The Role of User-Generated Emotion Data and their Optimized Visualization for Planning Decision-Making

Benjamin Sebastian Bergner[1], Daniel Steffen[2]

[1]Urban Sociology, University of Kaiserslautern, Germany, benjamin.bergner@ru.uni-kl.de
[2]AG wearHEALTH, University of Kaiserslautern, Germany, steffen@cs.uni-kl.de

Keywords: Emotions, GIS-based Visualization, Event Monitoring

Abstract

With the rise of wearable technologies in the field of ambulatory assessment and commercial body monitoring products, the human being itself becomes a sensor of its immediate environment. In particular, user-generated vital data allows to draw conclusions from peoples emotions *at every time and everywhere. This fact poses the question to what extent this data can be used for planning decision making.*
For decades, ambulatory assessment methods have been used to identify humans emotions *linked to distinctive stimuli. The research is mostly done in laboratories under controlled conditions. Knowledge transfer to real world applications is still rare due to many uncontrollable environmental issues. Psychophysiological monitoring, however, shows high potential of transferability to real-world studies.*
If this user-generated emotion data is to be used for planning decision processes, many challenges have to be met: a) providing valid physiological, geo-referenced data in a real world environment, b) preparing and processing data for following analyses, c) joining individual and environmental meta data, d) optimizing emerging visualizations and identifying emotional stimuli as basis for planning decision-making.
The research at hand confronts these challenges, exemplified by a case study in the field of urban safety and security. It aims at identifying stress eliciting stimuli during an open air event. The methodical approach comprises physiological data collection and analyses, standardized questionnaires of stress experience and event perception, subjective self-assessments and spatial analyses of the surroundings as well as the combination of the results in different GIS-based visualization techniques.

1. Introduction

Planning decision-making in urban and environmental planning is a highly complex process involving strong responsibilities. These responsibilities are manifold - including ecological, economical and sociological aspects. Planners, as main coordinators of spatial planning processes and therein different groups of players, have the duty to ensure citizens quality of life by preparing decision-making basis for politics. Citizens quality of life is reflected on different levels. Besides standard of living and social security, everyday quality of life is shaped by built environments and acceptable surroundings. To determine areas that are perceived as uncomfortable or unsafe, classical methods like interviews, observations or standardized questionnaires are used to collect the needed information. All these methods have the short-comings, that information is based on cognitive self-perception, experiences and social desirability. For a few years now, thanks to the fast technological progress, it is possible to measure and track physiological vital data as indicators for emotions in spatial environments. That in turn gives social scientists and urban planners the benefit to receive information about ci being (or stress) free from the mentioned short-comings at every time and everywhere. As precondition, people have to be equipped with body sensors for measuring physiological changes and

GPS trackers to determine their positions and routes. This method of psychophysiological monitoring implicates that it is still experimental, but shows high potential to get a more concrete and self-uninfluenced picture of spatial environments from a citizens perspective.
In this paper, the authors want to introduce and discuss this methodical approach as a real-world application, based on the experience of environmental planning studies on the one hand and the methodical approach exemplified at an open air event on the other hand.

2. Research Background

Improving human well-being is an essential part of many planning actions. The aspect of feeling safe and secure in the immediate environment influences the behaviour and provides a positive image of the space citizens live and move in daily. Environmental planners can strengthen that feeling by shaping the space around us adequately, e.g. accessibility for disabled people or avoiding places which cause anxiety with the help of lighting concepts. In practice, many disciplines (sociologists, psychologists or event planners to name a few) deal with this topic.
The research at hand is part of the research project Support Systems for Urban Events Multi-criteria Integration for Openness and Safety (MultikOSi) , research programme Research 2012 - 2017 , topic Urban Safety and Security , funded by the German Federal Ministry Education and Research. In the sub-project Social Aspects for Comfort and Safety at Urban Ev the authors occupy themselves with the measurement of well-being of event attendees, the planning and organization of safety as well as spatial components. In case of measuring the well-being, classical methods like questionnaires, observations and interviews are conducted, but extended by the here presented psychophysiological monitoring in a real world application.

