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An Integrative and Comprehensive Methodology for Studying Aesthetic Experience in the Field: Merging Movement Tracking, Physiology, and Psychological Data

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Abstract

In the interdisciplinary context of the Swiss National Research Project *eMotion—mapping museum experience,* an integrative methodology for visitor research was developed. The goal was to investigate aesthetic experiences in the environment of a fine-arts museum. The methodology and technical setup merged different data levels (movement tracking data, heart rate and skin conductance, sociological variables, emotional and aesthetic evaluations of specific artworks) into one integrated data set. The merging was achieved online with high spatial and temporal resolution, using data gloves and a wireless network. This

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data set was used to generate information cartographies of visitors, visualizing their spatial behavior and physiological responses in the environment. In a field study with 576 museum visitors, the methodology was successfully implemented. Significant associations between physiology and aesthetic evaluations supported the validity of the cartographic representations; participants reported little reactivity toward the technical equipment. This methodology appears feasible for environmental behavior research in general.

Keywords

research method, tracking, physiology, visitor behavior, embodiment, aesthetic experience, museum

Introduction

"What is needed is more observation and less speculation," Edward Steven Robinson wrote in *The Behaviour of the Museum Visitor* (Robinson, 1928), becoming a point of departure for visitor research. Since then, many others have followed this empirical research program throughout the past 80 years. Yet, as Yalowitz and Bronnenkant (2009) observed, it is only since the 1990s that systematic visitor studies have been broadly accepted as a valid and reliable method in the field of museum studies. Owing to the work of John H. Falk, Lynn D. Dierking, Zahava D. Doering, Hans-Joachim Klein, and others, systematic visitor studies are now increasingly conducted to comprehend visitor experience. Various methodological approaches have been developed with the aim of investigating visitor behavior in detail (e.g., Baur, 2010; Kirchberg, 2010; Macdonald, 2006; Martindale, 2007; Yalowitz & Bronnenkant, 2009). Systematic observation of visitor behavior in the museum environment addresses one essential aspect, namely, the behavior manifest in the interaction of the visitor with the exhibited artworks.

Another aspect often correlated to behavioral attributes is the visitor's experience of and in the environment. A visitor enters the exhibition and looks at several more or less interesting artworks until she or he is captivated by a specific artwork. This artwork may exert a very specific and idiosyncratic attraction on the visitor. It may generate emotions of joy or anger, and cause perceptible bodily responses. As Gumbrecht (2004) suggested, the "presence" of the artwork is perceived in such observations. Gumbrecht used this concept to accomplish a paradigmatic change from a hermeneutical culture of meaning (the *Sinnkultur* prevalent in the humanistic sciences) toward a culture of presence. Presence emphasizes the materiality and experiential nature of objects, and highlights the intensity of interaction between the observer and thing observed. From a social-psychological perspective, this concept of presence is reminiscent of the concept of affordance (Lewin, 1936; Wineman & Peponis, 2010); it is furthermore corresponding with the concept of embodied cognition (Tschacher & Bergomi, 2011). Such sensory-based reception theory has a predecessor in Kant's (1781/1929) transcendental aesthetics (§1 of his *Critique of Pure Reason*). According to Kant, objects affect the senses in a preconscious, sensory manner:

> The capacity (receptivity) for receiving representations through the mode in which we are affected by objects, is entitled *sensibility*. Objects are *given* to us by means of sensibility, and it alone yields us *intuitions*; they are *thought* through the understanding, and from the understanding arise concepts.

In the process of perception, there is thus a fleeting moment when an object is not yet thoroughly processed in the cognitive system: a stage of pure sensibility that may entail conscious representations and reflections. Following Immanuel Kant or Hans Ulrich Gumbrecht, such moments of experienced presence are at the center of the perception of artworks. It is obvious that these aesthetic experiences are hard to monitor and assess; it is unlikely that they can be investigated in a reliable way via questionnaires or surveys alone, because those depict the conscious processing of experiential stages of experienced presence.

What method could apprehend the experience of aesthetic presence? Questionnaires can only be deployed at a temporal distance from these moments of presence. Furthermore, they merely address the cognitive and linguistically processed echoes of previous experience. We thus decided to complement the data acquired via surveys and questionnaires by focusing on physiological responses: Neurobiological research on art reception has shown that there are a number of physiological correlates by which the experience of beauty may be embodied (e.g., Jacobsen, Schubotz, Höfel, & Cramon, 2006; Kawabata & Zeki, 2004; Nakahara, Furuya, Obata, Masuko, & Kinoshita, 2009). This research tradition, however, is based almost exclusively on laboratory environments. It was as such a principle goal of the present project to develop a methodology that would allow for the mapping of aesthetic responses in a "natural" environment of an arts museum. We believed that aesthetic experience should be best observed in an original environment, preserving the aura and affordances of the artworks in their context, allowing for moments of presence to unfold.

Current technical apparatuses provide only reliable measurements of peripheral physiology in a field context; brain-imaging techniques for the field, such as near-infrared spectroscopy, are still unavailable. Therefore, heart activity and electrodermal processes such as skin conductance were considered possible sources for our study. Their measurement can be carried out in a noninvasive way by fixing electrodes to the skin surface. Both measures are modulated by the autonomous nervous system (ANS), which regulates fundamental functions of the body independent of volitional control. Emotional and cognitive aspects are nevertheless represented in the ANS activity, for instance, affective arousal with its cognitive implications (alertness and focused information processing) leads to autonomic changes. The ANS has two branches: the sympathetic branch mobilizes energy in stressful situations, whereas the parasympathetic system harmonizes in the absence of environmental pressure. The heart is sympathetically (activating) and parasympathetically (balancing, damping) innervated. Put simply, heart rate (HR) increase is found in activating emotions and in expressive aesthetic situations (e.g., Nakahara et al., 2009). HR is decreased briefly whenever novel information is presented (orienting response) and for longer periods when parasympathetic influence prevails, that is, during rest. HR variability (HRV) was often found related to health and disease. Positive mood and the personality trait of "openness to experience" were found associated with increased HRV. The electrodermal activity underlies only sympathetic control: Sympathetic activity leads to increased skin conductance of the hands and feet. Thus, skin conductance levels (SCLs) indicate emotional and mental activation, irrespective of valence. The phasic electrodermal responses are reflected by skin conductance variability—orienting responses, which entail HR decrease and generate phasic increases of skin conductance, so-called fluctuations. The frequency of fluctuations correlates with the level of emotional arousal. Unexpected musical events, for example, have been detected in electrodermal activity (Koelsch, 2005). Physiological studies in marketing research (Bagozzi, Gopinath, & Nyer, 1999; Critchley, Elliott, Mathias, & Dolan, 2000) maintained that arousal underlies information processing, motivation, and emotions; Groeppel-Klein (2005) demonstrated that decision-making processes were driven by phasic arousal. In sum, the psychophysiological literature provides ample evidence that emotional and cognitive responses, including responses to artworks, are reflected by heart activity and skin conductance (Skov & Vartanian, 2009; Tschacher et al., 2012).

