyed their visit more, evaluated the museum more positively, were more engaged during the visit, and talked more to others. Dispositional interest, subjective knowledge before or after the visit, and the number of museum visits did not turn out to be statistically significant. While this is done post hoc and is therefore exploratory,

it can be an indicator museums can work with — and the lack of influence of disposi-
tional interest is quite favorable for museums. If the visit is important and not so much
the initial interest in science and technology, a good exhibition that is rated favorably
by the visitors can lead them to engage further in the topics. However, it should be
noted that these results are not only post hoc but are also a an intention from the re-
maining participants of the study, who are strongly self-selected at this point.

Regarding the hypotheses, Hypothesis 3 could not be supported by the study. How-
ever, the problem is that a precondition is not met, which prevented bookmarks from
having an effect. Without a follow-up of the visit, bookmarks cannot work, and at least
in this sample, a follow-up of the visit was only rarely done by the visitors. On the
other hand, a museum as a free choice setting cannot please everyone, but there is a
subgroup that is willing to invest further effort.

## Conclusion

Study 2 was conducted in a museum with regular visitors. While the setting had its
own constraints (e.g., regarding the possible treatments, a high self-selection and
dropout), it provided the high ecological validity needed.

The study showed that what makes an exhibit interesting can be very well explained
by using the person-object perspective of interest and the four factors identified: at-
traction power, instant enjoyment, familiarity, and informational value. While the
properties of interactivity and exceptional size are more common among the most
interesting exhibits, they seem to be confounding variables: Their effect can be ex-
plained by the influence of the four factors.

Giving visitors the opportunity to quickly access exhibit information via a mobile de-
vice led to a strong effect on one behavioral indicator of interest: visit duration, but not
to differences in self-reports regarding interest or engagement in the exhibition. This
can be explained by using Rounds' (2004) application of the information foraging the-
ory to visitor behavior: The interest landscape was easier to explore for visitors in the
experimental condition (probably the mobile device also had a certain motivational

quality), thus leading to longer visit duration but not to higher self-reported interest, as the quitting rules remained uninfluenced and interest was on similar levels when visitors terminated the visit.

While information on the device was frequently accessed, bookmarking was rarely used, despite most visitors having a favorable opinion of bookmarking. The questionnaire showed that follow-up activity is generally very low, and this is precisely where bookmarks have their limitations: they can only support, not induce follow-up activity, and they cannot support what is not done.

In summary, the second study complemented the first study well. It provided a praxis test for mobile devices to support interest during and after the visit and showed its strengths but also its limitations.

# General Discussion

## Research Questions and the Way They Were Addressed

Three questions and six hypotheses were in focus of this dissertation thesis:

### 1. What Makes an Exhibit Interesting?

*Specifically:* Which factors determine that an exhibit is interest for a visitor if the person-object relationship of interest is taken into account? This question was predominantly addressed in Study 2.

*Hypothesis 1.1:* Interactive exhibits are more often named as most interesting than expected by chance.

*Hypothesis 1.2:* Exceptionally large exhibits are more often named as most interesting than expected by chance.

*Hypothesis 1.3:* Subjective factors in the visitor-exhibit relationship determine what makes an exhibit most interesting for a particular visitor, although no specific hypotheses can be made regarding the factors (exploratory analysis).

## 2. (How) Can Interest Be Supported During the Museum Visit?

*Specifically:* If mobile media can provide additional information or immediate access to available information on the spot when the visitor is interested in an exhibit, is this used by the visitor in the hot moment when he or she experiences a state of interest, and does this lead to longer duration of visit, higher interest and learning?

*Hypothesis 2.1:* Providing additional information on mobile devices does support interest in terms of longer visit duration, higher interest and learning.

*Hypothesis 2.2:* Facilitating access to in the exhibition available information in front of the exhibit does support interest in terms of longer visit duration, higher interest and learning.

## 3. (How) Can Interest Be Supported After the Museum Visit?

*Specifically:* If visitors have the opportunity to bookmark exhibits as interesting, what are the consequences of this feature on interest, post-visit engagement with the topic of the exhibition, and knowledge exchange?

*Hypothesis 3:* Bookmarking leads to higher engagement with the exhibition topic, interest, and knowledge exchange after the visit.

These three questions and six hypotheses were addressed in two studies. The first study (Study 1) was a laboratory experiment with a small exhibition about nanotechnology that was displayed in the foyer of the Knowledge Media Research Center and visited by recruited student participants. This study allowed high control over the setting, a high internal validity, but, due to sample restrictions and homogeneity, external validity was low. Nevertheless the study worked well for research purposes, and interest occurred in all visitors, even though they were paid for participating. However, concerns about generalizability (low external validity) required a second study in the field. Study 2 was conducted at the "Deutsches Museum Bonn", an actual science and technology museum with a broader range of exhibit topics and a natural sample. As

a sister museum of the larger "Deutsches Museum München", where the exhibition used in the first study was originally on display, it is close enough to the first study. The exhibition of the first study would fit into the museum used in the seconds study, at least regarding the topic. However, the high ecological validity came with the price of lower internal validity — the setting and its visitors could not be controlled as in the first study and the possible influence (in terms of the treatments that could be examined) was limited. Table 29 shows an overview of the main similarities and differences between the two studies.

Taken together, both studies allowed an analysis of the three research questions from

| Dimension | Study 1: Laboratory Exhibition Nanodialogue | Study 2: Field study at Deutsches Museum Bonn |
|---|---|---|
| **Exhibition** | | |
| Topic | Science and Technology | |
| Exhibit range | homogeneous (nanotechnology) | heterogeneous (science and technology) |
| **Mobile Device in (Main) Experimental Condition** | | |
| Type | Fujitsu Siemens Pocket Loox 720 PDA | |
| Navigation | manual visual navigation | |
| Navigation based on | exhibition wall images | museum map |
| Content | additional information (3 per exhibit) link to Wikipedia | available information texts (same as displayed in museum) |
| Bookmarking | available on the device | |
| **Sample** | | |
| Experience | museum experienced | |
| Visitors | recruited student participants | regular visitors |
| Payment | monetary or study participation credit | none |
| Tests | Pretest (1 week before the visit) Posttest (immediately after visit) Follow-up test (3 weeks later) | Posttest (immediately after visit) Follow-up test (6 weeks later) |
| **Evaluation** | | |
| Main advantages | high internal validity high control over the setting | high ecological validity praxis test |
| Main disadvantages | low ecological validity untypical visitor sample | low internal validity high constraints of the setting |

*Table 29:* Main similarities and differences between Studies 1 and 2

different angles, resulting in a complementary approach via a laboratory and a field study where the weaknesses of one approach are compensated by the other. However, it was not possible to realize all conditions of the laboratory study in the field study due to the constraints of the field setting. Consequently, support of interest during the visit meant providing additional information in the first study and facilitating access to available information in the second.

# Question 1: What Makes an Exhibit Interesting?

The first question looked into the factors which determine that an exhibit is interesting for a visitor if the person-object relationship of interest is taken into account.

It turned out that interest is very heterogeneous even in a homogeneous exhibition (Study 1) and that there is an overlap between most and least interesting exhibits for different visitors (Study 2): What is most interesting for one visitor can be least interesting for another visitor. In accordance with some perspectives of museum curators, interactive exhibits and the by-far-largest exhibit were named as the most interesting exhibits more often that their frequency would have led to expect. Consequently, Hypothesis 1.1 (interactivity) and 1.2 (exceptionally large size) were supported. This preference does not seem to be the result of a embarrassment choice because the strength of interest and the dispositional interest did not differ between those who chose an interactive or the largest exhibit and those who did not. An exploratory factor analysis of 14 items, on which each participant rated the exhibit he or she considered the most interesting, indicates that four factors of the visitor-exhibit relationship influence that an exhibit is most interesting for a visitor: "Attraction Power", "Instant Enjoyment", "Familiarity", and "Information Value". This supported Hypothesis 1.3 that there are subjective factors in the visitor-exhibit-relationship which determine what makes an exhibit most interesting for a particular visitor. These four factors were also related to previous research (e.g., Rounds, 2004; Silvia, 2005). An exhibit which is (the most) interesting to a visitor attracts attention, is instantly enjoyable, familiar, and has information value. These four factors can explain why the interactive and by-far-largest ex-

hibit were mentioned more often as most interesting than expected by their occurence in the museum: They fulfill these four criteria better than other exhibits. It is argued that interactivity and exceptional size do not determine interestingness per se but only (yet strongly) contribute to the fulfillment of these four factors. Correspondingly, interactivity and exceptionally large size should not be relevant if they do not have a high attraction power, are instantly enjoyable, familiar, or have information value. For example, in a more science-center-like museum with a higher frequency of interactive exhibits, the role of interactivity for the interestingness of an exhibit should decrease. However, the exploratory factor analysis still leaves much variance unexplained and has to be replicated with a different sample, preferably as an integrated part of the museum visit. The questionnaire is short and could even be answered immediately during the museum visit in front of the most (or a very) interesting exhibit[36]. The results were also found in a science and technology museum. It is an open question whether the same or different factors are responsible for the most interesting exhibit, say, in art museums. Another open question is the evaluation of the least interesting exhibit. While best cases are helpful, much can be learned from worst cases. The name of the least interesting exhibit was asked in Study 2, but it was not evaluated on the 14 items to keep the questionnaire manageable[37], which leaves this question to a further study. It should also be noted that the least interesting exhibit named is at least remembered, so it could be "interesting" (or rather: memorable) due to its uninterestingness. It would be worthwhile to examine whether interest is related to memory in a linear or rather in an inverse-curvilinear fashion, such that absolutely uninteresting objects can be as well remembered as highly interesting exhibits, while objects which are neither interesting nor uninteresting can hardly be remembered at all. This could be related to personal relevance — something could become *un*interesting if it is not interesting and the person cannot leave the setting (e.g., during a school trip to the museum).

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36  Unfortunately, the attempt to achieve this by providing the questionnaire on the mobile device in the experimental condition did not succeed in the implementation used.

37  With a total of 9 pages, the questionnaire was not exactly "short".

In summary, museum practitioners should provide exhibits that attract attention, are instantly enjoyable, connect to prior knowledge of the visitor, and provide the visitor with information — and in probably many museums, interactive exhibits seem especially, but not solely, likely to achieve these criteria.

## Question 2: (How) Can Interest Be Supported During the Museum Visit?

The second question addressed whether mobile media, which provide additional information or direct access to available information on the spot when the visitor is interested in an exhibit, is actually used by the visitor in this hot moment (when he or she experiences the state of interest), and whether this usage leads to longer visit duration, higher interest and learning.

It turned out that visitors accepted the mobile devices in both studies and used them like the other information sources in the exhibition (Study 2). The device was no danger for the engagement with the exhibits, neither in amount or intensity (Study 2), not regarding what is remembered of the exhibition (Study 1). In Study 2, a self-selection effect has to be taken into account when considering the results; however, the sample in the experimental group was still very diverse, with, for example, age ranging from 12 to 70. It was found that the mobile device did not affect visitors' *self-reported* interest, knowledge, or engagement with the exhibition, but that it had a strong effect on *behavior* in the form of nearly doubling (Study 1) or strongly increasing (Study 2) average visit duration. Thus, hypotheses 2.1 (additional information) and 2.2 (facilitating access to information) were partly supported. In Study 1, we also found indications for a "foot in the door" effect of the mobile device regarding post-visit engagement in the topic (visitors self-reports).

These results partly support the hypothesis. While no differences on most self-report indicators of interest were found, strong differences were found on the behavioral indicator of interest — the time on task (here: visit duration), which is seen as a valid indicator of interest (see Silvia, 2005; Serrell, 1997; cf. page 26). Rounds' (2004) application of information foraging theory to museum visitors' behavior can be used to ex-

plain these results: The device provides a virtual information space which changes the interest landscape of the museum by placing a second, virtual one, above (or within) it. This virtual interest landscape has different properties than the interest landscape of the museum exhibition the visitor usually engages in: It provides a much larger information space (Study 1; see theoretical background for properties of mobile devices in museums on page 36), and allows easy access to this information at any time and in any place of the exhibition (Study 1 and 2). Consequently, looking up interesting information becomes less tiring, as the visitor does not have to move towards labels and other information sources or to wait in case they are occupied. In Study 1 the mobile device enlarged the information space by providing additional information, whereas in Study 2, it assisted in the exploration of the museum information space by providing a similar, but more easily accessible interest landscape (see Figure 26 for a visualization). This made movement over the landscape easier, or rather, it allowed easy access of information by the visitor immediately in front of the exhibit — or at any other point of the exhibition (essentially, it contracts the space and reduces movement costs).

These changes in the interest landscape available at the museum both led to longer visit durations, as visitors explored the additional information space in the virtual
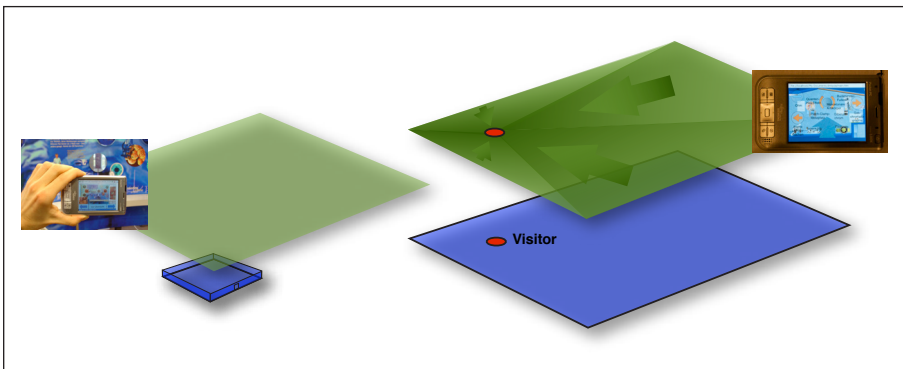


Adding a virtual information space on a mobile device (green) on top of the information space of the physical museum (blue) can enlarge the interest landscape for the museum visitor (Study 1, left) and assist the visitor in its exploration (Study 2, right).

*Figure 26:* Visualization of Interest Landscape

interest landscape (Study 1) or were assisted in exploring the available information of the museum by doing so virtually (Study 2). However, this change in the landscape can only assist visitors, but it cannot elicit or raise interest: The visitor decides where to move, or whether to move at all — physically and virtually. The first "hook" (cf. Csikszentmihalyi & Hermanson, 1995) must come from the exhibits themselves (see Question 1). If visitors are interested, then the mobile device can assist them and thereby support their interest.