2.1 Contextual Background

Communities are more and more in competition in order to obtain the status of an attractive place of residence and an attractive travel destination. Part of liveable communities and environments are increasingly open air events like city festivals, sport events or concerts. A favourite instrument in public sector marketing is the organisation of big events, which are magnet for numerous visitors of different milieus (Häußermann/Siebel, 1987). They allow the experience of entireness, community, mutuality and corporate identity for people with different backgrounds. In terms of socio-scientific collective experience, festivals and events are understood as largely emotional, by affect dictated events. They produce current, spontaneous, emotional and enthusiastic behaviour, which is not only socially allowed, but actually desired (Gebhardt, 2008, p.207). The common order is often dissolved. Violation of the order are in part explicitly allowed or tolerated (e.g. at street festivals). This behaviour includes a certain risk concerning the safety at events. Current state of research says, that feeling safe is an individual condition or emotion. This condition is composed of the general framework of (public) space and the personal perception (Floeting/Seidel-Schulze, 2012, p.1058). Spatial framework conditions are variables like path width, soil conditions, barrier-free design, view-shafts, lighting and knowingly placed obstacles (Reuter et al., 2012). Subjective attributes are factors like individual sense of self-worth, the capability of the body or the openness when dealing with other groups of people. Especially with increasing age, the dwindling of body s own capability leads to heightened percep of safety in (public) spaces and thus to heightened expectations towards safety measures (Ziegleder et al., 2011).
Visiting an event also comprises the arrival and departure, respectively the routes attendees take to come to an event and leave on their way back home. Planning an event consequently involves transport infrastructural aspects. Many events are characterized by security controls at the entry of a closed off area in order to avoid certain sources of risk. Masses of people can also be a danger for the attendees. That happens when the entries are too narrow, contraflows are allowed or the outflow of

people doesn t work (e.g. at the catastrophe at the Loveparade in Duisburg 2010). Another reaso long queuing times, with the consequence of building up a throng where people get bothered by others. Every now and then triggered stress and feelings of being unsafe can lead to risky behaviour towards other visitors or private security personnel, as well as to avoidance behaviour, and strongly affect the safe course of the event. Safety, security and comfort are significantly dependent on social action, attitudes and value systems of the visitors of the event. According to the sort of visitors, the chosen safety measures differ (e.g. quantity of private security personnel, barriers (fences, hoarding), etc.). A further relevant factor is the trust of visitors in available information in case of risk as well as trust in present private security personnel. In addition, the trust of private security personnel in event managers/planners and hosts plays a major role. Last-mentioned protagonists have the duty to execute a risk management based on a risk assessment in case of danger or emergency (Renn, 2010, p.165). These facts emphasize that planning of events is a highly complex process, involving many different players and information channels. The consequences of a bad planning are obvious the endangerment of the health and well-being of event visitors and all involved parties on-site. The guaranty of a safe stay is an essential requirement for large quantities of people visiting communities and events. An attractive and successful event thereby contributes to an improvement in identity and image and to an increase in competitiveness of a community (Getz, 2012, p.40).

Event planning and the ensurance of safety of such events is in a way comparable to tasks environmental planners are confronted with, regarding the complexity and involvement of different groups of players. Though, the constructional actions are generally temporary with the exception of really big events, like a Football World Championship or Olympia.

The example of the sense of safety in space and especially at events emphasizes the importance of emotional data of visitors and security personnel. If this data can be made available properly, it can influence planning decision-making for upcoming events as well as environmental planning actions in terms of design of space.

2.2 Methodical Background

As part of subjective well-being, emotions are a current, affective state of the individual, triggered by immediate experienced stimuli or events (Diener et. al, 1997; Kahnemann/Krueger, 2006; Fischer, 2009). In literature many differently named basic emotions exist. One of the leading researchers and pioneers in the study of emotions in context of facial expression is Paul Ekman. In his early work he distinguishes between six basic emotions: happiness (enjoyment), sadness, anger, surprise, disgust and fear (Ekman/Friesen, 1971), which are still valid in his later work. Anger and fear are highly negative emotions, which are follow-ups of stressful situations (Lazarus, 1993, p.12). According to Lazarus/Launier (1978, p.296) stress is any event in which environmental or eternal d exceed the resources of an individual, social system, or tissue system . F nonspecific response of the body to any demand (Selye, 1976, p.53). For both stress scientists, not only internal factors, but also external and environmental factors are responsible for experienced stress. Selye (1976, p.54) names specific environmental factors like air pollution and social influences as antecedent condition for stress, Lazarus (1993, p.5) names harm, threat and challenge, experienced in the environment or within the person. *Harm* refers to psychological damage that had already been done [ ]. *Threat* is the anticipation of harm that has not yet taken place but may be imminent. *Challenge* results from difficult demands that we feel confident about overcoming by effectively mobilizing and deploying our coping resources (Ibid). He further gives the exa unpleasant state of mind that may seriously block mental operations and impair functioning Just the terms threat, or in case of events the term danger, and harm are crucial conditions, which especially event planners want to avoid. Possible threats to events have to be identified in the planning process beforehand, in order to formulate danger avoidance and minimization strategies. Threat, or danger, at events implies a situation or behaviour, which causes harm and damage to property or people with a high chance, if the course of events is unhindered (Drews et al., 1986, p.220).