In the context of the National Research Project *eMotion—mapping museum experience*, conducted in Switzerland, a methodology was developed to study such moments of aesthetic experience in a comprehensive and integrative way. It was decided to amalgamate a manifold of methods: behavioral, physiological, and verbal responses. It was also decided to design novel visualizations and mappings based on all these different data, with the aim of better accessing the measurements for art research. This was the objective of collaboration between approximately 20 experts from different backgrounds—social and behavioral scientists, technicians, artists, and programmers.

The basic deliverable of the eMotion project was its integrative methodology, which is described in the present article. We assumed that this methodology would be of interest for different researchers who investigate the effects and affordances of objects in spaces, yielding “more observation,” in Robinson’s sense, for visitor studies. The methodology, however, is not confined to applications in museums. In the following, we will focus on methodological and technical aspects. That is why we will not deal with more specific questions and outcomes here. We first describe the setup and participants of the eMotion project and the environment in which the methodology was developed. We then introduce the methods of information cartography (single visitor mappings, multimappings, and the RegionViewer) by which position tracking was combined with physiological measurements. Information cartography was specifically designed to map experiential moments of presence. We also report how these approaches were complemented by conventional surveys and questionnaires carried out prior to and after museum visits. Finally, the reliability of the developed methods, their benefits, and limitations are discussed.

Participants and Procedures

Participants

The methodology was developed throughout a 2-year period before entering the field research phase between June and August 2009, in the Museum of Fine Arts in St. Gallen, Switzerland (www.kunstmuseumsg.ch). All adult individual visitors as well as members of small visitor groups of up to three persons were invited to participate in the empirical phase. Participants received a data glove (described below) and, with it, a participant ID (identification number). The individual participants’ IDs were essential to merging the different data sources. During the field study period, 1,385 individuals, including children and teenagers, visited the museum. Of these, 576 individuals (i.e., 41.5%) consented to actively participate in the project. A further 496 visitors of 34 organized groups were not approached by the project staff. On the basis of the project’s inclusion criteria, which did not

Figure 1. View into the exhibition hall. Spaces 2 and 3 with works by Max Liebermann and Ferdinand Hodler (picture: Kunstmuseum St. Gallen)

include children and teenagers, about every second museum visitor agreed to participate in the research project. Primary reasons for refusing consent were too little time or lack of interest. The "surveillance technique" or invasion of the private sphere was rarely named as a reason.

The Exhibition

This research project investigated an exhibition that was open to the public. The Museum of Fine Arts in St. Gallen is a classicist building located in the city park. Visitors have a choice to attend two different exhibitions, each on a separate floor of the museum. The eMotion project considered the exhibition titled "11: 1 +3," which comprised artworks from different periods and artworks that had been previously donated to the museum. The exhibition consisted of about 70 artworks and 14 detailed text panels where donators were introduced. The eight exhibition halls included works by Claude Monet, Edvard Munch, Giovanni Giacometti, Max Ernst, Le Corbusier, Paul Klee, Yves Klein, Andy Warhol, Roy Lichtenstein, On Kawara, and many more. Figure 1 gives an impression of the environment.

The ordering of the artworks was loosely chronological, starting with Monet (Space 2) and ending with contemporary works (Space 8). Space 1 was the ticket corner and the entrance, where the entrance survey was carried out. In Space 9, the exit survey was conducted (Figure 2).

Methodological Procedure

From the participants' point of view, after he or she had been informed about the project and given his or her consent, the methodology involved the following steps: (a) fitting of the data glove, (b) entry survey, (c) viewing of the exhibition without time constraints, and (d) exit survey. A pictorial overview of these steps is given in Figure 3.

Fitting of the Data Glove

After giving informed consent, a member of the project team helped the participant put on the data glove. The participant was told that the glove contained three electronic components: a small sender that determined the visitors' position in the museum space, electrodes that measured skin conductance between two fingers, and a sensor that determined HR. The participant was also informed about the fact that all information was transmitted and stored in a wireless network, and labeled by their respective ID, that is, anonymously. The technical details are described in the section, "Technical Setup."

Entry Survey

After having received the data glove, and before embarking on their tour, the participants completed the entry survey. The entry survey allowed for the collection of data relating to socioeconomic and sociodemographical characteristics, as well as information on the frequency with which participants visited museums, their expectations and motives for visiting the exhibition, as well as their experiences and knowledge of modern fine art and their present emotional state (interest, mood, etc.). The entry survey also collected data on social factors, sometimes referred to as *biographical baggage* (Griswold, 2004) or *entrance narrative* (Doering, 1999) in the discussion of culture reception and museum experiences. Thus, each participant's sociological and psychological self-report data were available.

The four-page questionnaire contained 24 short questions using 5-point Likert-type scales and a semantic differential. The instrument was standardized and was solely composed of closed-ended questions. The survey answers

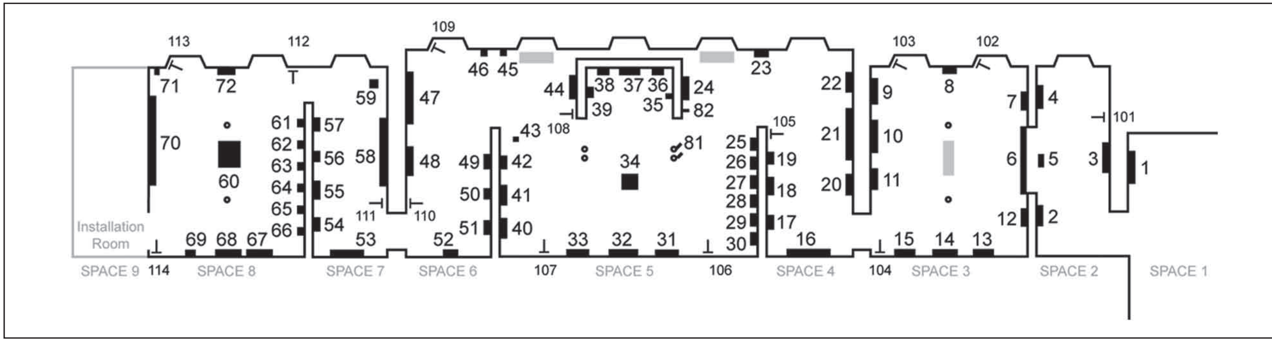


Figure 2. Floorplan of the exhibition: Spaces are labeled Space 1 to 9; Artworks 1 to 81 and Wall Texts 101 to 114.
Note: The three gray rectangles represent sitting benches. Visitors started their tour in Space 1 and finished in Space 9.