It would be interesting to see in future studies where visitors step into the virtual information space, e.g., whether they do it immediately in front of the exhibit, and how they explore the virtual interest landscape in comparison to the physical one in the museum. Can the navigation in the virtual interest landscape be compared to the physical one in the museum, e.g., do the same Search, Attention, and Quitting Rules of information foraging apply? Some of these comparisons would need further information on the device, e.g., the fourth search rule "Follow the crowd to water, but be slow to drink" (Rounds, 2004) by providing awareness which information is looked at and considered to be interesting by many visitors. Another question is what happens when the virtual information space adapts to the visitors by providing context-sensitive information according to the visitors' interest and knowledge, their position in the exhibition, and other characteristics. This would consequently lead to an adaptation of the virtual interest landscape to the visitor, something that the physical interest landscape cannot do. Without wanting to strain the metaphor, providing automatic, context-sensitive information could result in an interest landscape where visitors are carried around by conveyor belts or ski-lifts if they are directed to personally interesting exhibits — or a landscape that changed depending on the visitor if suited information texts are presented depending on the visitor's preference. Another issue is the strength of interest — while no difference was found on the self-report scales in the posttest questionnaires, the scales were all applied after the visit, i.e., when the quitting rules had already been used and museum fatigue had set in. Given the similar scale value, but significant behavior differences (visit duration), interest is either the

same for both groups but is *supported only in its duration* in the mobile device group, or it could also be *raised to a higher level, but only during the visit, not after the visit*. This might also explain the longer duration of the mobile device group, but it requires further studies with measurements *during the exhibition visit* — while exploring the physical interest landscape and the virtual one — to answer this question. For this, physiological measures might also be used, although these are difficult to relate to interest (cf. Reeve, 1993, regarding the difficulty of relating facial expression to interest). However, given that the rating of the museum visit itself did not differ either, it seems more likely that only the duration of engagement in the topics was supported, not the strength of this interest, although a memory bias might explain the lack of difference. The virtual information space might also be stocked with information from a different perspective to train skills that are not physically addressed in the physical information space of the museum. For example, critical thinking could be trained when the virtual information space assists visitors in engaging critically with the information, which would result in two thematically different but related interest landscapes. Regarding the large but not significant difference between solitary visitors and visitor groups when provided with a mobile device (Study 2), further studies should also examine this difference with a larger sample of solitary visitors. It could mean that mobile media is especially suited for solitary visitors as a digital companion. However, these results should be replicated in a museum by offering additional information or easier access to available information for a longer time frame and as an integrated part of the visit, e.g., by removing the information sources in the exhibition. This could satisfy both die-hard conservatives who want the auras of the exhibits to speak for themselves (even if the visitors do not have the background to understand or even hear them) and those who want to provide visitors with as much information as possible. While the effects are there, the question for museums is: Does it makes sense to offer information on mobile devices? Museums must decide. Do they want longer visit durations if visitors are not likely to return for a revenue-bringing second visit (Study 1 and 2) or engage in the topic afterwards and thereby help the museum fulfill their

educational mission (slight effect in Study 1, not found in Study 2)? Probably not if the museum is already crowded enough and visitors should not stay too long. But during the time spent at the museum, visitors accessed and in all likelihood read the information provided on the mobile device, i.e., they helped the museum fulfill its educational mission, even if visitors do not become more interested in the topics — which is their right in an informal free-choice setting. Technology is probably the largest hindrance in offering visitors the opportunity to access a virtual information space and interest landscape. However, there are viable solutions to this. The programs used in both studies were "simple" websites that could be offered on any smartphone with WiFi access. Given the increasing power of mobile phones (see for example: The New Media Consortium and EDUCAUSE Learning Initiative, 2006, 2007, 2008, 2009) and the increased propagation of smartphones, visitors' devices become more and more powerful. In all likelihood, it will soon be possible to rely on visitors devices and allow them to access an internal network of the museum where (additional) exhibit information can be accessed. While this might raise issues of excluding specific visitor groups, it should be noted that the digital divide seems to exclude cellphones. While the possible sources of the content have already been mentioned (see page 38), given the negative evaluation of Wikipedia (Study 1), it should be adapted specifically to the mobile device, e.g., divided into small information packages that can be accessed by visitors to explore the exhibits and topics that interest them more deeply. While fear of negative consequences of mobile devices are abundant in the museum community (see page 39), none could be found in the two studies. However, the sample was either pre-selected (students in Study 1) or self-selected (visitors who participated), so a more technophobic sample will lead to different results. On the other hand, perhaps visitors are better able to handle mobile devices (given that cellphones with comparable power become standard; cf. Filippini-Fantoni & Bowen, 2008) and emancipated enough to decide for themselves whether they want to use them or not. If a mobile device is not wanted or distracts during the visit, visitors will — in all likelihood — simply not use it and put it away.

## Results of Question Two in the Wider Context of Life-Long Learning

Due to the high similarity of learning in museums and learning in other informal settings (e.g., high autonomy of the learner; no formal evaluation; fleeting situational interest); the results might have implications for life-long learning in general. Mobile media give people in everyday life the possibility to explore a virtual interest landscape above the physical one they are currently in. While the normal interest landscape probably does not contain as many objects with the high attraction power as museum with their exhibits, most people are probably somewhat familiar with their surroundings and would appreciate information if it is valuable for them. This virtual every-day interest landscape could be created by providing online access to Wikipedia and linking the information with the context the owner of the device is in. Given that many Wikipedia articles contain GPS coordinates and GPS becomes more and more common in cellphones, it is only a question of time when someone offers a mashup that connects the current physical GPS position with the articles that are available in Wikipedia about objects that are near this position. There is already a Google Earth Showcase called Placeopedia (http://www.placeopedia.com) which connects Wikipedia articles with the places the articles refer to. Topics could be related to sight-seeing or — more closely related to this work — to science and technology, e.g., by connecting science topics with places that have "exhibit quality" (for example, principles behind the tides at a coast; information about the moon during full-moon when a weather site shows a clear sky at the user's current position; information about the train a person is riding on). The museum would become part of people's everyday lives. Given that Wikipedia was written by amateurs (e.g., oftentimes peers), the information should be understandable to the user, or, in other words, the user should be able to cope with the new information, which is a condition for interest according to appraisal theories of interest (Silvia, 2005). Since the technology will be developed because the money is in context-sensitive advertisement, why should it not be used for learning? Providing these context-sensitive links would reduce effort for the user

and facilitate movement in the interest landscape and lead to engagement with science and technology — at least for those who use it.

While mobile devices were often (and still are) advertised as allowing learning anywhere and anytime, this work indicates that they can very well support engagement, but that, at least as a reference based realization, they cannot motivate it. The motivation for engagement must come from the user, and while it can be stimulated by the environment (see Question 1), it cannot be done by the mobile device itself. Or, to put it more metaphorically: The power for learning is in the active movement of the hands (and minds) of the users, not in the device he or she holds.

## Question 3: (How) Can Interest Be Supported After the Museum Visit?

The third question examined whether providing the opportunity to bookmark exhibits as interesting had consequences on interest, post-visit engagement with the topic of the exhibition, and knowledge exchange.

This question is difficult to answer based on the data of the two studies. In Study 1, the bookmarking feature of the device was used well but the website was hardly accessed, the reasons being lack of time and interest. Consequently, bookmarking could not have an effect and no differences were found between the groups that had bookmarks available and those who did not. In Study 2, the use of the exhibition website was low but would have been sufficient for analysis of effects of bookmarking — only that the bookmarking feature on the device was hardly used. Even worse: those who did use it mostly did so to try it out, not to actually use it for reflection or to exchange knowledge. Consequently, due to the very low usage after (Study 1) and during the visit (Study 2), there were no measurable differences regarding bookmarking. The results of low usage are similar to those described by Filippini-Fantoni and Bowen (2007). What was surprising is that the evaluation of bookmarks was actually quite favorable — they are considered as useful and visitors want to have them available, although not to show them to others. However, it seems that bookmarks are only a "nice to have" but not motivating in itself — visitors' perception of bookmarking is

in stark contrast to their actual use of this feature when they had the chance to use it. However, while Hypothesis 3 could not be supported, it seems that the problem is not bookmarking in itself but lack of post-visit activity: Visitors' self-reported post-visit activity was generally low in both studies. Consequently, what is not done cannot be supported, and the results of the two studies support the conclusion of Filippini and Bowen (2007) that "for most visitors, the experience starts and finishes at the museum and there is no need or curiosity to extend it beyond its walls". Post-hoc comparisons of visitors who wanted to engage in the topics of the exhibition show that post-visit activity seems to depend on higher prior interest: In Study 1, a sub-group of visitors was identified whose interest was higher and remained so after the visit, while the interest, on average, increased immediately after the visit but then decreased again. However, this influence of prior interest was not found in Study 2. It is possible that this difference is due to the very homogeneous exhibition in Study 1 (it was a specific prior interest for nanotechnology), while the range of topics was too broad in Study 2 (with science and technology in general, which diluted the predictability of a dispositional interest) to show this effect. However, these are post-hoc analyses that have to examined in future studies. To find out whether bookmarks have an influence and which, this feature has to be offered in a museum for a long time-frame to get enough absolute cases of the low percentage of visitors who use the bookmarks. Then it would be possible to find out more about the characteristics of this group, why they use bookmarks, and what the effects are.

Currently, this work can only concur with the opinions in literature that visitors must be educated about the possibilities of bookmarking (which some visitors apparently did not fully understand in Study 2) and assure visitors that this feature will be available after the visit (allowing visitors to buy into the feature by investing time and effort in it). Personalization of the content might also help, such as providing photos of visitors in front of the exhibits (see Fleck et al., 2002). However, whether visitors actually engage in the scientific content or only look at themselves on the photos has to be analyzed critically. An overarching repository of interesting exhibits or exhibit

information could disseminate knowledge about this feature by offering bookmarks in different museums, e.g., by allowing an online "museum journal" with bookmarks and photos of different museum visits. As mentioned in the literature, e.g., Gammon and Burch (2008), bookmarking could be addressed to specific target audiences, "certain types of visitors — teachers, researchers, and subject enthusiasts".

It is very probable that bookmarking will only be useful for the majority of visitors when mobile devices are so commonly used that the feature can be offered on the visitors' devices, allowing easy access after the visit. Visitors disagreed that they would use bookmarks (or the exhibition website) to talk about the visit with others; however, this might change if the information is available not on a PC or notebook, but on the mobile device in the ex-visitor's pocket (comparable to showing party photos taken with a cellphone camera). A higher flexibility of the bookmarks might stimulate use in the meantime — at least for media-literate visitors: Not only the visitors are mobile, the data is (or should be) mobile as well, e.g., by allowing integration into blogs, on personal and social websites, etc.

If it became possible to offer easy access to bookmarks on visitors cellphones, bookmarking would also be interesting to analyze in conjunction with access to the virtual every-day information space and interest landscape mentioned in the general discussion to question two (page 179). It would enable users not only to access information in Wikipedia depending on the context they are in, but also allow them to keep a trail of their daily activities. This would give them structure and remind them of the subjects they found interesting. While, in essence, this would only transfer the features of browser history and bookmarks to mobile devices, it could be a valuable assistance in knowledge acquisition for life-long learning activities. The tool could also aggregate the information (e.g., by using semantic web features) and provide selective life-logging of things that were interesting during different times of the user's life. Given that in the future, bookmarks could also be set based on implicit interest (e.g., by physiological measures of interest and not by explicit action of the user), this offers some interesting possibilities as well.

# Conclusion

This research cannot answer all questions about interest during and after museums visits, and it raises more questions than it answers. But the newly raised questions are not the same as the ones asked at the beginning of this dissertation thesis, at the very least, they are more specific and can now be addressed with a more solid foundation than prior to this work.

First, this work has shed some light on *what makes exhibits interesting for museum visitors* by examining the visitor-exhibit relationship: Interesting exhibits are those that *attract attention*, are *instantly enjoyable*, *familiar*, and *provide information* to the visitor. Probably in most museums, interactive exhibits and exhibits of exceptional size are more likely to fulfill these criteria.

Second, this work showed that *mobile devices can assist visitors' interest by changing the interest landscape of the museum*. They can do so by enlarging the information space of the exhibition into a virtual information space, thereby creating another — virtual — interest landscape, and by facilitating exploration of the interest landscape of the museum by allowing virtual access to it even without additional information. However, interest has to be raised in the exhibition (see Question 1) — so mobile devices can support interest, but they cannot elicit or raise it.

Third, and finally, this work showed that *before evaluating the use of exhibit bookmarks, visitors must be supported in their post-visit follow-up*. Post-visit activity is rare, and bookmarks — like mobile devices — are not motivating in themselves, even if they are evaluated positively, and cannot support an activity that is not done.

However, it should be reminded that this work was done in an informal free-choice setting with heterogeneous visitors — and consequently, users. Unlike school settings it is less important that something is used by everyone or that everybody finds something interesting. The museum can offer information and engagement, but it cannot force. What is done with this offer is always the choice of the visitor, be that choice a mobile device or the exhibition visit itself.

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# Figures

# Tables

# Appendices

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# Appendix A: Questionnaire Study 1

## Pretest



**Studie zur Nanodialog Ausstellung**

iwm — Institut für Wissensmedien
Knowledge Media Research Center
kmrc

### Vorbefragung

**Instruktion**

Herzlichen Willkommen zur Vorbefragung zum Ausstellungsbesuch "Nanodialog"

Dieser Fragebogen wird ca. 10 Minuten in Anspruch nehmen.

Bitte beantworten Sie alle Fragen vollständig. Falls Ihr Browser JavaScript unterstützt, werden Sie darauf hingewiesen, falls Sie ein Feld nicht beantwortet haben. Bitte füllen Sie auch die Textfelder aus (selbst wenn sie "weiß nicht" oder "nein" hineinschreiben müssen).

Weiter

---

**Bisherige Erfahrungen mit der Ausstellung**

| Haben Sie die Nanodialog-Ausstellung vorher schon einmal gesehen? | |
|---|---|
| nein | ○ |
| ja, als virtuelle Ausstellung auf einem Smartboard (interaktive Tafel) | ⊙ |
| ja, als virtuelle Ausstellung auf einem Computerbildschirm | ○ |
| ja, ich habe sie mir im Institut für Wissensmedien angesehen | ○ |
| ja, in einem Museum | ○ |

Weiter

---

**Bisherige Erfahrungen mit der Ausstellung**

Wann und wo haben Sie die Ausstellung schon einmal gesehen?

> Wird nur eingeblendet, wenn die Ausstellung schon gesehen wurde (Wert > 1)

Weiter

**Museums- und Ausstellungsbesuche <u>allgemein</u>**

Zunächst einmal möchten wir Sie bitten, einige Fragen zu Ihren bisherigen Museums- und Ausstellungsbesuchen zu beantworten.

| Haben Sie im letzten Jahr ein Museum oder eine Ausstellung besucht? | |
|---|:---:|
| ja | ⦿ |
| nein | ○ |

( Weiter )

---

**Museums- und Ausstellungsbesuche <u>allgemein</u>**

Wie oft waren Sie im letzten Jahr im Museum oder einer Ausstellung?