Event planners as well as all involved groups of players (e.g. communities, fire brigade, police, private security companies, emergency rescue services, etc.) can fall back on manifold experiences concerning possible dangers at events. Resulting in an extensive catalogue, these are for example crowds, fire, collapse of constructional parts, danger by violent or drunken people or breakdown of relevant infrastructure (Hessian Ministry of the Interior and Sports, 2013).

Consequently, the event visitors themselves can act as immediate and direct detectors for threats or risky situations. If and how danger is individually perceived by visitors depends on their subjective, intuitive risk perception. This risk perception is affected by different factors. These are given information about the source of danger, psychological processing mechanisms of feeling unsafe and previous experiences (Renn, 2010, p.163).

In summary, there is a consistent story here; that feelings of safety have an interdependence with risk perception, emotions, feeling stressed and physiological changes, triggered by certain situations which are environmental, inner psychological processual or determined by social interaction with other people.

In research, emotional experiences in linkage to distinctive stimuli are typically acquired in laboratory experiments under controlled conditions and self-reported data, in form of questionnaires and interviews. The principal aim of the research at hand is the investigation of real-life emotions beyond the laboratory. The experience of emotions in laboratory settings can likely differ from natural unfolding emotions in the real world. Influencing factors for example are the lab environment itself, the feeling of being controlled, the alien technical apparatuses and sitting immobile for at least many minutes (Wilhelm/Grossman, 2010, p.555). The acquisition of emotion data via questionnaires and interviews also has its short-comings. They rely on retrospective memory recall with the problem that information can be forgotten, especially over a long period of time. Most recent events can also influence the overall ratings of emotion. Furthermore, retrospective recall is subject to idealized self-concepts and -perception, social expectations and desirability (Wilhelm/Grossman, 2010, p.556; Redelmeier/Kahnemann, 1996, p.6.; Pohl, 2004). When the specific aim is accurately as immediate experience, these factors [of retrospective recall] induce error variance at the best and systematic bias at worst (Wilhelm/Grossman, 2010, p.556). The here presented study engages in providing naturalistic emotion data in a real-world application, derived from physiological data (e.g. skin conductivity, heart rate) of test people during an open air event. The test people act as a sensor of their immediate environment. The authors want to find out where (spatial), when and in which situations stress as precondition of feeling unsafe is experienced. Almost all current scientific knowledge about emotions is based on laboratory research or inferred from retrospective reports, although understanding real-life emotions is clearly the principal aim (Wilhelm/Grossman, 2010, p.552). Ambulatory assessment means the objective real-time data acquisition of physiological marker with the help of wearable devices, which are more and more operational outside the laboratory (Papastefanou, 2009, p.443). Within ambulatory assessment, psychophysiological monitoring offers the most pragmatic and reasoned method to continuously and objectively measure vital data of test people. Other methods are experience sampling and behaviour recording. In case of psychophysiological monitoring, measurement devices are wearables with primarily non-invasive sensors. The measurement specifically focuses on changes in vital data, triggered by the prime biological emotion- and stress-reacting systems (Wilhelm/Grossman, 2010, p.559). Two main criteria for identifying affect-based physiological changes have turned out: a) Changes in vital data have to be recorded in real-time and for every instant during the study; b) the measurement must not hinder or disturb the individual in order to avoid the collection of influenced vital data by the method or measurement device itself (Bergner et al., 2012, p.740). For real-world studies it is also important to know where exactly the changes in physiological data have taken place. So it is necessary to equip the test people with a GPS (Global Positioning System) tracker, while moving through the study area.

After gathering and analyzing the resulting data for indications of certain emotion patterns, the next challenge is to make the data available for further analyzing in the context of space.