Figure 3. A depiction of the measurement process: (a) putting on the data glove, (b) electronically enabled entry survey, (c) two visitors on their tour in front of a work by Yves Klein, and (d) electronically enabled exit survey

were entered directly into a PC with the open-source software Lime Survey (www.limesurvey.org). The data set was anonymized by the visitor's participant ID. Following the entry survey, participants were able to move freely through the museum.

Exit Survey

At the end of the tour, a staff member removed the data glove. Subsequently, the electronically enabled exit survey was conducted. This survey was similarly quantitatively standardized, with a particular focus on the experiences during the visit. Items on art experiences were formulated analogous to the expectations mentioned in the entry survey. Visitors evaluated the arrangement of the artworks and information tables, which were provided in the exhibition. Further items concerned social interactions a visitor may have had during his or her visit.

In particular, responses to specific artworks were assessed: focusing on artworks to which the participant had responded physiologically and artworks with which the participant had spent significant viewing time. The criteria for selecting the prompted artworks were longest time spent in front of an artwork, maximum HRV, and the maximum variability in skin conductance. This ranking was accomplished automatically by the system on the basis of the collected tracking data. For each of the three artworks ranked as significant, the participant was reshown the particular work on a computer screen and was presented with items to assess the particular artwork. First, the participant was asked whether he or she still remembered the artwork, to exclude falsely attributed significance (the participant may have remained close to an artwork for reasons other than interest, for example, reading a text or talking to a person). If the participant remembered the artwork, questions were given relating to it (theme/content, artistic technique, composition, beauty), to the artwork's context (authorship, presentation of the artwork in the space, art historical significance, relation to other artworks in the exhibition), and to its effect (this artwork . . . surprised me, moved me, made me laugh, etc.). In comparison with these individually determined artworks (the "maximum works"), the same data were collected for three other artworks (the "index works"). Index artworks were identical for all participants.

Technical Setup

The demands on the technical infrastructure of the eMotion methodology were quite complex. A system design capable of integrating, in one location (the central server), three levels of data with incongruent properties was required:

1. *Sociological and psychological data*: The electronically enabled entry and exit surveys for assessments of the visitors, as well as assessment of artworks by the visitors, were entered at two time points into two different computer stations. The senders of these data parcels were the two computer stations.
2. *Physiological data*: HR and skin conductance were continuously measured throughout the exhibition visits, simultaneously for up to eight participants. This entailed two data streams for each participant to be fed into the central server. The sender of this data set was the moving participant.

3. *Behavioral data*: Position tracking was performed for the exact location of each of up to eight participants. Computation of position is only possible by triangulation in each museum space. The sender of this data set was each museum space. Thus, the source of position data is different from 1 and 2.

We now give some details of the technical equipment needed to acquire, process, and transmit these different data sets. The *data glove* developed specifically for the project consisted of a tag (sender) for position tracking and the instruments used to monitor the physiological activity of the visitor. Two electrodes were located on the tips of the index and middle fingers, whose function was to monitor skin conductance (active 0.5 V measurement). The glove also measured cardiac activity at a sampling rate of 50 Hz using an infrared sensor and light-emitting diode. This allowed detection of blood flow maxima in the capillaries, which are indicative of successive heartbeats. Via a programmable microcontroller (PSoC, Cypress Semiconductor) integrated into the glove, cardiac signals and skin conductance were preprocessed. Intervals between blood flow maxima were transformed to a measure of HR (beats per minute). The data streams were continuously transmitted using a wireless local area network (WLAN) module. The physiology data were given a timestamp so that they could be merged with the more or less simultaneously arriving position data on the central server.

Position tracking. A comprehensive study was carried out in 2007 on possible tracking systems. The position-tracking system had to fulfill various demands, such as a high tracking accuracy in several spaces, the ability to track several people simultaneously, and the ability to carry out real-time tracking and evaluation. In addition, only small technical interventions were allowed in the museum's interior, so as not to compromise the aesthetic of exhibition halls. After testing various systems, the Ubisense system was chosen. Ubisense is a spin-off company founded in 2002 by the Laboratory of Communications Engineering at Cambridge University that developed a real-time tracking system with ultra-wideband technology. This system consists of sensors, compact tags, a central server (Ubi server), and the network. The compact tag is a small transponder (4 × 4 × 2 cm), which enables the dynamic tracking of the museum visitor in real time with an accuracy of 15 cm. To determine the position, the tags emit impulses that are captured by multiple sensors. These sensors were installed in all corners of each room and were linked by a time-synchronizing cable. The signals, arriving at slightly different times due to different distances of a tag from the sensors, allow for the determination of the exact position of the tag. The reading of the position can occur several times per second. This arrangement allows for the continuous tracking of the movement of each visitor.

The sensors were attached to a standard Ethernet network infrastructure that forwarded their data to the central server (Figure 4). The physiological data were transferred from the visitors first to wireless access points and then via the Ethernet network to the central server. The computer stations of the entry survey (located in Space 1), the exit survey (Space 9), the Ubisense network, and the WLAN network were connected to this server. Using the participant ID, it was possible to merge the data of each participant, integrating online the data of the entry and exit surveys with the data collected during the participant's tour through the exhibition. Figure 4 shows the network infrastructure.

Up to this point, we have described the setting in which the eMotion methodology was implemented, the infrastructure needed to merge the different data sets, and we introduced the procedure required from the participants. In the following, we will outline how the collected physiological and tracking data were further processed and transformed into a variety of mappings and displays. This section will illustrate how the complex and multilevel data set that originated from several different sources could be integrated to achieve the primary aim of the eMotion methodology, that is, to provide an image of the experiential moments of presence.

Information Cartography

To introduce the different information cartographies, we will differentiate two ways of computing the data. First, physiological and tracking data can be computed based on the "region," and second, based on the overall tour. It is thus possible to carry out different evaluation processes and to illustrate different aspects, which are best achieved by providing examples of this procedure. Computations of overall statistics are described in Tröndle and Tschacher (2012) and Tschacher et al. (2012). In the following section, the region-based computation is explained.

For each individual work of the exhibition, we defined an "affective space" depending on how close a viewer must approach the work to observe it. Art experts including the museum director and the curator made the affective space definitions. The affective space of an artwork, its region, is depicted as light-gray fields and the artworks as dark-gray rectangles in Figure 5, which depict the floor plan of Spaces 2 and 3.