[        ] Mal im Jahr

( Weiter )

---

**Museums- und Ausstellungsbesuche <u>allgemein</u>**

| War das letzte Jahr typisch für die Anzahl Ihrer Museums- und Ausstellungsbesuche pro Jahr? | |
|---|:---:|
| ja | ○ |
| nein | ⦿ |

( Weiter )

---

**Museums- und Ausstellungsbesuche <u>allgemein</u>**

Wie häufig gehen Sie normalerweise pro Jahr in ein Museum oder eine Ausstellung?

[        ] Mal im Jahr

( Weiter )

## Museums- und Ausstellungsbesuche <u>allgemein</u>

| Aus welchem Anlass sind Sie in ein Museum oder eine Ausstellung gegangen? | nie | sehr selten | selten | manchmal | häufig | sehr häufig | ausschließlich |
|---|---|---|---|---|---|---|---|
| Teil der Aktivitäten im Urlaub | ○ | ○ | ○ | ◉ | ○ | ○ | ○ |
| Teil der Freizeitaktivitäten (außerhalb des Urlaubs) | ○ | ○ | ○ | ○ | ◉ | ○ | ○ |
| Teil der Unterhaltung von Gästen | ○ | ○ | ○ | ○ | ◉ | ○ | ○ |
| Teil der Unterhaltung von Kindern | ○ | ○ | ○ | ○ | ◉ | ○ | ○ |
| Im Rahmen der Arbeit zur Unterhaltung (z.B. Schulausflug, Betriebsauflug) | ○ | ○ | ○ | ○ | ○ | ◉ | ○ |
| Im Rahmen der Arbeit zur Weiterbildung (z.B. Exkursion mit Vorereitung/Nachbereitung) | ○ | ○ | ○ | ○ | ◉ | ○ | ○ |
| Spontane Entscheidung | ○ | ○ | ○ | ◉ | ○ | ○ | ○ |
| Interesse an einem konkreten Ausstellungsthema | ○ | ○ | ○ | ◉ | ○ | ○ | ○ |
| Geburtstagsgeschenk | ○ | ○ | ◉ | ○ | ○ | ○ | ○ |
| Gutscheinpaket ein | ○ | ◉ | ○ | ○ | ○ | ○ | ○ |
| textfeld3c | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

## Museums- und Ausstellungsbesuche <u>allgemein</u>

Welche Arten von Museen- und Ausstellungen haben Sie besucht?

| Museums- und Ausstellungsart | nie | sehr selten | selten | manchmal | häufig | sehr häufig | ausschließlich |
|---|---|---|---|---|---|---|---|
| Kunstmuseen/-ausstellungen | ○ | ○ | ○ | ○ | ○ | ◉ | ○ |
| Naturkundemuseen/-ausstellungen | ○ | ○ | ○ | ○ | ◉ | ○ | ○ |
| Naturwissenschaftlich-technische Museen und Ausstellungen | ○ | ○ | ○ | ○ | ○ | ◉ | ○ |
| Heimatkundemuseen/-ausstellungen | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Geschichtsmuseen/-ausstellungen | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Sonderausstellung (MoMA) | ○ | ○ | ○ | ◉ | ○ | ○ | ○ |
|  | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
|  | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

## Museums- und Ausstellungsbesuche <u>allgemein</u>

Die Fragen zum Museums- und Ausstellungsbesuch allgemein sind hiermit abgeschlossen. Falls Sie Anmerkungen zu den bisherigen Fragen haben, würden wir uns freuen, wenn Sie diese hier machen würden.

keine Anmerkungen

Weiter

---

# Vorbefragung

### Interessensvergleich

**Wir möchten Sie jetzt nochmals bitten, Ihre Interessen bezüglich verschiedene Gebieten anzugeben. Hierzu werden zunächst eine Reihe von Bereichen gegenübergestellt, bei denen Sie entscheiden sollen, welches der Bereiche Sie mehr interessiert. Je stärker Sie ein Bereich im Vergleich zum anderen interessiert, desto näher klicken Sie bitte an den entsprechenden Bereich.**

**Beispiel (nicht anklickbar)**

| Menschliche Gesellschaft | | Die Zweige des Wissens |
|---|---|---|
| Soziale Gruppen: Menschen und Kulturen, soziale Organisationen und soziale Veränderungen, Produktion, Verteilung und Nutzung von Reichtum, Politik und Regierungen, Gesetze, Bildung | ○ ○ ○ ○ ○ ○ <br> Senden | Logik, Mathematik, Wissenschaft, Geschichte und Geisteswissenschaften, Philosophie |

Sollten Sie sich im Vergleich wesentlich mehr für die "Menschliche Gesellschaft" interessieren, klicken Sie bitte das ganz linke Feld an. Sollten Sie sich eher für die "Menschliche Gesellschaft" als für "Die Zweige des Wissens" interessieren, dann klicken Sie bitte eines der linken Felder an, abhängig von der Stärke des Unterschiedes. Sollten Sie "Die Zweige des Wissens" mehr Interessieren, verfahren Sie bitte entsprechend. Sollte Sie beide Bereiche gleich interessieren, entscheiden Sie bitte, welches Sie mehr interessiert. Stellen Sie sich z.B. vor, Sie haben nur begrenzte Zeit, sich mit einem von beiden Gebieten auseinanderzusetzen, welches würden Sie eher nehmen?

---

### Interessensvergleich

Vergleich 1 von 45

**Bitte bewerten Sie auf der angegebenen Skala,
für welches der dargestellten Gebiete Sie sich eher interessieren.**

| Die Erde (als Planet) | | Materie und Energie |
|---|---|---|
| Eigenschaften, Struktur, Zusammensetzung, Atmosph | ○ ○ ○ ○ ○ ● <br> Weiter | Atome, Energie, Strahlung, Transformation von Materie |

[repeated 45 times with all combinations]

---

### Interessensvergleich

Der Interessenvergleich ist abgeschlossen, jetzt geht es mit den normalen Fragen weiter.

Weiter

**Interesse an Nanotechnologie**

| | Interessieren Sie sich für Nanotechnologie? | |
|---|---|---|
| überhaupt nicht | ○ ○ ○ ○ ○ ○ ● ○ ○ ○ | absolut |

[ Weiter ]

**Abschlusskommentar**

Das ist die letzte Frage der heutigen Untersuchung: Falls Sie möchten, haben Sie hier nochmals die Gelegenheit sich frei zum Fragebogen zu äußern.

keine

[ Weiter ]

**Vielen Dank!**

Vielen Dank für Ihre Teilnahme an dem Fragebogen vor dem Besuch der Ausstellung. Der Fragebogen ist hiermit abgeschlossen.

Wir danken nochmals sehr herzlich für die Teilnahme.

# Posttest

## Studie zur Nanodialog Ausstellung

## Befragung nach dem Ausstellungsbesuch

Herzlichen Willkommen zur Nachbefragung zum Ausstellungsbesuch "Nanodialog"

Dieser recht lange Fragebogen wird ca. 40 Minuten in Anspruch nehmen. Bitte beantworten Sie die Fragen vollständig. Falls Angaben fehlen bekommen Sie automatisch eine Rückmeldung. Dies bezieht sich auch auf Textfelder -- falls Sie dort keine Angaben machen möchten, schreiben Sie bitte einfach ein 'n' oder einen anderen Platzhalter hinein.

Ihre Angaben werden selbstverständlich anonymisiert ausgewertet.

Vielen Dank.

Weiter

---

Die Informationen der Ausstellung können Sie sich auch nach dem heutigen Tag ansehen. Sie erhalten nach dem Besuch eine Visitenkarte, auf der sich die Webadresse und Logindaten für eine Wiki (änderbare Website) befinden. In dieser sind alle Informationen der Ausstellung verfügbar.



Nach der Anmeldung können Sie oben rechts auf der Seite auf Ihre Login-Nummer klicken (neben dem Personen-Bild ()). Dann erhalten Sie eine Liste aller Objekte, die Sie in der Ausstellung interessant gefunden haben.

Weiter

## Eindrücke zum Ausstellungsbesuch

| Bitte bewerten Sie, in wie weit die folgenden Aussagen für Ihren Ausstellungsbesuch zutreffen: | überhaupt nicht | sehr selten | selten | teilweise | häufig | sehr häufig | immer |
|---|---|---|---|---|---|---|---|
| Beim Betrachten der Objekte/Informationen sind mir eigene Erlebnisse und Erfahrungen eingefallen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich hatte beim Betrachten der Objekte/Informationen auf den Inhalt bezogene bildhafte Vorstellungen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich habe mir beim Betrachten der Objekte/Informationen auch eigene auf den Inhalt bezogene Gedanken gemacht. | ○ | ○ | ○ | ○ | ○ | ○ | ● |
| Ich habe versucht, die Objekte/Informationen mit meinen eigenen Worten zu beschreiben. | ○ | ○ | ○ | ○ | ○ | ○ | ● |
| Ich konnte den Inhalt der Ausstellung mit meinem bisherigen Wissen in Verbindung bringen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich hab mir Gedanken über Sinn und Zweck der Ausstellungsinhalte gemacht. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich konnte zwischen den verschiedenen Konzepten und Ideen der Ausstellung eine Reihe von Beziehungen feststellen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich hatte das Gefühl, während des Besuches optimal aktiviert zu sein. | ○ | ○ | ○ | ○ | ○ | ○ | ● |
| Ich habe mich während des Besuches kompetent bezüglich der Ausstellung gefühlt. | ○ | ○ | ○ | ○ | ○ | ○ | ● |
| Ich hatte das Gefühl, in der Ausstellung autonom und selbst bestimmt handeln zu können. | ● | ○ | ○ | ○ | ○ | ○ | ○ |

Weiter

## Eindrücke zum Ausstellungsbesuch

| Bitte bewerten Sie, in wie weit die folgenden Aussagen für das Ausstellungsthema zutreffen: | überhaupt nicht | sehr wenig | wenig | teilweise | stark | sehr stark | absolut |
|---|---|---|---|---|---|---|---|
| Nanotechnologie ist ein interessantes Thema. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Nanotechnologie sieht so aus, als würde mir eine weitere Beschäftigung damit Spaß machen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Es macht mir Spaß, mich mit Nanotechnologie zu beschäftigen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Sich mit Nanotechnologie weiter zu beschäftigen ist interessant für mich. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich möchte mich intensiv mit Nanotechnologie befassen, um ein Gespür dafür zu bekommen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich möchte alle Feinheiten von Nanotechnologie entdecken. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich möchte mehr über Nanotechnologie erfahren. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich möchte mehr über die Details von Nanotechnologie wissen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich finde die Nanotechnologie unterhaltsam. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich finde die Nanotechnologie aufregend. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Die Nanotechnologie bewegt mich dazu, mich damit auseinanderzusetzen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |

| | überhaupt nicht | | | | | | absolut |
|---|---|---|---|---|---|---|---|
| Die Nanotechnologie spricht mich an. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Nanotechnologie war neu für mich. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Nanotechnologie ist ein aktuelles Thema. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Die Beschäftigung mit Nanotechnologie war eine neuartige Erfahrung für mich. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Nanotechnologie ist ein außergewöhnliches Thema. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Bei der Beschäftigung mit Nanotechnologie war meine Aufmerksamkeit hoch. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Bei der Beschäftigung mit Nanotechnologie war ich die ganze Zeit sehr aufmerksam. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Bei der Beschäftigung mit Nanotechnologie habe ich mich nicht ablenken lassen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Bei der Beschäftigung mit Nanotechnologie war ich konzentriert. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Nanotechnologie ist ein komplexes Thema. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Nanotechnologie ist kompliziert. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Die Auseinandersetzung mit Nanotechnologie ist eine herausfordernde Aufgabe. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Es fiel mir schwer, mich mit Nanotechnologie auseinanderzusetzen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

## Bewertung der Ausstellung

| Bitte bewerten Sie, in wie weit die folgenden Aussagen für die Ausstellung zutreffen | überhaupt nicht | sehr selten | selten | teilweise | häufig | sehr häufig | absolut |
|---|---|---|---|---|---|---|---|
| Die Ausstellung sah interessant aus. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Die Ausstellung sah so aus, als würde mir eine Beschäftigung damit Spaß machen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Es machte mir Spaß, mich eingehend mit der Ausstellung zu beschäftigen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Sich mit der Ausstellung weiter zu beschäftigen, ist interessant für mich. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich habe mich mit der Ausstellung eingehend befasst, um ein Gespür dafür zu bekommen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich wollte alle Feinheiten der Ausstellung entdecken. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich wollte mehr über die ausgestellten Objekte/Informationen erfahren. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich wollte mehr über die Details der ausgestellten Objekte/Informationen wissen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich fand die Ausstellung unterhaltsam. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich fand die Ausstellung aufregend. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Das Ausstellung regte mich an, mich mit ihr auseinanderzusetzen. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Das Ausstellung sprach mich an. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Diese Ausstellung ist neu für mich. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Diese Ausstellung ist aktuell. | ● | ○ | ○ | ○ | ○ | ○ | ○ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Diese Ausstellung ist eine neuartige Erfahrung für mich. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Die Ausstellung beinhaltete außergewöhnliche Ausstellungsstücke/Informationen. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Meine Aufmerksamkeit war hoch. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich war die ganze Zeit sehr aufmerksam. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich war fokussiert. | ○ | ○ | ○ | ○ | ○ | ○ | ⦿ |
| Ich war konzentriert. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Die Ausstellung war inhaltlich komplex. | ○ | ○ | ○ | ○ | ○ | ○ | ⦿ |
| Die Ausstellung war inhaltlich kompliziert. | ○ | ○ | ○ | ○ | ○ | ○ | ⦿ |
| Die Auseinandersetzung mit der Ausstellung ist eine herausfordernde Aufgabe. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Es war schwer für mich, mich mit den ausgestellten Objekten/Informationen auseinanderzusetzen. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

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## Eindrücke zum Ausstellungsbesuch

**Bewerten Sie bitte, wie stark Sie sich mit der Ausstellung auseinandergesetzt haben.**

überhaupt nicht ⦿ ○ ○ ○ ○ ○ ○ ○ ○ ○ sehr stark

[ Weiter ]

---

## Interessensvergleich

**Wir möchten Sie jetzt nochmals bitten, Ihre Interessen bezüglich verschiedene Gebieten anzugeben. Hierzu werden zunächst eine Reihe von Bereichen gegenübergestellt, bei denen Sie entscheiden sollen, welches der Bereiche Sie mehr interessiert. Je stärker Sie ein Bereich im Vergleich zum anderen interessiert, desto näher klicken Sie bitte an den entsprechenden Bereich.**

**Beispiel (nicht anklickbar)**

| **Menschliche Gesellschaft** | | **Die Zweige des Wissens** |
|---|---|---|
| Soziale Gruppen: Menschen und Kulturen, soziale Organisationen und soziale Veränderungen, Produktion, Verteilung und Nutzung von Reichtum, Politik und Regierungen, Gesetze, Bildung | ○ ○ ○ ○ ○ ○ [ Senden ] | Logik, Mathematik, Wissenschaft, Geschichte und Geisteswissenschaften, Philosophie |

[ Weiter ]

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## Interessensvergleich

Vergleich 1 von 45

**Bitte bewerten Sie auf der angegebenen Skala,
für welches der dargestellten Gebiete Sie sich eher interessieren.**

| **Leben auf der Erde** | | **Materie und Energie** |
|---|---|---|
| Eigenschaften/Vielfalt von lebenden Dingen, Strukturen und Funktionen von Organismen, Biosph | ⦿ ○ ○ ○ ○ ○ [ Weiter ] | Atome, Energie, Strahlung, Transformation von Materie |

## Interessensvergleich

Der Interessenvergleich ist abgeschlossen - klicken Sie bitte auf weiter.