2.3 Visualization Background

The idea of mapping peoples perceptions and emotions in space is not new. Kevin Lynch with his concept of mental maps worked out, that people are able to memorize paths and key locations in urban environments and draw a mental image of the city they live in. He found out that five basic elements exist, which people perceive and construct their mental image of a city from. These are paths, certain areas or districts, significant edges (e.g. walls), nodes (e.g. junctions like crossroads) as well as landmarks. How these elements are perceived is a two-way process between observer and the observed object (Lynch, 1960). Almost half a century later, Christian Nold introduced his projec Mapping as one of the first psychophysiological monitoring projects in the cont His intention was to use this method as a participatory bottom-up approach to improve a sense of community and citizens own identity with their residential area. Nold deals with the question how citizens perceptions of community and environment will change when they become aware of their own and others intimate body states (Hope, 2009, p.75). In his studies (e.g. Greenwich Emotion Map) he sent people through their residential area, equipped with a galvanic skin response sensor at the finger as well as a GPS tracker for locating the wearer s position on earth. In ret shows the participants their walk as a personal emotion map. The track shows the wearer s geographical location while the height indicates the intensity of physiological response at any particular point. The response can be positive or negative and requires active interpretation to make sense of it (Nold, 2009, p.67). Despite the weaknesses in data accuracy and subjective interpretations as well as visualization, Nold coined the term Emotion Map or Emotional Mapping and is seen as pioneer in combining psychophysiological indications of emotions and geo-referenced data in a spatial context.

The visualization of geospatial data is an important task in environmental modelling, data analysis, and geographic applications. Specifically, two-dimensional maps offer a well-known way to present a static visualization of geographic data. Additional variables can be displayed with the help of contours, colours, and heat-map overlays.

However, when considering complex data sets that contain geographic locations, time series, and multiple variables, the visualization and data mining of spatio-temporal data is a challenging problem. When thinking of multivariate time series it is also important that the visualization is tailored to the needs of the end-user, i.e., both domain experts and non-specialist public, in a way that the visualization instantly shows whether something is good or bad.

The main challenge in visualization of spatio-temporal physiological data is the integration and optimization of emerging visualization techniques as basis for the planning and decision process. Having information displayed in a way that it is easy to understand is crucial. Without this kind of visualization the participation of the public in a decision and / or planning process is limited. The visual effectiveness (Guo et al., 2006) concerns the usefulness of data views in revealing patterns. With a large data set, data items can overlap in the visual display and make patterns very hard to perceive.

With the aim of effectively visualizing multivariate, spatio-temporal data mostly two solutions have been proposed in literature: (1) animating data in a 2D representation or (2) extruding 2D representations into a third dimension. Digital Globe Systems, e.g. 3D virtual globes, meet these requirements and offer the possibility to use the third visualization dimension.

The idea of a digital earth was described for the first time in 1991 by Ne Snow Crash : A globe about the size of a grapefruit, a perfectly detailed re hanging in space at arm’s length [ ] It is a piece of [ ] software called, simply, Ea interface that [ ] uses to keep track of every bit of spatial information that

weather data, architectural plans, and satellite surveillance (Stephenson, 1992, p
Berlin company ART+COM developed TerraVision , inspired by Stephensons novel
system on SGI-units. TerraVision is a 1:1 virtual copy of planet earth. One significant feature of TerraVision is the human machine interface. With the help of an interface, designed like a globe, the so called Earthtracker, the user gets the possibility to navigate to every desired spot on earth interactively and in realtime over the virtual globe (ART+COM, 1994). The first and free consumer based virtual globe system was developed by NASA and was called World Wind (NASA, 2013). For the first time, it was possible to import and export spatial data through a user interface. In addition, the integration of Web Map Services and the visualization of textured meshes were realized. Keyhole Earth Browser, in the beginning operated by Keyhole, was the initiation point for the development of Google Earth, which is today the best-known and widespread software for digital globes. As associated programming language, the Keyhole Markup Language (KML), also developed by Keyhole, is established as an Open Geospatial Consortium (OGC) standard by now.

All the above-mentioned systems offer different import and export functions, but there are only a few options to develop some additional new types of visualizations. There are some software tools available, which can transform collected data into 3D visualizations, which need to be combined manually for an appealing look. An integrated and interactive 3D-GIS application, which allows the easy integration, visualization and animation of heterogeneous data are not available today.

Within this paper the authors target the visualization of spatio-temporal physiological data, i.e., stress at a specific location at a specific time, from multiple users during large events. Stress is a major concern in our daily life and impacts both individuals and society. Furthermore, stress is a big concern when looking at the safety during events with a large audience, e.g., soccer games or music festivals.