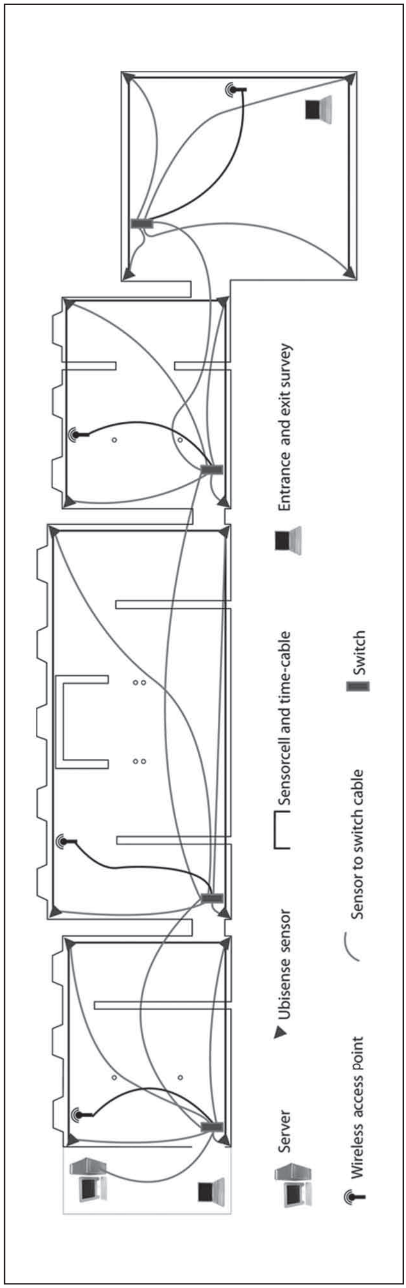


Figure 4. Network infrastructure

Figure 5. Regions (light-gray fields) of artworks (gray, fine rectangles on the walls) in Spaces 2 and 3

Note: In the middle of the two columns in Space 3, a sitting bench is located. Regions are not located directly in front of the work but slightly to the right of it (approximately 30 cm, respectively). This is due to the convention that participants wore the data glove on their right hands. In some cases, regions overlap. This can be attributed to the fact that a tag has to be at least 15 cm inside the region for it to be counted in that region.

Single Visitor Maps

The region-based calculations only involve data recorded within a region. The region-based measurements were thus particularly suitable for statistical evaluations, for example, of averages or the general associations between variables. One of these variables is "visit duration," defined as a participant's time of exit from a specific region minus the time of entry into the region. SCL and HR were calculated based on the region, as average SCL or HR throughout visit duration.

SCL and HR may also be portrayed graphically, based on the overall tour through the exhibition. Here, the time a participant spent inside the region of an artwork was of lesser interest than the participant's moving patterns. In Figure 6, an extract of the movement of Participant ID 25 is shown. Whenever SCL or HR deviates, in a moving window of 2 s, by more than 2% from this particular visitor's global mean, markers are attached to the mapping of this visitor's path; in the original, SCL and HR markers are colored differently. As changes in SCL or HR can fluctuate with different magnitudes, the physiological markers become larger in larger fluctuations. In Figure 6, gray rectangles represent the artworks and the very small rectangles represent a wall work by Nedko Solakov consisting of several small pieces. The two gray rectangles are benches, and the "T"s indicate text panels on the wall. Participant ID 25 entered the space from the bottom right-hand side in Space 4 and left it at the top left-hand side of Space 5 (Figure 6).

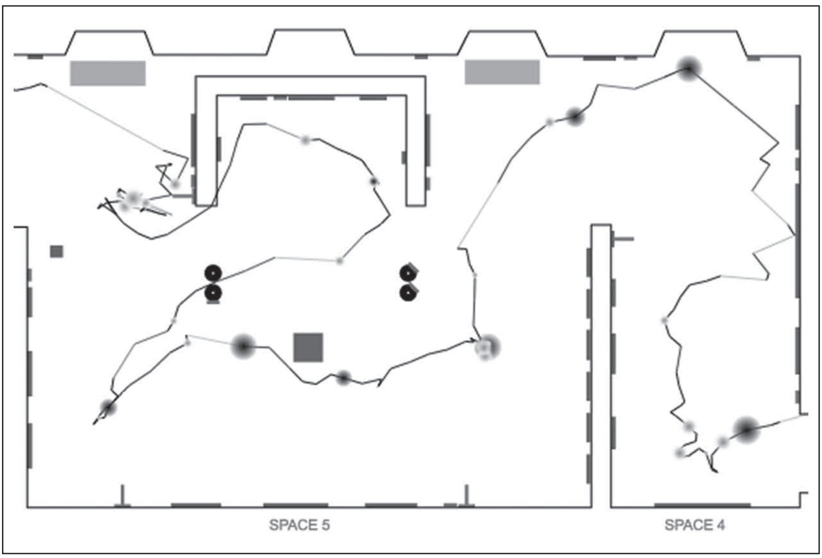


Figure 6. Path and physiological markers of Participant 25, Spaces 4 and 5
Note: Changes in skin conductance level are depicted light gray and changes in heart rate are depicted dark gray. With increasing magnitude, the physiological markers are painted larger.

The position data accurately displayed visitors' spatial behavior in the museum. We found the graphical portraits of individual tours easy to interpret. According to the entry survey, Participant 25 was a woman between 18 and 29 years of age. Most of the time, she passed by the artworks keeping a large distance and appeared to show little interest in the artworks. The exception was the text panel "T 108" (Space 5; for numberings, see Figure 2). She also showed interest in the series of the six water colors by Julius Bissier (Works 25-30) but did not approach these subtle works close enough to be able to observe their small details. She read only one label, associated with the five works by Paul Klee (hanging in the ∏-alcove). Her tour through the exhibition might be described as *cursory* or *hasty*. In the entry survey, she correspondingly stated that she did not visit the exhibition because of the art but due to "other reasons."

In comparison, Figure 7 is an extract from the tour taken by Participant ID 75, who exhibited a completely different spatial behavior and showed considerably more physiological markers. Similar to Participant 25, she was between 18 and 29 years old (Figure 7).

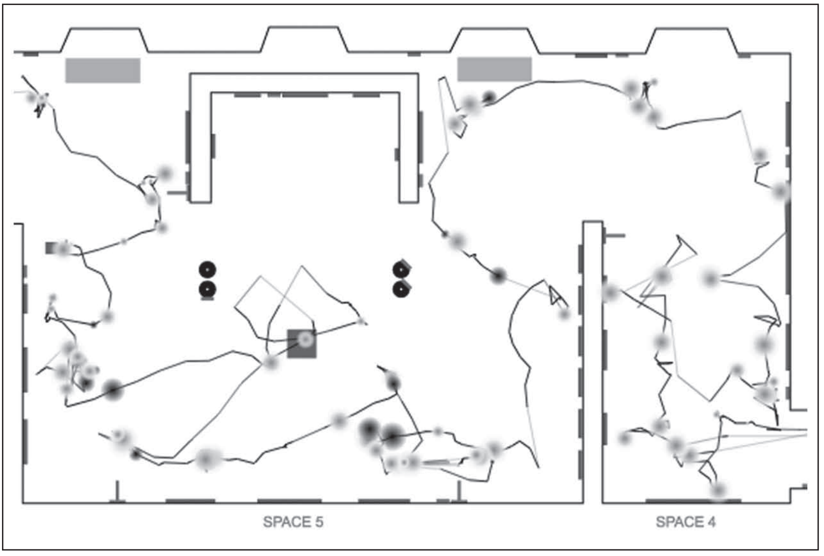


Figure 7. Path and physiological markers of Participant 75, Spaces 4 and 5

This visitor moved from artwork to artwork, observing closely most of the 30 works; she exhibited predominant HR fluctuations (yellow/light-gray markers). As we statistically found that HRV, represented by these markers, was positively associated with assessments of "Aesthetic

Quality," "Curatorial Quality," and "Surprise/Humor" (Tschacher et al., 2012), this may prove helpful in the individual interpretation of single visitor maps. Analyzing the visit of Participant 75, two foci of attention were observable in the regions of Work 31 (Henryk Stazewski, 1929, "Komposition") and Work 41 (Hans Hartung, 1961, "T 1961 H 1"). This participant remained in these regions for a longer period of time and moved here and there (black line), showing manifold fluctuations of skin conductance as well as HR (dark- and light-gray markers). Her two centers of attraction thus become observable.