[ Weiter ]

## Interesse an Nanotechnologie

| **Interessieren Sie sich für Nanotechnologie?** |
| --- |

überhaupt nicht  ● ○ ○ ○ ○ ○ ○ ○ ○ ○  sehr stark

[ Weiter ]

## Interessante Objekte und Informationen

| Gab es Objekte oder Informationen in der Ausstellung, die Ihr Interesse geweckt haben? | |
| --- | --- |
| ja | ● |
| nein | ○ |

[ Weiter ]

## Interessante Objekte und Informationen

Sie haben sich in der Ausstellung 14 Objekte gemerkt -- warum waren diese Objekte interessant für Sie?

[                                          ]

[ Weiter ]

## Wissen über Nanotechnologie (Rückblick)

Haben Sie **vor dem heutigen Ausstellungsbesuch** schon einmal etwas von Nanotechnologie gehört? Falls ja, schildern Sie bitte was Sie über Nanotechnologie schon wussten.

[                                          ]

[ Weiter ]

## Wissen über Nanotechnologie (Rückblick und gegenwärtiger Stand)

| Schätzen Sie bitte Ihr Wissen über Nanotechnologie ein, einmal rückblickend vor dem Besuch der Ausstellung und einmal für den aktuellen Wissensstand. | überhaupt nichts | sehr wenig | wenig | mittel | viel | sehr viel | (fast) alles |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Wissen **vor** dem Besuch der Ausstellung. | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Wissen **jetzt, nach** dem Besuch der Ausstellung. | ● | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

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**Wissen über Nanotechnologie**

Sie haben angegeben, dass Sie vor dem Besuch das Folgende über Nanotechnologie wussten:

> nix hoch vier

Was hat sich bei Ihrem Wissen geändert -- was wissen Sie jetzt?

[                                        ]

[ Weiter ]

---

**Wissen über Nanotechnologie**

Bitte beantworten Sie die folgenden Fragen

| **Können Nanopartikel selbstbestimmt handeln?** | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Ja, sie können sich sogar selbst reproduzieren. | ◉ | ○ | ○ | ○ | ○ |
| Nein, aber eine von der NSF beauftragte Forschergruppe in den USA arbeitet derzeit an einer entsprechenden Entwicklungen. | ◉ | ○ | ○ | ○ | ○ |
| Ja, z. B. in der Medizin und im Militär gibt es schon Entwicklungen, in denen Nanopartikel aktiv auf ihre Umgebung reagieren. | ◉ | ○ | ○ | ○ | ○ |
| Nein, da Nanopartikel zu klein sind, um selbstbestimmte Handlungen auszuführen. | ◉ | ○ | ○ | ○ | ○ |

[ Weiter ]

---

| **Die Auswirkungen der Nanotechnologie auf die Umwelt ...** | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| ... sind vernachlässigbar, es wird sich nichts ändern. | ◉ | ○ | ○ | ○ | ○ |
| ... sind gravierend, da bestehende Elemente verändert werden. | ◉ | ○ | ○ | ○ | ○ |
| ... sind sowohl positiv als auch negativ und halten sich die Waage. | ◉ | ○ | ○ | ○ | ○ |
| ... sind noch unzureichend untersucht. | ◉ | ○ | ○ | ○ | ○ |

[ Weiter ]

---

| **Welche der folgenden Eigenschaften treffen auf Nanopartikel zu?** | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Das Verhältnis der Oberfläche zum Volumen nimmt bei kleineren Partikeln zu. | ◉ | ○ | ○ | ○ | ○ |
| Sie bewegen sich zufällig, also unsystematisch. | ◉ | ○ | ○ | ○ | ○ |
| Sie sind *nicht* sehr reaktionsfreudig. | ◉ | ○ | ○ | ○ | ○ |
| Sie folgen den Gesetzen der klassischen Physik. | ◉ | ○ | ○ | ○ | ○ |

[ Weiter ]

| Welche der folgenden Wissenschaftsdiziplinen beschäftigen sich mit Nanotechnologie? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Elektrotechnik | ◉ | ○ | ○ | ○ | ○ |
| Genetik | ◉ | ○ | ○ | ○ | ○ |
| Architektur | ◉ | ○ | ○ | ○ | ○ |
| Ökonomie | ◉ | ○ | ○ | ○ | ○ |

Weiter

| Unter Farbdispersion versteht man ... | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| ... die Brechung von Licht in seine Spektralfarben in Flüssigkeiten. | ◉ | ○ | ○ | ○ | ○ |
| ... eine systematische Variation der Leuchtfarbe von Flüssigkeiten aufgrund der enthaltenen Nanopartikel. | ◉ | ○ | ○ | ○ | ○ |
| ... Quantenpunkte oder Nanokristalle, die unter UV-Licht leuchten. | ◉ | ○ | ○ | ○ | ○ |
| ... die gute Lesbarkeit von nanotechnologisch bearbeiteten LCD-Bildschirmen von allen Seiten aus. | ◉ | ○ | ○ | ○ | ○ |

Weiter

| Wann ist die Nanotechnologie entstanden? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Die Ursprünge gehen auf Plato zurück, während der industriellen Revolution wurden seine Entwicklungen wieder aufgegriffen. | ◉ | ○ | ○ | ○ | ○ |
| Die Nanotechnologie wurde bereits im 2. Weltkrieg eingesetzt. | ◉ | ○ | ○ | ○ | ○ |
| Einige erste wissenschaftliche Erkenntnisse aus dem 19. Jahrhundert haben zur Entwicklung der Nanotechnologie beigetragen. | ◉ | ○ | ○ | ○ | ○ |
| Die Nanotechnologie entstand erst in den letzten 30 Jahren. | ◉ | ○ | ○ | ○ | ○ |

Weiter

| Was hat ein Fußball mit der Nanotechnologie zu tun? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Bestimmte Nanopartikel haben die gleiche Form wie ein Fußball. | ◉ | ○ | ○ | ○ | ○ |
| Die Bezeichnung "Buckeyball" in der englischen Sprache. | ◉ | ○ | ○ | ○ | ○ |
| Nanotechnologisch veränderte Fußbälle fliegen besser. | ◉ | ○ | ○ | ○ | ○ |
| Ein Fußball besteht aus Nanopartikeln. | ◉ | ○ | ○ | ○ | ○ |

Weiter

| Das Größenverhältnisse von einem Meter zu einem Nanometer entspricht in etwa der Größe eines Menschen zur ... | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| ... Größe seiner DNA. | ⦿ | ○ | ○ | ○ | ○ |
| ... zur seiner Hand. | ⦿ | ○ | ○ | ○ | ○ |
| ... zur eines roten Blutkörperchens. | ⦿ | ○ | ○ | ○ | ○ |
| ... zur seines Augapfels. | ⦿ | ○ | ○ | ○ | ○ |

[ Weiter ]

| Welche der folgenden Naturphänomene sind auf die Farbdispersion zurückzuführen? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Regenbogen | ⦿ | ○ | ○ | ○ | ○ |
| Polarlicht | ⦿ | ○ | ○ | ○ | ○ |
| Morgen- bzw. Abendrot | ⦿ | ○ | ○ | ○ | ○ |
| Fata Morgana | ⦿ | ○ | ○ | ○ | ○ |

[ Weiter ]

| Die Leistungsfähigkeit von Computern steigt in den letzten Jahren, weil ... | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| ... immer kleinere Chips produziert werden können. | ⦿ | ○ | ○ | ○ | ○ |
| ... nanotechnologisch veränderte Chips eine größere Speicherkapazität haben. | ⦿ | ○ | ○ | ○ | ○ |
| ... Nanochips mehrere Datensets parallel speichern können. | ⦿ | ○ | ○ | ○ | ○ |
| ... in Nanochips der Strom in beide Richtungen fließen kann. | ⦿ | ○ | ○ | ○ | ○ |

[ Weiter ]

| Ein Sonnencremeproduzent möchte einen neuen Sonnenschutz auf den Markt bringen und in der Produktion Nanotechnologie einsetzen. Welche Vorteile könnte ein solches Produkt gegenüber herkömmlichen Sonnencremen haben? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Der Schutz hält länger an. | ⦿ | ○ | ○ | ○ | ○ |
| Sie ist besser resistent gegen Wasser. | ⦿ | ○ | ○ | ○ | ○ |
| Sonnenenergie wird besser abgehalten. | ⦿ | ○ | ○ | ○ | ○ |
| Sie ist undurchlässig für UV-Strahlen. | ⦿ | ○ | ○ | ○ | ○ |

[ Weiter ]

| Womit könnte man die Arbeitsweise des Rastertunnelmikroskops vergleichen? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Mit einem blinden Menschen, der sich mit dem Stock die Straße entlang tastet. | ⦿ | ○ | ○ | ○ | ○ |
| Mit einem CD-Laufwerk, das eine CD abtastet. | ⦿ | ○ | ○ | ○ | ○ |
| Mit einem LP-Laufwerk, das eine Schallplatte abtastet. | ⦿ | ○ | ○ | ○ | ○ |
| Mit der eines optischen Mikroskops. | ⦿ | ○ | ○ | ○ | ○ |

[ Weiter ]

| Kreuzen Sie bitte an, ob es sich bei den folgenden Aussagen um Tatsachen oder erfundene Annahmen / Zukunftsvisionen handelt: | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Nanopartikel können Wirkstoffe an bestimmten Stellen im menschlichen Körper abliefern. | ● | ○ | ○ | ○ | ○ |
| Mit Nanotechnologie wird die menschliche DNA verändert. | ● | ○ | ○ | ○ | ○ |
| Nano-Kampfanzüge schützen Soldaten vor herannahenden Projektilen. | ● | ○ | ○ | ○ | ○ |
| Mit Nanochips werden straffällige Personen überwacht. | ● | ○ | ○ | ○ | ○ |

( Weiter )

| Wie kann man die Nanotechnologie für die Energiegewinnung nutzen? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Man kann effektivere Solarzellen produzieren. | ● | ○ | ○ | ○ | ○ |
| Man kann den Tunnelstrom nutzen. | ● | ○ | ○ | ○ | ○ |
| Da in Nanopartikeln der Strom gleichzeitig in 2 Richtungen fließen kann, entsteht mehr Energie. | ● | ○ | ○ | ○ | ○ |
| Durch die Brown'sche Molekularbewegung erzeugen Nanopartikel Strom. | ● | ○ | ○ | ○ | ○ |

( Weiter )

| Wie kann man die Nanotechnologie für die Energiegewinnung nutzen? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Man kann effektivere Solarzellen produzieren. | ● | ○ | ○ | ○ | ○ |
| Man kann den Tunnelstrom nutzen. | ● | ○ | ○ | ○ | ○ |
| Da in Nanopartikeln der Strom gleichzeitig in 2 Richtungen fließen kann, entsteht mehr Energie. | ● | ○ | ○ | ○ | ○ |
| Durch die Brown'sche Molekularbewegung erzeugen Nanopartikel Strom. | ● | ○ | ○ | ○ | ○ |

( Weiter )

| Was ist ein Nanometer? | weiß ich nicht | sicher, dass falsch | glaube, dass falsch | glaube, dass richtig | sicher, dass richtig |
|---|---|---|---|---|---|
| Ein Millliardstel Meter. | ● | ○ | ○ | ○ | ○ |
| $10^{-7}$ | ● | ○ | ○ | ○ | ○ |
| Ein "Zwergenmaß" | ● | ○ | ○ | ○ | ○ |
| Der Durchmesser eines Wasserstoffatoms. | ● | ○ | ○ | ○ | ○ |

( Weiter )

| | überhaupt nicht | sehr wenig | wenig | mittel | stark | sehr stark | vollkommen |
|---|---|---|---|---|---|---|---|
| War der Umgang mit dem elektronischen Ausstellungsführer heute neu für Sie? | ● | ○ | ○ | ○ | ○ | ○ | ○ |

( Weiter )

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**Als Sie das Gerät verwendet haben -- wofür haben Sie mehr Zeit verwendet -- um das Gerät "auszuprobieren" oder um den Inhalt zu lesen?**

| Gerät ausprobieren | ○ ○ ○ ○ ○ ○ ○ ○ ○ ● | Inhalt lesen |
|---|---|---|

[ Weiter ]

---

## Bedienung des Geräts

**Bewerten Sie bitte, wie gut Sie mit dem Gerät zurecht gekommen sind**

| überhaupt nicht | ● ○ ○ ○ ○ ○ ○ ○ ○ ○ | sehr gut |
|---|---|---|

[ Weiter ]

---

## Bedienung des Geräts

|  | keinen | sehr wenig | wenig | teilweise | viel | sehr viel | vollkommen |
|---|---|---|---|---|---|---|---|
| Bewerten Sie bitte, inwieweit es Ihnen Spaß gemacht hat, sich mit dem **Gerät selbst** (unabhängig vom Inhalt) zu beschäftigen. | ○ | ○ | ○ | ○ | ○ | ○ | ● |
| Bewerten Sie bitte, inwieweit es Ihnen Spaß gemacht hat, sich mit den **Inhalten** des Geräts (Informationen über Nanotechnologie) zu beschäftigen. | ○ | ○ | ○ | ○ | ○ | ○ | ● |

[ Weiter ]

---

## Bedienung des Geräts

Bewerten Sie bitte die folgenden Aspekte des Geräts.

| Bereich | sehr schlecht | schlecht | mittel | gut | sehr gut |
|---|---|---|---|---|---|
| Gerät: Hardware | ● | ○ | ○ | ○ | ○ |
| Gerät: Software | ● | ○ | ○ | ○ | ○ |
| Menüführung | ● | ○ | ○ | ○ | ○ |
| Gewicht | ● | ○ | ○ | ○ | ○ |
| Handhabung | ● | ○ | ○ | ○ | ○ |
| Lesbarkeit der Informationen | ● | ○ | ○ | ○ | ○ |
| Qualität der dargestellten Informationen | ● | ○ | ○ | ○ | ○ |
| Nützlichkeit der dargestellten Informationen | ● | ○ | ○ | ○ | ○ |
| Störungsfreie Integration in den Besuchsablauf (Gerät beeinträchtigte die Ausstellungserfahrung nicht) | ● | ○ | ○ | ○ | ○ |
| Gerät insgesamt | ● | ○ | ○ | ○ | ○ |

[ Weiter ]

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**Bedienung des Geräts**

Gab es **Aspekte des Geräts oder der Software**, die Ihnen **gut gefallen** haben? Falls ja, welche Aspekte fanden Sie gut?