Multivisitor Maps

In addition to the analysis of individual visitors, any number of visitors, who need not be actually present in the museum at the same time, can be aggregated in a graphical mapping. To illustrate this, the following mapping (Figure 8) shows the paths and physiological reactions of 30 randomly chosen museum visitors, who shared the property that they "did not converse about art" during the visit. These visitors approached the entrance of the exhibition, coming from the survey stations in the foyer (Space 1). Again, the light-gray (yellow) and dark-gray (orange) markers represent the physiological variabilities of HR and SCL, respectively (Figure 8).

After the entry survey, the visitors crossed the entrance hall (Space 1) and walked toward Space 2 where the exhibition started. Figure 8 indicates the changes of locomotion behavior and of physiological fluctuations when visitors entered Space 2. Observing the first pictures by Monet (Work 3), Liebermann (Work 4), Munch (Work 2), and Hodler (Work 5), and also when reading the wall text (T 101), visitors showed marked physiological responses (for artwork numbers, see, Figure 2). It can be observed how visitors responded to the presence of artworks, also to text panels, in Space 2.

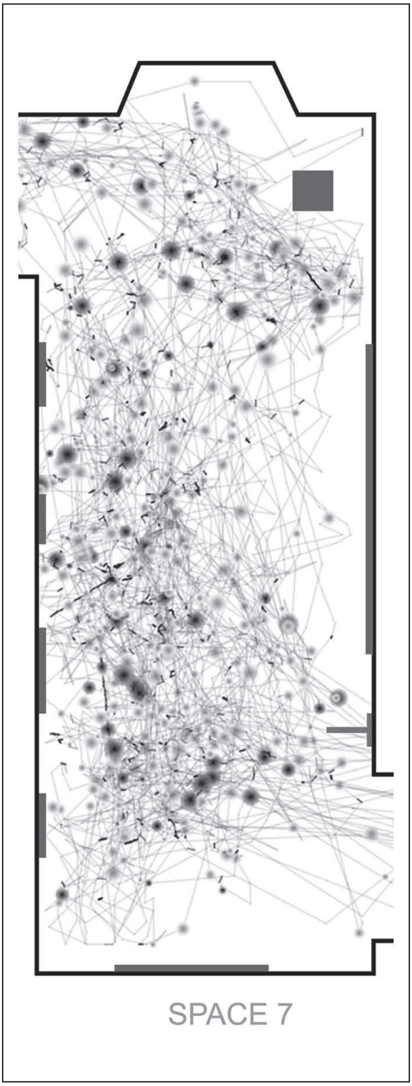
Comparisons of Multivisitor Maps

The method of multivisitor mappings allows analyzing various visitor groups. What are the differences of age and gender? What effects do artwork reordering and rearrangement have on visitors' behavior? How do frequent visitors differ from infrequent visitors? To illustrate comparisons of this kind, the following mappings show the paths and physiological reactions of 30 randomly chosen participants, who either conversed about art while in the exhibition (Figure 9a) or who did not converse (Figure 9b).

Figure 8. Paths and physiological reactions of 30 randomly chosen visitors in Spaces 1 and 2

Note: The fine gray lines represent the walking paths. Changes in skin conductance level are depicted as light-gray markers attached to the walking path of the individual visitor, and changes in heart rate are depicted dark gray.

In both cases, the visitors entered Space 7 at the bottom right-hand side and left the room at the top left-hand side. All exhibition visitors had to traverse this space on their tour. In comparing the two mappings, it seems that the visitors who did not talk during the exhibition had a higher degree of



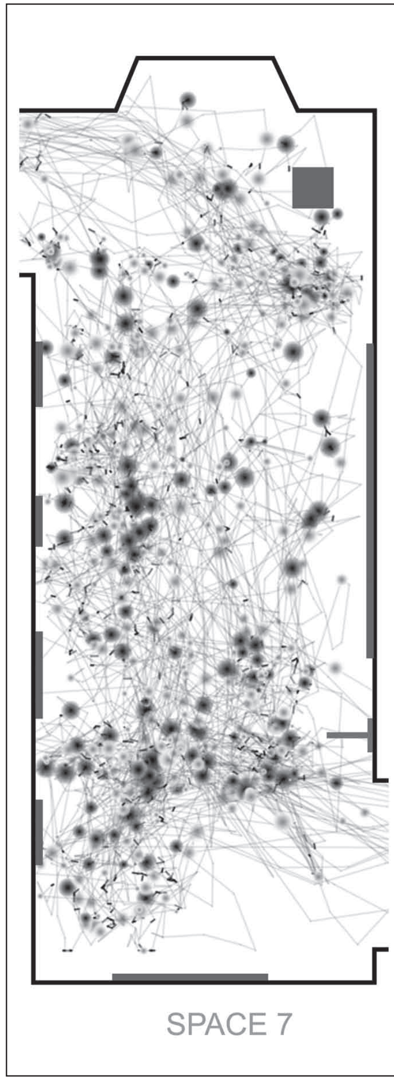


Figure 9. A total of 30 participants (a) who conversed while in the exhibition and (b) who did not converse while in the exhibition

movement and physiological activity than conversing participants. This different intensity of the two groupings is similarly recognizable in the way in which the visitors moved through the space (Tröndle, Wintzerith, Wäspe, & Tschacher, 2012).

Contrasting Experimental Settings

In addition to the portrayals of different visitor groups, the effect of experimental curatorial interventions can be analyzed using multivisitor maps. For example, during the project, we reinstalled individual artworks, shifted them or exchanged them for other artworks, or worked with different kinds of information tables to test various hypotheses (see Tröndle, Greenwood, Bitterli, & van den Berg, in press; Tröndle & Tschacher, 2012). The effects of such experimental situations can be analyzed by looking at the respective mappings.

In the following example, the artwork "Treibriemen-Skulptur," 1989 (driving belt sculpture) by Thomas Virnich, made of plywood, leather, and color, was displayed as one piece or taken apart in several pieces. The sculpture was located in Space 8, together with works by Imi Knoebel, On Kawara, Franz Wanner, and others. We were interested in how the different configurations of the piece would change the atmosphere of an exhibition room and affect visitor reactions.

In experimental Situation 0, the work was displayed in one piece. In Situation 1, it was displayed in parts, and in Situation 3, a bench replaced the work. In Figures 10a, 11a, 12a, a photograph of the respective situation is shown and is followed by the corresponding multivisitor map (Figures 10b, 11b, 12b).

The three figures (10b, 11b, 12b) of Situations 0, 1, and 3 show that the spatial arrangement and the atmosphere of the exhibition space affected visitor reactions. The altered spatial arrangements were embodied in visitors' physiological responses (for more details, see Tröndle & Tschacher, 2012).

In consideration of these mappings, the described methodology might be used as a tool to analyze all kinds of objects in space and their affective resonance on visitor behavior.

RegionViewer

The RegionViewer is a cartographical instrument developed specifically for the data analysis in the eMotion project. It allows for visualizing the time spent inside a region by various visitor groups; the visualizations may

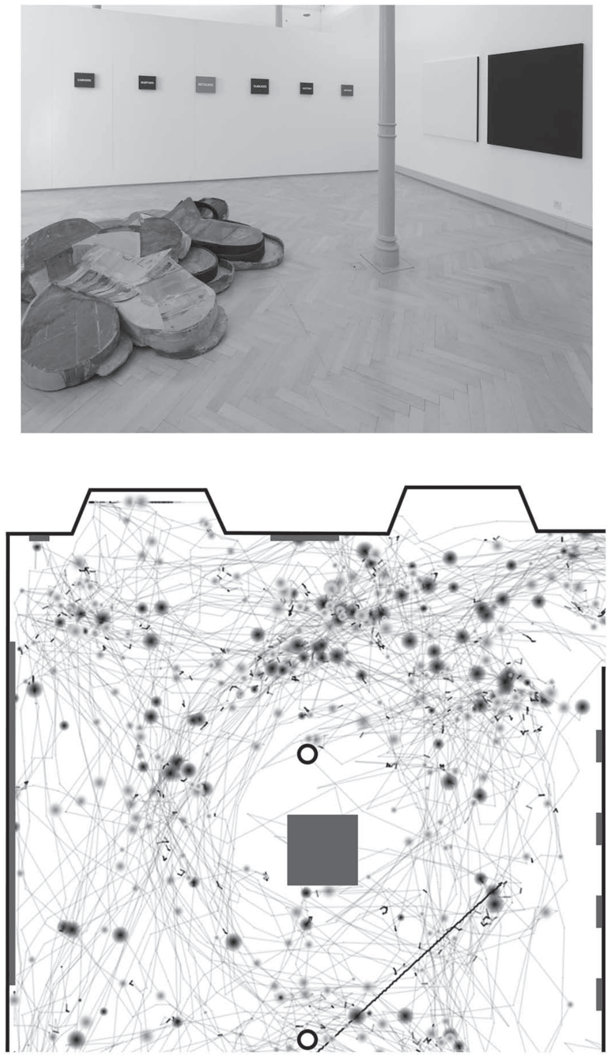


Figure 10. Situation 0, compact. (a) With the work on the floor in a compact form, the exhibition space gives a clear and structured impression: The artworks are put in an expected order, and the display situation is a "typical" museum situation. The atmosphere can be described as rather tidy and conventional. (b) The visitors enter the exhibition Space 8 in the top right-hand corner. They stop and respond, as may be seen in the clustered physiological markers. Afterward, they move around the sculpture. This is indicated by their behavior: stopping, watching, moving on (the straight, black line is a tracking failure to be ignored)

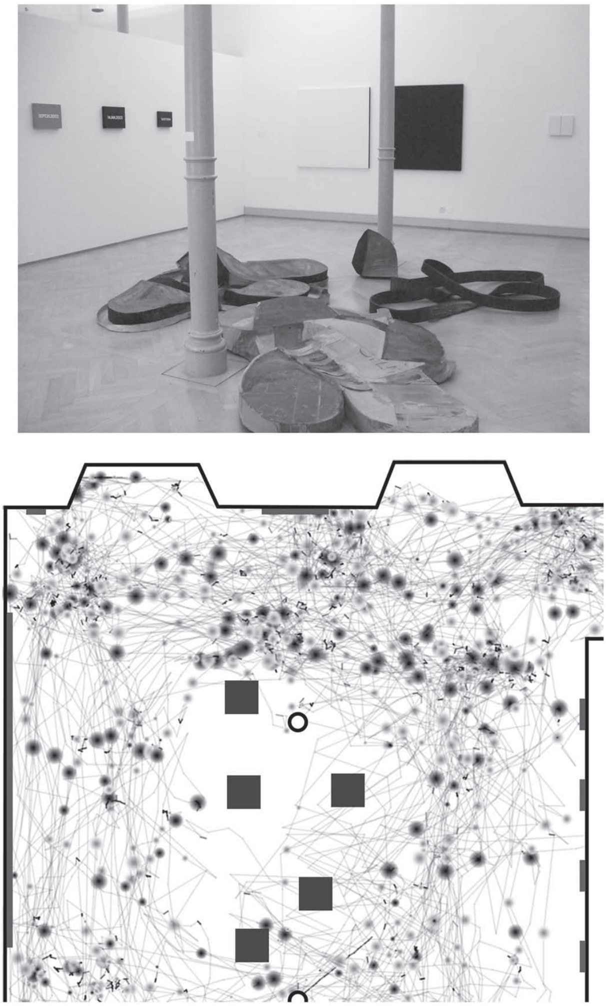


Figure 11. (a) Situation 1: dismantling the artwork "Treibriemen-Skulptur" and spreading it in the exhibition space. The impression of the space becomes more dynamic and slightly more dramatic. (b) Situation 1, spread out: The parts of the sculpture are spread out through the room. This altered spatial arrangement causes very different physiological responses. The more dramatic and dynamic room situation seems to have a direct impact on visitor reactions. More physiological reactions can be seen, especially of SCL.
Note: SCL = skin conductance level.