Gab es **Aspekte des Geräts oder der Software**, die Ihnen **nicht so gut** gefallen haben? Falls ja, welche Aspekte fanden Sie nicht so gut?

( Weiter )

**Verwendung des Geräts**

| Würden Sie ein solches Gerät auch bei einem normalen Museumsbesuch verwenden? |
|---|

nein ○ ● ○ ○ ○ ○ ○ ○ ○ ○ ja

Wovon hängt es ab, ob Sie es verwenden würden?

( Weiter )

**Ihr heutiger Besuch**

Welchen Preis würden Sie für den Ausstellungsführer angemessen halten?

**Euro Ausleihgebühr pro Besuch**

( Weiter )

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## Vergleich mit anderen Museumsführern

**Bewerten Sie das Gerät bitte im Vergleich zu anderen Museumsführern -- was würden Sie bevorzugen?**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| eine kundige Begleitung (z.B. Kollege, Verwandter, Bekannter) | ◉ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | verwendetes Gerät |
| eine Führung durch das Museumspersonal | ◉ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | verwendetes Gerät |
| einen Flyer (Kurzinformationen auf einem Blatt) | ◉ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | verwendetes Gerät |
| eine kleine Broschüre | ◉ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | verwendetes Gerät |
| einen Ausstellungskatalog | ◉ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | verwendetes Gerät |
| einen Audioguide (Toninformationen über Kopfhörer) | ◉ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | verwendetes Gerät |
| einen elektronischer Ausstellungsführer (PDA/Handheld) mit grafischer Darstellung | ◉ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | verwendetes Gerät |
| einen Besuch ohne Führung | ◉ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | verwendetes Gerät |

[ Weiter ]

---

## Wünsche

Gibt es **Funktionen**, die Sie sich bei dem Gerät wünschen würden?

[                    ]

Gibt es **inhaltliche** Informationen, die Sie sich bei dem Gerät wünschen würden?

[                    ]

[ Weiter ]

---

## Bedienung des Geräts

**Besitzen Sie einen PDA (ca. handgroßer Minicomputer) oder ein Smartphone (Telefon und PDA in einem)?**

| | |
|---|---|
| ja, beides | ◉ |
| ja, einen PDA | ○ |
| ja, ein Smartphone | ○ |
| nein | ○ |

[ Weiter ]

## Anmerkungen zum Gerät

Falls Sie das Gefühl haben, dass wir bei dem Gerät etwas zu Fragen vergessen haben oder Sie noch andere Anmerkungen machen möchten, würden wir uns freuen, wenn Sie diese hier machen würden.

[ Weiter ]

## Bisherige Erfahrungen mit Museumsführern

| Bewerten Sie bitte die folgenden Arten von Museumsführern. | nie ausprobiert | sehr schlecht | schlecht | mittel | gut | sehr gut |
|---|---|---|---|---|---|---|
| kundige Begleitung (z.B. Kollege, Verwandter, Bekannter) | ● | ○ | ○ | ○ | ○ | ○ |
| Führung durch das Museumspersonal | ● | ○ | ○ | ○ | ○ | ○ |
| Flyer (Kurzinformationen auf einem Blatt) | ● | ○ | ○ | ○ | ○ | ○ |
| kleine Broschüre | ● | ○ | ○ | ○ | ○ | ○ |
| Ausstellungkatalog | ● | ○ | ○ | ○ | ○ | ○ |
| Audioguide (Toninformationen über Kopfhörer) | ● | ○ | ○ | ○ | ○ | ○ |
| elektronische Ausstellungsführer mit grafischer Darstellung | ● | ○ | ○ | ○ | ○ | ○ |

Falls Sie andere Arten von Museumsführern kennen, beschreiben und bewerten Sie diese bitte hier entsprechend.

[ Weiter ]

## Mediennutzung

| Verfügen Sie über einen Internetzugang? | Ja | Nein |
|---|---|---|
| privat | ● | ○ |
| beruflich | ● | ○ |
| mobil | ● | ○ |

Wie häufig sind Sie im durchschnitt privat online? [ immer online ▾ ]

Wie häufig sind Sie im durchschnitt bei der Arbeit online? [ immer online ▾ ]

Wie häufig rufen Sie private eMails ab? [ immer online ▾ ]

Wie viele Stunden sind Sie schätzungsweise in der Woche privat online? [ 0 ]

[ Weiter ]

## Mediennutzung

| | überhaupt nicht | sehr selten | selten | mittel | häufig | sehr häufig | immer |
|---|---|---|---|---|---|---|---|
| Wie häufig schlagen Sie generell Begriffe nach, wenn Sie etwas nicht wissen? | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wie häufig verwenden Sie zum Nachschlagen Google? | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wie häufig verwenden Sie zum Nachschlagen Wikipedia? | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wie häufig verwenden Sie eine andere Internet-Suchmaschine? | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |

Welche anderen Quellen benutzen Sie zum nachschlagen, wenn Sie etwas nicht wissen?

[ Weiter ]

---

## Mediennutzung

| Bitte bewerten Sie die folgenden Aussagen. | überhaupt nicht | minimal | etwas | teilweise | stark | sehr stark | völlig |
|---|---|---|---|---|---|---|---|
| Den Informationen aus Wikipedia vertraue ich. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wikipedia ist mit höherer Wahrscheinlichkeit richtig als eine normale Website. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Wikipedia stellt Informationen aus verschiedenen Perspektiven zusammen. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich würde Wikipedia auch in einem Museum verwenden. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ein Museum sollte selbst vertiefende Informationen zusammenstellen und nicht nur auf Wikipedia zurückgreifen. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Zugriff auf Wikipedia im Museum gibt mir die Möglichkeit, die Ausstellung kritisch zu hinterfragen. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Zugriff auf Wikipedia im Museum erlaubt mir, meinen Interessen in einer Ausstellung zu folgen. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Die Informationen in Wikipedia sind fehlerfrei. | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

## Ausstellungsbesuch

| Wie fanden Sie die Ausstellung? | sehr schlecht | schlecht | mittel | gut | sehr gut |
|---|---|---|---|---|---|
| Auswahl der Informationen und Objekte | ⦿ | ○ | ○ | ○ | ○ |
| Medieneinsatz | ⦿ | ○ | ○ | ○ | ○ |
| Verfügbare Informationen in der Ausstellung | ⦿ | ○ | ○ | ○ | ○ |
| Größe | ⦿ | ○ | ○ | ○ | ○ |
| verfügbare Zeit | ⦿ | ○ | ○ | ○ | ○ |
| Übereinstimmung mit Ihren Erwartungen vor dem Besuch | ⦿ | ○ | ○ | ○ | ○ |
| Gesamteindruck | ⦿ | ○ | ○ | ○ | ○ |

[Weiter]

---

## Ausstellungsbesuch

Was gefiel Ihnen an der Ausstellung?

[                                                  ]

Was gefiel Ihnen eher weniger an der Ausstellung?

[                                                  ]

[Weiter]

---

## Ausstellungsbesuch

| Bewerten Sie bitte Ihren Besuch auf den folgenden Eigenschaften | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| selbstbestimmt | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | fremdbestimmt |
| bedeutsam | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | bedeutungslos |
| sinnvoll | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | sinnlos |
| selbstbestimmt | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | kontrolliert |
| langweilig | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | kurzweilig |
| ich kontrolliere die Technik | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | die Technik kontrolliert mich |

[Weiter]

## Nachschlagen von Informationen

| | nie | sehr selten | selten | teilweise | häufig | sehr häufig | immer |
|---|---|---|---|---|---|---|---|
| Ihr Gerät bot schon die Möglichkeit, Informationen in Wikipedia nachzuschlagen. Gab es Situationen, in denen Sie Informationen in Wikipedia nachschlagen wollten, sich dann aber dagegen entschieden haben? | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ihr Gerät bot verschiedene Hintergrundinformationen auf dem Gerät an. Gab es Situationen, in denen Sie Informationen ansehen wollten, sich dann aber dagegen entschieden haben? | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

---

## Nachschlagen von Informationen

Aus welchem Grund und bei welchen Objekten haben Sie **Informationen in Wikipedia nicht** nachgeschlagen?

[                                    ]

Aus welchem Grund und bei welchen Objekten haben Sie **die Informationen auf dem PDA nicht** nachgeschlagen?

[                                    ]

[ Weiter ]

---

## Wahrnehmung der Ausstellungsgestaltung

| Geben Sie bitte an, in wie weit Sie den folgenden Aussagen zustimmen. | überhaupt nicht | sehr wenig | wenig | teilweise | stark | sehr stark | absolut |
|---|---|---|---|---|---|---|---|
| Ich hatte das Gefühl, als Besucher von den Ausstellungsmachern ernst genommen zu werden. | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich hatte das Gefühl, dass die Ausstellungsmacher Wissen vermitteln wollten. | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich hatte das Gefühl, dass mich die Ausstellungsmacher auf Augenhöhe angesprochen haben. | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich konnte mich aktiv mit der Ausstellung auseinandersetzen. | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

**Bisherige Erfahrungen mit Nanotechnologie-Ausstellungen**

| Haben Sie die Nanodialog-Ausstellung vorher schon einmal gesehen? | |
|---|---|
| nein | ○ |
| ja, als virtuelle Ausstellung auf einem Smartboard (interaktive Tafel) | ● |
| ja, als virtuelle Ausstellung auf einem Computer | ○ |
| ja, vor dem heutigen Tag hier im Gebäude | ○ |
| ja, in einem Museum | ○ |

( Weiter )

---

**Bisherige Erfahrungen mit Nanotechnologie-Ausstellungen**

Wann und wo haben Sie die Ausstellung schon einmal gesehen?

( Weiter )

---

**Bisherige Erfahrungen mit Nanotechnologie-Ausstellungen**

| Haben Sie eine ähnliche Ausstellung schon einmal gesehen? | |
|---|---|
| nein | ○ |
| ja | ● |

( Weiter )

---

**Bisherige Erfahrungen mit Nanotechnologie-Ausstellungen**

Wann und wo haben Sie eine ähnliche Ausstellung schon einmal gesehen?

( Weiter )

---

**Freier Kommentar zur Ausstellung**

Falls Sie dies möchten, können Sie sich hier frei zur Ausstellung äußern, insbesondere wenn Sie das Gefühl haben, dass wir bestimmte Fragen oder Themen übersehen haben oder Sie andere Anmerkungen machen möchten.

( Weiter )

## Ihr heutiger Besuch

| Geben Sie bitte an, in wie weit Sie den folgenden Aussagen zustimmen. | überhaupt nicht | sehr wenig | wenig | teilweise | stark | sehr stark | absolut |
|---|---|---|---|---|---|---|---|
| Ich habe mich auf den Besuch gut vorbereitet. | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich stehe unter Zeitdruck. | ○ | ○ | ○ | ○ | ○ | ○ | ◉ |
| Ich habe mir die Ausstellung gerne angesehen. | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ich habe gerade viel um die Ohren. | ○ | ○ | ○ | ○ | ○ | ○ | ◉ |
| Ich bin freiwillig hier. | ○ | ○ | ○ | ○ | ○ | ○ | ◉ |
| Ich hätte mir die Ausstellung auch außerhalb der Untersuchung angesehen. | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

---

## Ihr heutiger Besuch

Haben Sie sich auf den heutigen Besuch vorbereitet (sich zum Beispiel im Vorfeld Informationen über Nanotechnologie angesehen)? Falls ja, schildern Sie bitte was Sie zur Vorbereitung gemacht haben.

[ ]

[ Weiter ]

---

## Fragen zu Ihrer Person

Bitte geben Sie Ihr Alter in Jahren an: [ 0 ]

Bitte geben Sie Ihr Geschlecht an:

| Geschlecht | |
|---|---|
| männlich | ○ |
| weiblich | ◉ |

Bitte geben Sie Ihren höchsten erreichen Bildungsabschluss an. [ Hochschule ▾ ]

Studieren Sie oder haben Sie studiert?

[ ja, ich studiere derzeit ▾ ]

[ Weiter ]

---

## Studium

Bitte beschreiben Sie kurz, welche **Studienfächer** Sie studieren bzw. studiert haben, wie viele **Semester** Sie studiert haben und welchen **Abschluss** Sie jeweils erreicht haben.

[ ]

[ Weiter ]

**Beruf und Studium**

Bitte geben Sie Ihren Beruf an (inkl. "Schüler" oder "Student"):

[ Weiter ]

**Abschlusskommentar**

Das ist die letzte Frage der heutigen Untersuchung: Falls Sie möchten, haben Sie hier nochmals die Gelegenheit sich frei zur Untersuchung zu äußern (z.B. Untersuchungsbedingung, Versuchsleiter, Technik, Dauer, etc.).

[ Weiter ]

**Vielen Dank!**

Vielen Dank für Ihre Teilnahme an der heutigen Untersuchung. Der Fragebogen ist hiermit abgeschlossen. In ca. 3 Wochen erhalten Sie von uns eine Mail mit der Bitte, einen **kurzen** Fragebogen online auszufüllen.

Wir danken nochmals sehr herzlich für die Teilnahme.

**Bitte informieren Sie jetzt den Versuchsleiter.**

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# Follow-up Test

**iwm** Institut für Wissensmedien
Knowledge Media Research Center
**kmrc**

## Studie zur Nanodialog Ausstellung

## Follow Up

Herzlichen Willkommen zum letzten Fragebogen zur Studie "Nanodialog"

Dieser kurze Fragebogen wird ca. 15 Minuten in Anspruch nehmen. Bitte verwenden Sie während der Beantwortung keine Hilfsmittel, auch nicht die Ausstellungswebsite (Wiki).

Bitte beantworten Sie die Fragen vollständig. Falls Angaben fehlen bekommen Sie automatisch eine Rückmeldung. Dies bezieht sich auch auf Textfelder -- falls Sie dort keine Angaben machen möchten, schreiben Sie bitte einfach ein 'n' oder einen anderen Platzhalter hinein.

Ihre Angaben werden selbstverständlich anonymisiert ausgewertet.

Vielen Dank.