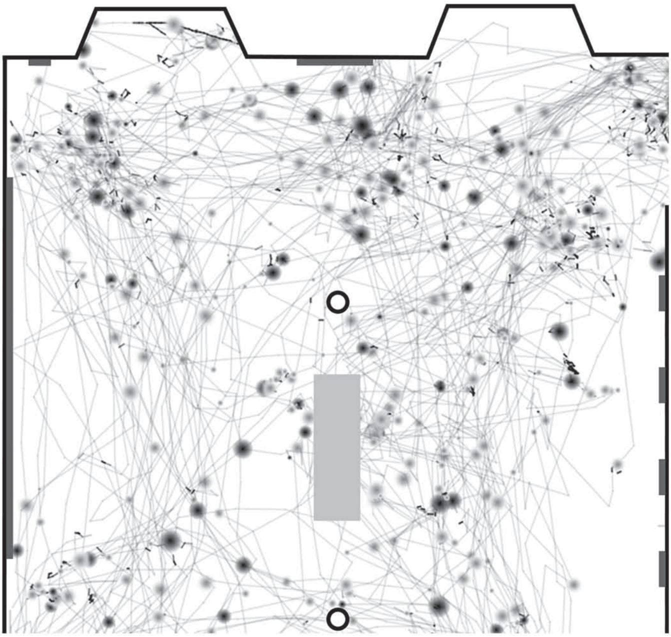


Figure 12. (a) Situation 3: removing the artwork "Treibriemen-Skulptur" and replacing it by a bench immediately changes the atmosphere of the room again. A clean, straight, and slightly contemplative/intellectual impression evolves.
(b) Situation 3, the bench: The dark gray SCL markers diminished in this "cleaned-up" situation; the impression is now much cooler and even "distant." The artwork does not function any more as an attractor; visitor paths are much more diffuse

Figure 13. Visitors (a) did not converse and (b) conversed

represent, for example, gender and age of visitor groups or different experimental situations. The differences are then displayed using different transparencies in depicting the regions, depending on the average time spent in the region by all participants of the respective subgroup.

The following example may illustrate this method. In the mappings of Figures 13a and 13b, the times spent by participants in regions of Space 3 are shown for two conditions mentioned above: those who "did not converse about art" (n = 86, cf. Figure 13a) and those who "did converse about art" (n = 82, cf. Figure 13b). The region with the highest average visit duration, portrayed by the darkest rectangle, was the region in the above right-hand corner of Figure 13a—Relative to it, all other regions are lighter (Figures 13a and 13b).

The difference of visitor behavior in the displays above is quite noticeable. The visitors who did not enter conversations during their exhibition tour spent more time in front of individual artworks (Figure 13a). The presence of artworks differed from that in the conversing group (Figure 13b). A difference was also seen when comparing the detailed text panels "T": Visitors in the company of others were less attracted by text panels (Figure 13b; for more details, see Tröndle, Wintzerith, Wäspe, & Tschacher, 2012).

The RegionViewer appears to provide an appropriate method for comparing the relative impacts of displayed objects for different social or behavioral groupings of visitors.

Validity of the Methodological Approach

A possible criticism of findings originating from the methodology of the eMotion project is that the extensive technical instruments, and the complex, relatively long entry and exit surveys may reduce the experience of the exhibition and thereby distort the results obtained (Hawthorne effect; see Roethlisberger & Dickson, 2003). We consequently tested the following aspects of this methodology: the putting on and wearing of the data glove, feeling observed by the data collections in the context of the visit, being annoyed by the devices on the wrist and hand, and having an active interest in the eMotion study.

To determine potential reactivity due to wearing the data glove, a control group (n = 24) consisted of randomly selected visitors, who were asked to visit the exhibition without the glove but to participate in the surveys. The two groups with (n = 552) and without the glove were compared by variance analyses, to determine whether the visitors without a glove responded differently, that is, were biased in their answers. A total of 12 exit-survey items on

Table 1. Comparison of Visitors' Experiences With and Without Data Gloves

Item ("The exhibition . . .")	*M* without glove	*M* with glove	*F*	*p*
. . . was thought provoking	3.67	3.41	1.253	.263
. . . design was convincing to me	3.54	3.31	1.002	.317
. . . made me enjoy the silence	3.83	3.71	0.233	.630
. . . improved my understanding of the arts	3.25	3.23	0.008	.936
. . . gave me a nice time with family/ friends	2.92	3.03	0.100	.752
. . . opened and alerted my senses	2.92	3.39	4.014	.046*
. . . gave me a deep connection to the arts	2.71	2.80	0.173	.162
. . . let me experience familiar art	4.04	4.04	0.000	.984
. . . let me experience beauty	3.67	3.83	0.755	.385
. . . was entertaining	3.88	3.70	0.703	.402
. . . surprised me	3.71	3.56	0.442	.506
. . . let me experience famous art	4.29	4.07	1.133	.384

*$p < .05$.

exhibition experiences were compared between these visitor groups (Table 1). The experiences were measured on scales from 1 (*no impact, no experience*) to 5 (*very high impact, very strong experience*).

The variance analyses showed that wearing the glove had little impact on the exhibition experiences, except for the statement of the exhibition "opening up and alerting my senses," showing a significant F-value ($p < .05$). Thus, visitors with a glove experienced the exhibition with higher openness/ alertness than visitors without a glove. In this instance, the glove made visitors more aware of their roles as "experiencing" visitors. None of the other items of experiencing the exhibition appeared to be biased by wearing the glove.

Further possible biases generated by the eMotion survey were assessed by asking the visitors directly in the exit survey how interested they were in analyzing their own museum experience, whether they felt like being observed, whether they were annoyed by the measurement equipment, whether they evaluated the surveys as tiresome, and whether taking part in the project eMotion influenced their perception of the artworks. In response to these items, 94% of the visitors ($n = 552$) replied that they were interested in analyzing their museum experience. Only 4% of the visitors felt overly observed, 3% reported being annoyed by the equipment, and 10% regarded the surveys as tiresome. A larger group of 26% regarded their art perception as influenced by the eMotion project (30% partly influenced, 44% not influenced). We further analyzed visitors' responses to this item "art perception influenced by the eMotion project" by correlating it with their assessments of the exhibition experiences. Several correlations were significant (e.g., "gave me a deep connection," "experiencing famous art"), showing that the influence felt by the eMotion project was generally associated with a more positive exhibition experience.

Summing up the influence of the glove and the survey, the impact of the measuring device had small to minimal effects, both as measured in the control group and as measured by the respective items. Hence, only small effects of reactivity were found. The study, in general, did have an effect on self-rated experiences, generally in a favorable, sensitizing direction: The awareness of participating in the eMotion study improved the art experience.

Discussion

The goals of this article were to describe, and explore an integrative and encompassing methodology for museum visitor studies. There were multiple demands that shaped the development of this methodology: constructing an encompassing methodology in the sense that all relevant data levels—behavioral, psychological, social, and physiological—be considered, and to be integrative in the sense that these different data sets should be merged in visualizations and mappings. In addition to these challenges, we put an emphasis on assessing the experienced presence of artworks. This ruled out, in our view, an investigation of the artworks in a laboratory environment, which is the case in most of the current neurobiological research on aesthetics. Instead, we chose the context of a fine art museum that is open to the public and recruited common museum visitors as participants. This integrative, field-based methodology was successfully implemented in the empirical project eMotion and tested in a sample of 576 adult visitors, whom we considered to constitute a representative sample. The integration of physiological measurements, position tracking, and self-report surveys entailed various cartography methods, such as single and multivisitor maps with integrated physiological markers.

Robinson (1928) had considered physiological measurement but advised to be cautious:

> There were thoughts of catching the visitor before and after his artistic or scientific excursion and of determining subtle differentials of blood

> pressure, pulse rate, respiration, psychogalvanic reflex. Almost surely some facts could have been had in such manner—and almost surely nobody would have the slightest idea what to do with them and so it was decided, and we think wise, to ask simpler questions. (p. 9)

Thus, already in the 1920s, physiological methods were discussed in the analysis of aesthetic experience. But technically they were only rudimentarily developed and therefore had little impact on experimental psychology (Allesch, 2006). On the basis of contemporary technology, however, data acquisition has become more reliable and even currently allows for the combining of position tracking with permanent physiological measurements in the field, as was shown in the aforementioned methods of cartography.

The costs have largely decreased in the past decade, but are still substantial, which can determine the methodological setup of visitor research. For example, Klein (1993) referred to Robinson's and Melton's studies when reporting on his surveys of visitor circulation in the museum. Klein mentioned various methods of visitor tracking, such as multimoment shots of photographs or video observation (Klein, 1993). Nonetheless, Klein and other researchers preferred the conventional method of direct observation. Visitors' paths were drawn by pencil onto floor plans, and stopwatches were widely used. With such methods, Bailey, Bronnenkant, Kelley, and Hein (1998) recorded the total time spent in the exhibition of a science museum, time spent in front of the exhibits, and time spent in the stoppings in front of the exhibits (see also Choi, 1997; Tzortzi, 2003). Recently, handheld computers have become an option to record where visitors stop, whether they talk or read the written descriptions, how much time they spend, and so on (Arnsdorf, 2010).

Compared with such methods of visitor and time tracking, the advantages of the presented tracking technology are obvious. Visitors can be tracked with approximately 15 cm spatial resolution. This is more precise than any other method. In addition, the software developed automatically draws the visitor paths in the museum and allows to track several visitors at once. All temporal measurements, total visit durations as well as specific region-based durations, have good temporal resolution (in our methodology, 1 Hz; higher frequencies were possible but were not chosen to save storage capacity). Because of the digital format of data, visualizations of visitor movements can not only be displayed statistically as in several of the above figures but may also be presented in movie format (see www.mapping-museum-experience.com/en/results/artistic—"visitor 6—Flash Video"). These displays can be used not only ex post but also in real time, with no or little additional cost or effort. Finally, the methodology was shown to be less interfering than manual observation: Wearing the data glove entailed little reactivity on the visitor's side. Our general impression, as such, was that the benefits of this methodology outweighed the costs.

Using this methodology, various data types are assimilable, such as the association of physiological responses and aesthetic experiencing to artworks in an exhibition. Via this methodology, we could show for the first time that aesthetics can be statistically grounded in viewers' physiology in an ecologically valid environment—the art gallery (Tschacher et al., 2012). We also tested the effects of specific artworks and asked, "Does a famous work attract more attention than a less renowned one and a 'loud' artwork more than a subtle one?" "Do similar artworks generate similar visitor reactions?" "Does an artwork lose its attraction if manipulated (Tröndle & Tschacher, 2012)?" Recently, we analyzed the social aspects of viewing art and were able to demonstrate that the social behavior of museum visitors, such as companionship and conversation, has a decisive influence on art reception, which entails consequences for the strategic orientation of museums as sites of experience (Tröndle et al., 2012). Furthermore, the effects of curatorial arrangements and hangings on museum visitor behavior (Tröndle, Greenwood, et al., in press) and the effects of visitor's knowledge on art reception (Tröndle, Wintzerith, Tschacher, van den Berg, & Kirchberg, in press) were investigated. For an overview of the various publications, see www.mapping-museum-experience.com/en/publications.

The methodology of combining subjective and objective data sets might well complement the various theories of art, aesthetics, curating, museum studies, art sociology, or museum education, refining our understanding of the museum as a place of aesthetic experience (see, for example, Anderson, 2004; Burnham & Kai-Kee, 2011; Greenberg, Ferguson, & Nairne, 2005; Macdonald, 2006).

An important concern and potential limitation of the integrated methodology is the reliability of physiological measurements. Psychophysiology research has shown that heart activity and skin conductance, the two measures integrated in the present methodology, provide important cognitive and emotional information. But can these variables be assessed in a reliable way in a field setting? Our results suggest a partial yes. In an encompassing analysis, all physiological data measured in specific regions of the exhibition were linked with all self-report assessments (obtained via the exit survey) that addressed the artworks displayed in these same regions (Tröndle & Tschacher, 2012; Tschacher et al., 2012). Results showed that physiological measures were significantly and meaningfully associated with aesthetic-emotional assessments. HRV, especially, was a substantial marker: "Beautiful" artworks and “surprising/humorous” artworks were significantly associated with raised HRV. HR level and skin conductance variability were also significant markers of the art-related experiences reported by the visitors. SCLs, however, were not significantly linked. This means that there is statistical evidence that three physiological parameters provided informative markers of aesthetic-emotional appraisal. This supported the validity and reliability of the measures obtained via the data gloves. The physiological markers were integrated into the cartographies (e.g., Figure 8), which depict points in a visitor’s path where heart activity or skin conductance showed phasic shifts. Shifts are parameters analogous to the variabilities that were both shown to be connected to psychological experiencing in the field. Thus, we may consider these findings a solid statistical ground for the general reliability of the cartographies.

Limitations of the presented methodology may lie in reactivity: Technical apparatuses are not just instruments for researchers “to do their research”; they may also have a considerable influence on what is observed (Cetina, 1999; Tröndle et al., 2011). Correspondingly, the introduced integrative methodology is concentrating on specific questions of aesthetic experience, and not on many others that could be observed in the context of museums, objects, and beholders.

Does the methodology developed here provide surplus value compared with the traditional and cheaper methods of observations, questionnaires, or interviews (see, for example, Falk, 2009; Umiker-Sebeok, 1994)? As mentioned in the introduction, our interest was to develop a methodology for the investigation and visualization of moments of presence, that is, when viewers are affected by (art) objects. Such moments of the immediate sensitivity occur before being aware of them, prior to cognitive and linguistic processing.

In addition in the newer media studies, the term *presence* has lately been used to describe the moments when emotional reactions are caused and the beholder is immersed in another world (Weibel, Wissmath, Habegger, Steiner, & Groner, 2008). The authors state that the feeling of presence indicates that the frame of reference shifts from the real world to the medium, and thereby the medium causes emotional responses.

The methodology and cartography presented in this article constitute the most direct approach to map moments of presence, by synthesizing path recording and physiological measurements. Although both data levels are observations and not biased by post hoc processing, still they may be easily merged with psychological data from the surveys and questionnaires. Such an approach thus provides information that current self-report and observational methods alone cannot supply.

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Authors' Note

For more information on the research project, see www.mapping-museum-experience.com/en

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