[ Weiter ]

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### Weitere Beschäftigung mit der Ausstellung "Nanodialogue"

**Geben Sie bitte an, wie stark Sie sich seit dem Besuch der Nanodialog-Ausstellung mit dem Ausstellungsthema "Nanotechnologie" beschäftigt haben.**

überhaupt nicht  ● ○ ○ ○ ○ ○ ○ ○ ○ ○  sehr stark

[ Weiter ]

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### Nutzung der Ausstellungswebsite (Wiki)

**Sie hatten nach dem Besuch die Möglichkeit, sich die Informationen der Ausstellung nochmals auf einer Website (Wiki) anzusehen. Haben Sie diese Möglichkeit genutzt?**

| | |
|---|---|
| nein | ● |
| ja | ○ |

[ Weiter ]

---

### Nutzung der Ausstellungswebsite (Wiki)

Aus welchem Grund haben Sie die Ausstellungswebsite (Wiki) nicht genutzt?

[                                                    ]

[ Weiter ]

## Unterhaltungen mit anderen

| Geben Sie bitte an, inwiefern Sie sich mit den folgenden Personen nach dem Ausstellungsbesuch über die Ausstellung unterhalten haben: | überhaupt nicht | sehr wenig | wenig | mittel | viel | sehr viel |
|---|:---:|:---:|:---:|:---:|:---:|:---:|
| mit vor dem Besuch **schon bekannten/befreundeten Personen** welche die Ausstellung **nicht besucht** haben | ◉ | ○ | ○ | ○ | ○ | ○ |
| mit vor dem Besuch **schon bekannten/befreundeten Personen** welche die Ausstellung **ebenfalls besucht** haben | ○ | ◉ | ○ | ○ | ○ | ○ |
| mit vor dem Besuch **nicht bekannten Personen**, welche die Ausstellung **nicht besucht** haben | ○ | ○ | ◉ | ○ | ○ | ○ |
| mit vor dem Besuch **nicht bekannten Personen**, welche die Ausstellung **ebenfalls besucht** haben | ○ | ○ | ○ | ◉ | ○ | ○ |

[ Weiter ]

## Bereitschaft zu einem erneuten Besuch

| Wie gerne würden Sie sich die Ausstellung ein weiteres Mal ansehen (weder als Teil einer Studie noch gegen Entlohnung)? | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| überhaupt nicht | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ◉ | auf jeden Fall |

[ Weiter ]

## Weiterempfehlung der Ausstellung

| Würden Sie anderen Personen empfehlen, sich die Ausstellung anzusehen (weder als Teil einer Studie noch gegen Entlohnung)? | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| nein, überhaupt nicht | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ◉ | ○ | ja, auf jeden Fall |

[ Weiter ]

## Interessant bewertete Objekte/Informatonen

Bitte beantworten Sie die folgenden Fragen, wie Sie für den **Besuch der Nanodialog-Ausstellung** zutreffen.

| Die persönliche Webseite mit den Ausstellungsinformationen (Text und Foto) von den von mir in der Ausstellung als interessant bewerteten Ausstellungsobjekte/-informationen ... | stimmt gar nicht | stimmt eher nicht | weder/noch | stimmt eher | stimmt genau |
|---|:---:|:---:|:---:|:---:|:---:|
| ... habe ich gerne zur Verfügung gehabt. | ◉ | ○ | ○ | ○ | ○ |
| ... habe ich mir angesehen | ○ | ◉ | ○ | ○ | ○ |
| ... habe ich nicht genutzt. | ○ | ○ | ◉ | ○ | ○ |
| ... hat keinen Mehrwert für mich verglichen mit einer vollständigen Aufzählung aller Ausstellungsobjekte/-informationen. | ○ | ○ | ○ | ◉ | ○ |
| ... halte ich für sinnvoll. | ○ | ○ | ○ | ○ | ◉ |
| ... hat mich dazu bewegt, mich nach dem Besuch mit dem Thema auseinanderzusetzen. | ○ | ○ | ○ | ◉ | ○ |
| ... war mir in der Erstellung während des Ausstellungsbesuches zu viel Aufwand für den Nutzen, den ich davon habe. | ○ | ○ | ◉ | ○ | ○ |
| ... war ein guter Ausgangspunkt für eine weitere Beschäftigung mit dem Thema. | ○ | ◉ | ○ | ○ | ○ |
| ... ziehe ich einem Ausstellungskatalog gegenüber vor. | ◉ | ○ | ○ | ○ | ○ |
| ... habe ich als "roten Faden" verwendet um anderen von dem Besuch zu erzählen. | ○ | ◉ | ○ | ○ | ○ |

[ Weiter ]

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## Weiter Beschäftigung mit dem Thema

| Haben Sie vor, sich weiter mit dem Ausstellungsthema (Nanotechnologie) auseinanderzusetzen? | |
|---|:---:|
| ja, auf jeden Fall | ○ |
| ja, wahrscheinlich | ○ |
| unentschieden, abhängig von ... | ○ |
| nein, eher nicht | ○ |
| nein | ◉ |

[ Weiter ]

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## Weiter Beschäftigung mit dem Thema

Warum halten Sie es für unwahrscheinlich, dass Sie sich weiter mit dem Thema beschäftigen?

```
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[ Weiter ]

## Interessant bewertete Objekte/Informatonen

Bitte beantworten Sie die folgenden Fragen, wie Sie für einen **typischen Museums-/Ausstellungsbesuch von Ihnen** zutreffen.

| Eine persönliche Webseite mit den Ausstellungsinformationen (Text und Foto) von den von mir in der Ausstellung als interessant bewerteten Ausstellungsobjekte/-informationen ... | stimmt gar nicht | stimmt eher nicht | weder/noch | stimmt eher | stimmt genau |
|---|---|---|---|---|---|
| ... hätte ich gerne nach einem Besuch zur Verfügung. | ◉ | ○ | ○ | ○ | ○ |
| ... würde ich mir angesehen | ○ | ◉ | ○ | ○ | ○ |
| ... würde ich nicht nutzen. | ○ | ○ | ◉ | ○ | ○ |
| ... hätte keinen Mehrwert für mich verglichen mit einer vollständigen Aufzählung aller Ausstellungsobjekte/-informationen. | ○ | ○ | ○ | ◉ | ○ |
| ... halte ich für sinnvoll. | ○ | ○ | ○ | ○ | ◉ |
| ... würde mich dazu bewegen, mich nach dem Besuch mit dem Thema weiter auseinanderzusetzen. | ○ | ○ | ○ | ◉ | ○ |
| ... wäre mir in der Erstellung während des Ausstellungsbesuches zu viel Aufwand für den Nutzen, den ich davon habe. | ○ | ○ | ◉ | ○ | ○ |
| ... wäre ein guter Ausgangspunkt für eine weitere Beschäftigung mit dem Thema | ○ | ◉ | ○ | ○ | ○ |
| ... würde ich einem Ausstellungskatalog gegenüber vorziehen | ◉ | ○ | ○ | ○ | ○ |
| ... würde ich als "roten Faden" verwenden um anderen von dem Besuch zu erzählen. | ○ | ◉ | ○ | ○ | ○ |

| | stimmt gar nicht | stimmt eher nicht | weder/noch | stimmt eher | stimmt genau |
|---|---|---|---|---|---|
| ... würde ich vor dem Besuch anhand einer Darstellung aller Ausstellungsstücke in der Ausstellung erstellen. | ○ | ○ | ◉ | ○ | ○ |
| ... würde ich während des Besuches erstellen. | ○ | ○ | ○ | ◉ | ○ |
| ... würde gerne während des Besuches erweitern. | ○ | ○ | ○ | ○ | ◉ |
| ... würde gerne nach dem Besuches erweitern. | ○ | ○ | ○ | ◉ | ○ |

[Weiter]

## Vorbereitung von Besuchen

| Geben Sie bitte an, ob und wie häufig Sie die folgenden Informationsquellen normalerweise verwenden, um sich auf einen Ausstellungsbesuch vorzubereiten. | nie | sehr selten | selten | mittel | häufig | sehr häufig | immer |
|---|---|---|---|---|---|---|---|
| Website des Museums/der Ausstellung | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Bücher über das Ausstellungsthema | ○ | ● | ○ | ○ | ○ | ○ | ○ |
| Gespräch über das Thema mit Personen mit ihnen die Ausstellung besuchen (z.B. Partner, Freunde) | ○ | ○ | ● | ○ | ○ | ○ | ○ |
| Gespräche mit Personen, welche die Ausstellung nicht besuchen möchten | ○ | ○ | ○ | ● | ○ | ○ | ○ |
| Artikel in der Zeitung | ○ | ○ | ○ | ○ | ● | ○ | ○ |
| Wikipedia | ○ | ○ | ○ | ○ | ○ | ● | ○ |
| andere Website | ○ | ○ | ○ | ○ | ○ | ○ | ● |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

## Nachbereitung von Besuchen

| Geben Sie bitte an, ob und wie häufig Sie die folgenden Informationsquellen normalerweise verwenden, um sich einen Ausstellungsbesuch nachzubereiten. | nie | sehr selten | selten | mittel | häufig | sehr häufig | immer |
|---|---|---|---|---|---|---|---|
| Website des Museums/der Ausstellung | ● | ○ | ○ | ○ | ○ | ○ | ○ |
| Bücher über das Ausstellungsthema | ○ | ● | ○ | ○ | ○ | ○ | ○ |
| Gespräch über das Thema mit Personen mit ihnen die Ausstellung besucht haben (z.B. Partner, Freunde) | ○ | ○ | ● | ○ | ○ | ○ | ○ |
| Gespräche mit Personen, welche die Ausstellung nicht besucht haben | ○ | ○ | ○ | ● | ○ | ○ | ○ |
| Artikel in der Zeitung | ○ | ○ | ○ | ○ | ● | ○ | ○ |
| Wikipedia | ○ | ○ | ○ | ○ | ○ | ● | ○ |
| andere Website | ○ | ○ | ○ | ○ | ○ | ○ | ● |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| [                    ] | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

[ Weiter ]

### Interessensvergleich

Wir möchten Sie jetzt ein letztes Mal bitten, Ihre Interessen bezüglich verschiedene Gebieten anzugeben. Hierzu werden zunächst eine Reihe von Bereichen gegenübergestellt, bei denen Sie entscheiden sollen, welches der Bereiche Sie mehr interessiert. Je stärker Sie ein Bereich im Vergleich zum anderen interessiert, desto näher klicken Sie bitte an den entsprechenden Bereich.

**Beispiel (nicht anklickbar)**

| Menschliche Gesellschaft | | Die Zweige des Wissens |
|---|---|---|
| Soziale Gruppen: Menschen und Kulturen, soziale Organisationen und soziale Veränderungen, Produktion, Verteilung und Nutzung von Reichtum, Politik und Regierungen, Gesetze, Bildung | ○ ○ ○ ○ ○ ○ <br> [Senden] | Logik, Mathematik, Wissenschaft, Geschichte und Geisteswissenschaften, Philosophie |

[Weiter]

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### Interessensvergleich

Vergleich 1 von 45

**Bitte bewerten Sie auf der angegebenen Skala,
für welches der dargestellten Gebiete Sie sich eher interessieren.**

| Die Zweige des Wissens | | Religion |
|---|---|---|
| Logik, Mathematik, Naturwissenschaften, Geschichte und Geisteswissenschaften, Philosophie | ⦿ ○ ○ ○ ○ ○ <br> [Weiter] | Religion im Allgemeinen und im Speziellen |

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### Interessensvergleich

Der Interessenvergleich ist abgeschlossen - klicken Sie bitte auf weiter.

[Weiter]

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### Interesse an Nanotechnologie

| **Interessieren Sie sich für Nanotechnologie?** | | |
|---|---|---|
| überhaupt nicht | ⦿ ○ ○ ○ ○ ○ ○ ○ ○ | sehr stark |

[Weiter]

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### Erinnerung an das Ausstellungsthema

Geben Sie bitte an, woran Sie sich bezüglich des Ausstellungsthemas "Nanotechnologie" noch erinnern.

[                    ] [Weiter]

### Verhalten während der Studie

Während einer psychologischen Studie kommt es vor, dass man als Teilnehmer/in Vermutungen darüber hat, wie man sich verhalten sollte, damit ein vom Versuchsleiter gewünschtes Ergebnis auftritt. Dieses Verhalten kann von den Anweisungen des Versuchsleiters abweichen. Hatten Sie während der Studie Vermutungen darüber, wie Sie sich "verhalten sollten" und falls ja, welche waren dies und wie haben Sie sich verhalten?

[ Weiter ]

---

### Vermutung über die Ziele der Untersuchung

Was glauben Sie, sollte mit dieser Studie überprüft werden?

[ Weiter ]

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### Informationen über die Ergebnisse der Studie

**Möchten Sie die Ergebnisse der Studie per eMail zugesandt bekommen (ca. 3. Quartal 2007)?**

| | |
|---|---|
| nein | ○ |
| ja | ● |

[ Weiter ]

---

### Abschlusskommentar

Das ist die letzte Frage der Untersuchung: Falls Sie möchten, haben Sie hier nochmals die Gelegenheit sich frei zur Untersuchung zu äußern.

[ Weiter ]

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### Vielen Dank!

Vielen Dank für Ihre Teilnahme an der Untersuchung. Der Fragebogen und die Untersuchung ist hiermit abgeschlossen.

Im dritten Quartal diesen Jahres erhalten Sie eine eMail mit Informationen zum Zweck und den Ergebnissen der Studie.

Nochmals vielen herzlichen Dank und auf Wiedersehen.

# Appendix B: Questionnaire Study 2

## Posttest

Fragebogen zu Ihrem Besuch im Deutschen Museum Bonn

PDA: _____

Datum: _____

Uhrzeit: _____

Fragebogen zu Ihrem Besuch

im Deutschen Museum Bonn

iwm kmrc
Institut für Wissensmedien
Knowledge Media Research Center

Deutsches Museum Bonn
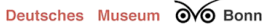
Dipl.-Psych. Daniel Wessel
Institut für Wissensmedien
Konrad-Adenauer-Straße 40
72072 Tübingen

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**Zum Fragebogen**

In diesem Fragebogen werden Ihnen Fragen zu Ihrem heutigen Museumsbesuch im Deutschen Museum Bonn gestellt. Die Fragen sind sehr detailliert, aber nicht detaillierter als nötig. Bitte nehmen Sie sich die Zeit, diesen Fragebogen vollständig auszufüllen.

Ihre Angaben werden vertraulich behandelt und anonym ausgewertet.

Vielen herzlichen Dank.

**Besuchen Sie heute das Museum allein oder in Begleitung?**

(mehr als eine Antwort ist möglich)

☐ alleine

☐ mit (Ehe-) Partner(in)

☐ mit Kind(ern)

Anzahl: _____ Alter des/der Kindes/er _____ Jahre

☐ mit Freund(in)(en)(innen), Bekannte(m)(n), Kollege(in)(n)(innen)

Anzahl (ohne Sie selbst): _____ Personen

☐ anderen: _____

**Aus welchem Grund sind Sie heute ins Museum gegangen?**

(mehr als eine Antwort ist möglich)

☐ ungeplant/spontan

☐ um sich zu unterhalten

☐ um etwas zu lernen

☐ Empfehlung von Anderen

☐ um das Museum Verwandten/Freunden/Bekannten zu zeigen

☐ Interesse an einem bestimmten Thema/Ausstellungsstück

Thema/Ausstellungsstück: _____

☐ Interesse an naturwissenschaftlich-technischen Themen

☐ Teil eines Ausflugs in die Region

☐ sonstiges: _____

**Ihre bisherigen Museumsbesuche**

Wie oft (außer heute) waren Sie schon im Deutschen Museum Bonn?

_____ Mal

Wie häufig haben Sie in den letzten 12 Monaten Museen besucht?

_____ Mal

Wie häufig haben Sie in den letzten 12 Monaten naturwissenschaftlich-technische Museen besucht?

_____ Mal

Fragebogen zu Ihrem Besuch im Deutschen Museum Bonn

| Denken Sie bitte an das Ausstellungsstück/Thema, **das Sie am meisten während Ihres heutigen Besuches interessiert hat**. Worum handelte es sich dabei?<br><br>Ausstellungsstück/Thema: _____<br><br>Bewerten Sie bitte, in wie weit Sie den folgenden Aussagen zustimmen: | starke Ablehnung | Ablehnung | leichte Ablehnung | leichte Zustimmung | Zustimmung | starke Zustimmung |
|---|---|---|---|---|---|---|
| Das Ausstellungsstück war unterhaltsam. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Auseinandersetzung mit dem Ausstellungsstück hat mir sofort Spaß gemacht. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Das Ausstellungsstück war für mich persönlich relevant. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Das Ausstellungsstück hat zu Diskussionen angeregt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Das Ausstellungsstück war neu für mich. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Das Ausstellungsstück hat meine Aufmerksamkeit angezogen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Das Ausstellungsstück war herausfordernd. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Das Ausstellungsstück regte mich zu einer aktiven Auseinandersetzung mit dem Thema an. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Über das Ausstellungsstück habe ich vor dem Besuch schon viel gewusst. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Zu dem Ausstellungsstück hatte ich viele Fragen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Zu dem Ausstellungsstück wurden viele Fragen direkt vor Ort beantwortet. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Zu dem Ausstellungsstück gab es in der Ausstellung viele Informationen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mit dem Thema des Ausstellungsstücks habe ich mich schon häufig beschäftigt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mir gefällt das Ausstellungsstück. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Wie sehr interessieren Sie sich für dieses Ausstellungsstück/Thema? Wenn Sie es auf einer Skala einordnen, die von "überhaupt kein Interesse" bis zu "dem derzeit in Ihrem Leben interessantesten Thema" geht, wo würde dieses Ausstellungsstück/Thema liegen? Kreuzen Sie diesen Punkt bitte an:

kein Interesse  ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐  für mich derzeit interessantestes Thema in meinem Leben

Wenn Sie jetzt an das für Sie **uninteressanteste** Ausstellungsstück/Thema denken -- worum handelte es sich dabei?

Ausstellungsstück/Thema: _____

Wie sehr interessieren Sie sich für dieses Ausstellungsstück/Thema? Wenn Sie es auf einer Skala einordnen, die von "überhaupt kein Interesse" bis zu "dem derzeit in Ihrem Leben interessantesten Thema", wo würde dieses Ausstellungsstück/Thema liegen? Kreuzen Sie diesen Punkt bitte an:

kein Interesse  ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐  für mich derzeit interessantestes Thema in meinem Leben

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Fragebogen zu Ihrem Besuch im Deutschen Museum Bonn

| Ihr heutiger Museumsbesuch<br>Bitte bewerten Sie, in wie weit die folgenden Aussagen für Ihren **heutigen Museumsbesuch** zutreffen: | starke Ablehnung | Ablehnung | leichte Ablehnung | leichte Zustimmung | Zustimmung | starke Zustimmung |
|---|---|---|---|---|---|---|
| Der Museumsbesuch hat mir Spaß gemacht. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Beschäftigung mit Ausstellungsstücken/Themen während des heutigen Museumsbesuches hat mir Spaß gemacht. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Einige Ausstellungsstücke/Themen haben mich überrascht. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Ausstellungsstücke bewegten mich dazu, mich mit ihnen auseinander zu setzen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich war während es Besuches konzentriert. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Ausstellungsstücke/Themen waren interessant für mich. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Während des Besuches hatte ich viele Fragen zu den Ausstellungsstücken und Themen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich möchte mehr über die Ausstellungsstücke erfahren. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Ausstellungsstücke/Themen waren kompliziert. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich fand die Ausstellungsstücke aufregend. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mich während des Besuches kompetent bezüglich der Ausstellungsthemen gefühlt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Informationen, die ich durch den Ausstellungsbesuch gelernt habe, sind wichtig im Leben. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Meine Fragen zu den Ausstellungsstücken/Themen wurden von den Informationen in der Ausstellung beantwortet. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Ausstellungsstücke waren neu für mich. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich war während des Besuches die ganze Zeit aufmerksam. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Manche Ausstellungsstücke fand ich nicht interessant. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich möchte mich weiter mit den Ausstellungsstücken beschäftigen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Einige Informationen in der Ausstellung waren überraschend für mich. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Während der Beschäftigung mit den Ausstellungsstücken habe ich persönlich relevante Erfahrungen gemacht. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich hatte während des Besuches tiefergehende Fragen zu den Ausstellungsstücken und Themen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Ausstellungsstücke sind aktuell. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Bei den Informationen in der Ausstellung habe ich schnell das Interesse verloren. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Fragebogen zu Ihrem Besuch im Deutschen Museum Bonn

| Ihr heutiger Museumsbesuch (Fortsetzung)<br>Bitte bewerten Sie, in wie weit die folgenden Aussagen für Ihren **heutigen** Ausstellungsbesuch zutreffen: | starke Ablehnung | Ablehnung | leichte Ablehnung | leichte Zustimmung | Zustimmung | starke Zustimmung |
|---|---|---|---|---|---|---|
| Andere Aktivitäten sind für mich viel interessanter als die Beschäftigung mit den Ausstellungsstücken/Themen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Beim Betrachten der Ausstellungsstücke sind mir eigene Erlebnisse und Erfahrungen eingefallen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich werde die Informationen, die ich während des Besuches gelernt habe, nie wieder benötigen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich hätte gerne mehr über die Ausstellungsstücke/Themen erfahren. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe während des Besuchs selbst Gedanken gemacht, anstatt mir nur die Texte durchzulesen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Ausstellungsstücke/Themen waren komplex. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Auseinandersetzung mit den Ausstellungsstücken war eine fordernde Aufgabe für mich. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die in der Ausstellung verfügbaren Informationen haben mein Interesse gestillt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich konnte den Inhalt der Ausstellung mit meinem bisherigen Wissen in Verbindung bringen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich konnte zwischen den verschiedenen Themen der Ausstellung eine Reihe von Beziehungen feststellen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich hatte das Gefühl, in der Ausstellung selbst bestimmt handeln zu können. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| In diesem Museum wurden die Informationen für mich unterhaltsam vermittelt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mir viele Ausstellungsstücke/Themen angesehen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mich intensiv mit den von mir angesehenen Ausstellungsstücken/Themen auseinander gesetzt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe viele Beschriftungen der Ausstellungsstücke gelesen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mich intensiv mit den von mir angesehenen Beschriftungen der Ausstellungsstücke auseinander gesetzt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mir viele Inhalte der Medienstationen (schwarze Computer mit Sitzbank) angesehen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mich intensiv mit den von mir angesehenen Inhalten der Medienstation auseinander gesetzt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mir viele Filme in der Ausstellung angesehen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mir viele der drehbaren Texte zu den Ausstellungsstücken/Themen durchgelesen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mich intensiv mit den von mir angesehenen drehbaren Texten zu den Ausstellungsstücken/Themen auseinandergesetzt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| Ihr Interesse für Naturwissenschaft und Technik allgemein<br>Bewerten Sie bitte, in wie weit Sie den folgenden Aussagen **im Allgemeinen** zustimmen. | starke Ablehnung | Ablehnung | leichte Ablehnung | leichte Zustimmung | Zustimmung | starke Zustimmung |
|---|---|---|---|---|---|---|
| Naturwissenschaft/Technik machen mir Spaß. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik bedeuten mir viel. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich finde Naturwissenschaft/Technik aufregend. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik beinhalten neuartige Erfahrungen für mich. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik ist kompliziert. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik ist komplex. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich beschäftige mich häufig mit Naturwissenschaft/Technik. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Verglichen mit anderen Fächern finde ich Naturwissenschaft/Technik aufregend. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik bewegen mich dazu, mich damit auseinander zu setzen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik sind ein wichtiger Teil meines Lebens. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| In den Naturwissenschaft/Technik gibt es oft Neuerungen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik sprechen mich an. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich finde Naturwissenschaft/Technik unterhaltsam. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Auseinandersetzung mit Naturwissenschaft/Technik ist eine fordernde Aufgabe für mich. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Verglichen mit anderen Fächern fiel es mir leicht, naturwissenschaftlich/technische Fächer zu lernen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Es ist schwer für mich, mich mit Naturwissenschaft/Technik auseinander zu setzen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Bei der Auseinandersetzung mit Naturwissenschaft/Technik bin ich aufmerksam. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik haben mir in der Schule immer Spaß gemacht. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich weiß viel über Naturwissenschaft/Technik. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich möchte mehr über Naturwissenschaft/Technik erfahren. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Bei Naturwissenschaft/Technik bin ich konzentriert. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Naturwissenschaft/Technik finde ich interessant. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| Begleitung bei Museumsbesuchen<br>Bewerten Sie bitte, in wie weit Sie den folgenden Aussagen zustimmen: | starke Ablehnung | Ablehnung | leichte Ablehnung | leichte Zustimmung | Zustimmung | starke Zustimmung |
|---|---|---|---|---|---|---|
| Ich besuche Museen gerne in Begleitung, weil es mehr Spaß macht, sich mit den Themen auseinander zu setzen, wenn man sich darüber unterhalten kann. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich besuche Museen gerne in Begleitung, weil ich dann andere fragen kann, wenn ich etwas nicht verstehe. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Von meiner Begleitung erhalte ich eine verständliche Erklärung. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| In Begleitung kann ich während des Besuches Ideen austauschen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Wenn ich in Begleitung in ein Museum gehe, dann sehen wir uns auch alles gemeinsam an. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| In Begleitung ist eine Ausstellung verständlicher. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| In Begleitung macht ein Museumsbesuch mehr Spaß. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich kann meine/m/r/n Begleiter/in/ern/innen die Ausstellungsstücke erklären. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Wie viel haben Sie **vor dem Besuch** über die naturwissenschaftlich-technischen Themen gewusst, die in der Ausstellung präsentiert werden?

| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|---|---|
| überhaupt nichts | sehr wenig | wenig | mittel | viel | sehr viel | (fast) alles |

Wie viel wissen Sie jetzt **nach dem Besuch** über die naturwissenschaftlich-technischen Themen, die in der Ausstellung präsentiert wurden?

| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
|---|---|---|---|---|---|---|
| überhaupt nichts | sehr wenig | wenig | mittel | viel | sehr viel | (fast) alles |

| Ihre Bewertung des elektronischen Ausstellungsführers<br>Bewerten Sie bitte, in wie weit Sie den folgenden Aussagen zustimmen: | starke Ablehnung | Ablehnung | leichte Ablehnung | leichte Zustimmung | Zustimmung | starke Zustimmung |
|---|---|---|---|---|---|---|
| Ich bin mit dem elektronischen Ausstellungsführer gut zurecht gekommen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Verwendung des elektronischen Ausstellungsführers hat mir Spaß gemacht. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Der elektronische Ausstellungsführer hat mein Interesse zu den Ausstellungsstücken/Themen gestillt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich verwende diesen elektronischen Ausstellungsführer gerne in Ausstellungen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mit dem elektronischen Ausstellungsführer kann ich Sachen selbst entdecken. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich fühlte mich durch den elektronischen Ausstellungsführer eingeschränkt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich fand die Informationen auf dem elektronischen Ausstellungsführer verständlich. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Die Verwendung des elektronischen Ausstellungsführers hat mich beim Ausstellungsbesuch nicht beeinträchtigt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe auf dem Gerät schnell gefunden, was ich gesucht habe. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich konnte mich auf der Karte gut orientieren. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich entdecke gerne Sachen auf dem elektronischen Ausstellungsführer. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich fühlte mich von der Technik kontrolliert. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mir viele Informationen auf dem Ausstellungsführer angesehen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ich habe mich intensiv mit den von mir angesehenen Informationen auf dem Ausstellungsführer auseinander gesetzt. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Wie neu war der Umgang mit dem elektronischen Ausstellungsführer für Sie?**

☐ ☐ ☐ ☐ ☐ ☐ ☐

überhaupt nicht    sehr wenig    wenig    mittel    stark    sehr stark    vollkommen

**Bewerten Sie bitte, wie gut Sie mit dem Gerät zurecht gekommen sind**

überhaupt nicht    ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐    sehr gut

**Wie gerne würden Sie ein solches Gerät wieder verwenden?**

überhaupt nicht    ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐    auf jeden Fall

Fragebogen zu Ihrem Besuch im Deutschen Museum Bonn

| Haben Sie Informationen auf dem elektronischen Ausstellungsführer markiert?<br>☐ ja<br>☐ nein<br><br>**Falls ja: Aus welchem Grund haben Sie Informationen markiert?** | starke Ablehnung | Ablehnung | leichte Ablehnung | leichte Zustimmung | Zustimmung | starke Zustimmung |
|---|---|---|---|---|---|---|
| ... um mir die Informationen später selbst noch einmal anzusehen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| ... um die Informationen anderen zu zeigen. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| ... als Ausgangspunkt für eine weitere Auseinandersetzung mit dem Thema. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| ... um das Gerät auszuprobieren. | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Weitere Gründe:

_____
_____
_____
_____
_____

**Falls nein: Aus welchem Grund haben Sie keine Informationen markiert?**

_____
_____
_____
_____
_____
_____

— — — End Excluded in Control Group — — — — — —

| Bewertung des Museums<br>Wie beurteilen Sie das Deutsche Museum Bonn bezüglich der folgenden Eigenschaften. | sehr schlecht | schlecht | mittel | gut | sehr gut |
|---|---|---|---|---|---|
| Dargestellte Informationen und Objekte | ☐ | ☐ | ☐ | ☐ | ☐ |
| Medieneinsatz | ☐ | ☐ | ☐ | ☐ | ☐ |
| Verfügbare Informationen in der Ausstellung | ☐ | ☐ | ☐ | ☐ | ☐ |
| Größe | ☐ | ☐ | ☐ | ☐ | ☐ |
| Verfügbare Zeit | ☐ | ☐ | ☐ | ☐ | ☐ |
| Gesamteindruck | ☐ | ☐ | ☐ | ☐ | ☐ |

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Fragebogen zu Ihrem Besuch im Deutschen Museum Bonn

Zum Abschluss haben wir noch ein paar Fragen bezüglich Ihrer Person:

Bitte geben Sie Ihr **Alter** in Jahren an:

_____ Jahre

Bitte geben Sie Ihr **Geschlecht** an:

☐ männlich

☐ weiblich

Bitte kreuzen Sie Ihren höchsten erreichten Bildungsabschluss an:

☐ keinen

☐ Sonderschulabschluss

☐ Volks- bzw. Hauptschulabschluss

☐ Realschulabschluss

☐ Abitur

☐ Studium technisch-naturwissenschaftliche Richtung oder Mathematik

☐ Studium geistes-sozialwissenschaftliche Richtung

☐ sonstiges: _____

Verfügungen Sie über einen Internetzugang?

☐ ja

☐ privat    ☐ beruflich    ☐ mobil

☐ nein

Falls ja: Wie viele Stunden pro Woche sind Sie durchschnittlich privat online?

_____ Stunden die Woche

Wie häufig rufen Sie Ihre eMails ab?

_____ Mal pro _____ (Tag/Woche/Monat)

Falls Sie Kommentare, Anmerkungen oder Anregungen machen möchten, würden wir uns freuen, wenn Sie diese hier notieren würden. Falls der Platz nicht ausreicht, verwenden Sie bitte die Rückseite dieser Seite.

_____

_____

_____

_____

_____

_____

_____

_____

_____

**Nochmals vielen herzlichen Dank für Ihre Teilnahme.**

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# Follow-up Test

## Fragebogen

Institut für Wissensmedien **Tübingen**    **Fragebogen**    **Deutsches Museum** Bonn

### Herzlichen Willkommen zur Nachbefragung zu Ihrem Besuch im Deutschen Museum Bonn

Vielen Dank für Ihre Bereitschaft, diesen Fragebogen auszufüllen. Bitte beantworten Sie die Fragen vollständig, da nur so eine Auswertung möglich ist. Dieser Fragebogen wird ca. 10 Minuten in Anspruch nehmen. Bitte verwenden Sie während der Beantwortung keine Hilfsmittel, auch nicht den digitalen Ausstellungskatalog.

[ Weiter ]

### Weitere Beschäftigung mit den Ausstellungsstücken/Themen

**Geben Sie bitte an, wie stark Sie sich seit dem Besuch des Deutschen Museums Bonn mit den dort ausgestellten Ausstellungsstücken oder Themen beschäftigt haben.**

überhaupt nicht   ⦿ ○ ○ ○ ○ ○ ○ ○ ○ ○   sehr stark

[ Weiter ]

### Unterhaltungen mit anderen

| Geben Sie bitte an, wie stark Sie sich mit anderen Personen nach Ihrem Besuch über die Ausstellung unterhalten haben: | überhaupt nicht | sehr wenig | wenig | mittel | viel | sehr viel |
|---|---|---|---|---|---|---|
| mit vor dem Besuch **schon bekannten/befreundeten Personen** welche die Ausstellung **nicht besucht** haben | ⦿ | ○ | ○ | ○ | ○ | ○ |
| mit vor dem Besuch **schon bekannten/befreundeten Personen** welche die Ausstellung **ebenfalls besucht** haben | ○ | ⦿ | ○ | ○ | ○ | ○ |
| mit vor dem Besuch **nicht bekannten Personen**, welche die Ausstellung **nicht besucht** haben | ○ | ○ | ⦿ | ○ | ○ | ○ |
| mit vor dem Besuch **nicht bekannten Personen**, welche die Ausstellung **ebenfalls besucht** haben | ○ | ○ | ○ | ⦿ | ○ | ○ |

[ Weiter ]

### Bereitschaft zu einem erneuten Besuch

**Wie gerne würden Sie sich das Museum ein weiteres Mal ansehen?**

überhaupt nicht   ⦿ ○ ○ ○ ○ ○ ○ ○ ○ ○   auf jeden Fall

**Würden Sie anderen Personen empfehlen, sich das Museum anzusehen?**

nein, überhaupt nicht   ○ ⦿ ○ ○ ○ ○ ○ ○ ○ ○   ja, auf jeden Fall

[ Weiter ]

## Weiter Beschäftigung mit dem Thema

| **Haben Sie vor, sich weiter mit dem Ausstellungsstücken oder Themen weiter auseinanderzusetzen?** | |
|---|:---:|
| ja, auf jeden Fall | ○ |
| ja, wahrscheinlich | ○ |
| unentschieden, abhängig von ... | ● |
| nein, eher nicht | ○ |
| nein | ○ |

Weiter

---

## Weiter Beschäftigung mit dem Thema

Was spricht aus Ihrer Sicht dafür, dass Sie sich mit dem Thema weiterbeschäftigen, was spricht dagegen?

Weiter

---

## Interesse

| | Wie stark interessieren Sie sich für die Ausstellungsthemen und Inhalte, die Sie im Deutschen Museum gesehen haben? | |
|---|:---:|---|
| überhaupt nicht | ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ | absolut |

Weiter

---

## Digitaler Ausstellungskatalog

Bewerten Sie bitte, in wie weit Sie den folgenden Aussagen zustimmen:

| Der digitale Ausstellungskatalog (Website) mit den Ausstellungsinformationen (Texte und Fotos) ... | stimmt gar nicht | stimmt eher nicht | weder/noch | stimmt eher | stimmt genau |
|---|:---:|:---:|:---:|:---:|:---:|
| ... habe ich gerne zur Verfügung gehabt. | ● | ○ | ○ | ○ | ○ |
| ... habe ich mir angesehen. | ○ | ● | ○ | ○ | ○ |
| ... habe ich nicht genutzt. | ○ | ○ | ● | ○ | ○ |
| ... halte ich für sinnvoll. | ○ | ○ | ○ | ● | ○ |
| ... hat mich dazu bewegt, mich nach dem Besuch mit dem Thema auseinanderzusetzen. | ○ | ○ | ○ | ○ | ● |
| ... war ein guter Ausgangspunkt für eine weitere Beschäftigung mit dem Thema. | ○ | ○ | ○ | ● | ○ |
| ... habe ich verwendet um anderen Personen von dem Besuch zu erzählen. | ○ | ○ | ● | ○ | ○ |

Weiter

## Separate Webseite mit als interessant markierten Objekten

Bewerten Sie bitte, in wie weit Sie den folgenden Aussagen zustimmen:

| Sie hatten die Möglichkeit, sich die im Museum mit Hilfe des elektronischen Ausstellungsführer gemerkten Ausstellungsstücke separat auf einer Webseite anzeigen zu lassen. Diese individuelle Webseite mit den Ausstellungsinformationen (Text und Foto) von den von mir in der Ausstellung als interessant bewerteten Ausstellungsobjekte/-informationen ... | stimmt gar nicht | stimmt eher nicht | weder/noch | stimmt eher | stimmt genau |
|---|---|---|---|---|---|
| ... habe ich gerne zur Verfügung gehabt. | ● | ○ | ○ | ○ | ○ |
| ... habe ich mir angesehen. | ○ | ● | ○ | ○ | ○ |
| ... habe ich nicht genutzt. | ○ | ○ | ● | ○ | ○ |
| ... hat keinen Mehrwert für mich verglichen mit einer vollständigen Aufzählung aller Ausstellungsobjekte/-informationen. | ○ | ○ | ○ | ● | ○ |
| ... halte ich für sinnvoll. | ○ | ○ | ○ | ○ | ● |
| ... hat mich dazu bewegt, mich nach dem Besuch mit dem Thema auseinanderzusetzen. | ○ | ○ | ○ | ● | ○ |
| ... war mir in der Erstellung während des Ausstellungsbesuches zu viel Aufwand für den Nutzen, den ich davon habe. | ○ | ○ | ● | ○ | ○ |
| ... war ein guter Ausgangspunkt für eine weitere Beschäftigung mit dem Thema. | ○ | ● | ○ | ○ | ○ |
| ... ziehe ich einem Ausstellungskatalog gegenüber vor. | ● | ○ | ○ | ○ | ○ |
| ... habe ich verwendet um anderen von dem Besuch zu erzählen. | ○ | ● | ○ | ○ | ○ |

[ Weiter ]

## Generelle Verfügbarkeit der separaten Webseite mit als interessant markierten Objekten

Bewerten Sie bitte, in wie weit Sie den folgenden Aussagen zustimmen:

| Bewerten Sie jetzt bitte die Möglichkeit, eine persönliche Webseite mit den Ausstellungsinformationen (Text und Foto) von den von ihnen in der Ausstellung als interessant bewerteten Ausstellungsobjekte/-informationen für alle Ihre Museumsbesuche zur Verfügung zu haben. Eine solche Website ... | stimmt gar nicht | stimmt eher nicht | weder/noch | stimmt eher | stimmt genau |
|---|---|---|---|---|---|
| ... hätte ich gerne nach einem Besuch zur Verfügung. | ● | ○ | ○ | ○ | ○ |
| ... würde ich mir ansehen | ○ | ● | ○ | ○ | ○ |
| ... würde ich nicht nutzen. | ○ | ○ | ● | ○ | ○ |
| ... hätte keinen Mehrwert für mich verglichen mit einer vollständigen Aufzählung aller Ausstellungsobjekte/-informationen. | ○ | ○ | ○ | ● | ○ |
| ... halte ich für sinnvoll. | ○ | ○ | ○ | ○ | ● |
| ... würde mich dazu bewegen, mich nach dem Besuch mit dem Thema weiter auseinanderzusetzen. | ○ | ○ | ○ | ● | ○ |
| ... wäre mir in der Erstellung während des Ausstellungsbesuches zu viel Aufwand für den Nutzen, den ich davon habe. | ○ | ○ | ● | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| ... wäre ein guter Ausgangspunkt für eine weitere Beschäftigung mit dem Thema | ○ | ⦿ | ○ | ○ | ○ |
| ... würde ich einem Ausstellungskatalog gegenüber vorziehen | ⦿ | ○ | ○ | ○ | ○ |
| ... würde ich verwenden um anderen von dem Besuch zu erzählen. | ○ | ⦿ | ○ | ○ | ○ |
| ... würde ich vor dem Besuch anhand einer Darstellung aller Ausstellungsstücke in der Ausstellung erstellen. | ○ | ○ | ⦿ | ○ | ○ |
| ... würde ich während des Besuches erstellen. | ○ | ○ | ○ | ⦿ | ○ |
| ... würde gerne während des Besuches erweitern. | ○ | ○ | ○ | ○ | ⦿ |
| ... würde gerne nach dem Besuches erweitern. | ○ | ○ | ○ | ⦿ | ○ |

Weiter

## Vorbereitung von Besuchen

| Geben Sie bitte an, ob und wie häufig Sie die folgenden Informationsquellen normalerweise verwenden, um sich auf einen Ausstellungsbesuch vorzubereiten. | nie | sehr selten | selten | mittel | häufig | sehr häufig | immer |
|---|---|---|---|---|---|---|---|
| Website des Museums/der Ausstellung | ⦿ | ○ | ○ | ○ | ○ | ○ | ○ |
| Bücher über das Ausstellungsthema | ○ | ⦿ | ○ | ○ | ○ | ○ | ○ |
| Gespräch über das Thema mit Personen mit ihnen die Ausstellung besuchen (z.B. Partner, Freunde) | ○ | ○ | ⦿ | ○ | ○ | ○ | ○ |
| Gespräche mit Personen, welche die Ausstellung nicht besuchen möchten | ○ | ○ | ○ | ⦿ | ○ | ○ | ○ |
| Artikel in der Zeitung | ○ | ○ | ○ | ○ | ⦿ | ○ | ○ |
| Wikipedia | ○ | ○ | ○ | ○ | ○ | ⦿ | ○ |
| andere Website | ○ | ○ | ○ | ○ | ○ | ○ | ⦿ |
| | ○ | ○ | ○ | ○ | ○ | ⦿ | ○ |
| | ○ | ○ | ○ | ○ | ⦿ | ○ | ○ |
| | ○ | ○ | ○ | ⦿ | ○ | ○ | ○ |
| | ○ | ○ | ⦿ | ○ | ○ | ○ | ○ |
| | ○ | ⦿ | ○ | ○ | ○ | ○ | ○ |

Weiter

## Nachbereitung von Besuchen

| Geben Sie bitte an, ob und wie häufig Sie die folgenden Informationsquellen normalerweise verwenden, um sich einen Ausstellungsbesuch nachzubereiten. | nie | sehr selten | selten | mittel | häufig | sehr häufig | immer |
|---|---|---|---|---|---|---|---|
| Website des Museums/der Ausstellung | ◉ | ○ | ○ | ○ | ○ | ○ | ○ |
| Bücher über das Ausstellungsthema | ○ | ◉ | ○ | ○ | ○ | ○ | ○ |
| Gespräch über das Thema mit Personen mit ihnen die Ausstellung besucht haben (z.B. Partner, Freunde) | ○ | ○ | ◉ | ○ | ○ | ○ | ○ |
| Gespräche mit Personen, welche die Ausstellung nicht besucht haben | ○ | ○ | ○ | ◉ | ○ | ○ | ○ |
| Artikel in der Zeitung | ○ | ○ | ○ | ○ | ◉ | ○ | ○ |
| Wikipedia | ○ | ○ | ○ | ○ | ○ | ◉ | ○ |
| andere Website | ○ | ○ | ○ | ○ | ○ | ○ | ◉ |
| [_____] | ○ | ○ | ○ | ○ | ○ | ◉ | ○ |
| [_____] | ○ | ○ | ○ | ○ | ◉ | ○ | ○ |
| [_____] | ○ | ○ | ○ | ◉ | ○ | ○ | ○ |
| [_____] | ○ | ○ | ◉ | ○ | ○ | ○ | ○ |
| [_____] | ○ | ◉ | ○ | ○ | ○ | ○ | ○ |

( Weiter )

## Informationen über die Ergebnisse der Studie

| Möchten Sie die Ergebnisse der Studie per eMail zugesandt bekommen (ca. Ende 2008)? | |
|---|---|
| nein | ◉ |
| ja | ○ |

( Weiter )

## Abschlusskommentar

Das ist die letzte Frage der Untersuchung: Falls Sie möchten, haben Sie hier nochmals die Gelegenheit sich frei zur Untersuchung zu äußern.

[                                                    ]

( Weiter )

## Vielen Herzlichen Dank

Der Fragebogen ist abgeschlossen. Nochmals vielen herzlichen Dank für Ihre Teilnahme.