Due to the nature of the data that has been collected during the execution of the experiment, as described above, visualizations have to be applicable for multivariate spatio-temporal data. Guo et al. (2006) present a geovisual analytic approach and the implementation of a visualization system for space-time and multivariate patterns (VIS-STAMP) that integrates a suit of visual, computational and cartographic methods. The implemented system is capable of effectively detecting and visualizing geographic, temporal, and multivariate patterns in multiple ways using a self-organizing map (SOM) and a parallel coordinate plot (PCP). The authors state that the system is limited when it comes to small-sized spatial objects, since they are barely visible on the used two-dimensional maps. The technique Lexis Pencils provides a way of viewing event history data. The approach uses a pencil metaphor and maps different time-dependent variables onto different faces of a pencil, starting with the top of the pencil (Francis, 1997). This visualization allows controlling the color mapping, the width of the pencil faces, and the assignment of the variables to the faces. Here, the pencil point could mark a static location in the spatial context of a 2 ½ D or 3D representation. The advantage of this approach is that both continuous and discrete variables can be shown in one plot. However, depending on the complexity of the time series this technique might not be tailored for large time-dependent data sets. Forlines et al. (2010) present the Wakamevisualization system. The Wakame system extends a multi-dimensional radar chart (2D technique) for static data by extruding into a third dimension to represent time. Thus, sequential measurements become radar-graph profiles at different heights of the ground plane. The shape that is formed by the radar profiles at different heights, i.e., at different time steps, illustrates the changes in the time-dependent dataset over time. As with the previous visualization techniques this method allows assigning different colours to the variables of the dataset, i.e., the vertices of the radar profile. However, in order to create an easily understandable visualization the user has to pay attention to the ordering of the variables around the centre axis. Tominski et al. (2005) present the Helix icons for visualizing spatio-temporal data on maps. This technique is especially useful for time-dependent data that has cyclic characteristics. A spiral helix provides the geometric shape. The helix icon is made of a spiral ribbon where every time step extends the ribbon in angle and height. Again colour coding can be used to encode data values along the ribbon. In order to be able to represent multiple variables the ribbon can be subdivided into smaller ribbons. Finally, the interested reader is referred to the work of Aigner et al. (2010) providing a detailed overview of different visualization techniques for time-oriented data.

3. Relevance and Objectives

The education of environmental planners is already in certain terms a cross-sectional field of study and in praxis very interdisciplinary. There are many information and data channels a planner has to filter and coordinate. In case of sociological aspects, like the identification of well-being in spatial environments, classical methods like questionnaires and interviews with citizens are primarily used. With the rise of new wearable body sensors it is possible to identify indications on human emotions towards their imminent surroundings everywhere, at every time and in particular unaffected by personal views, experiences and social desirability.
The main objective is the development of a decision support tool for planners across disciplines. The tool should better the understanding of emotions and consequently of the behaviour of people in and towards space with the help of body monitoring technologies. Out of it the questions have to be answered how the emerging emotional data is visualized and what conclusions can be drawn.
Exemplified by a case study at an open air event, the authors want to illustrate how body monitoring technologies can be applied, what data can be elevated, how this data is processed and visualized as support tool for planning decision-making. The usage of ambulatory assessment in real-world studies is still experimental. As a consequence the following challenges are inherently methodical:

(a) providing valid physiological, geo-referenced data in a real world environment
(b) preparing and processing data for following analyses
(c) joining individual and environmental meta data
(d) optimizing emerging visualizations and identifying emotional stimuli as basis for planning decision-making

The potential gain for environmental planners in general and in context of safety of open air events is obvious. In a last step, the authors critically deal with the usage of this data and their significance for decision-making at this juncture of research.

4. Conceptual Framework and Study Design

In order to exemplify the introduced methodical approach and in context of safety at events, an experimental case study at the event Back to the Woods Open Air 2014 in Gar
July 2014 was conducted. It is a one-day outdoor music festival with about 5000 attendees. The event was stopped and cleared because a massive thunderstorm with intense rain, lightning strike and sudden drop of temperature has occurred.
The resulting data was derived from six student test people, whereas three were female and three male and aged between 20 and 24. An average state of health, no physical limitations as well as a typical age for the character of the event were preconditions. The test people didn t have to perform a s
task during the study. They should behave naturally and in their usual way. Only if they get too drunk, they should end the study and come to the meeting point. After a short briefing, the test people signed a letter of agreement and data protection. Next, the measurement device for physiological data, in form of a comfortable wristband, was strapped around their left wrist, in order to provide an adjustment period. Before the beginning of the study, the test people had to complete a self-evaluation questionnaire concerning their actual mental state. Afterwards, they received a GPS tracker and a tape recorder for subjective self-assessments when they felt extremely stressed and unsafe. All the devices were switched-on at the same time for later data synchronization. Then they were sent out to experience the open air festival at the event area for as long as they desired. At the end of the study,

the devices were turned off and the test people had to complete a general questionnaire with questions to event affinity, perceived sense of safety, social basic data, personality traits and the same self-evaluation questionnaire concerning their actual mental state as at the beginning of study.
The research area is situated on a meadow, enclosed by woods and two streams from north-west to south. The complete area is surrounded by a hoarding. The main entrance and the pay desk are located in the south/south-west. In the eastern part there is the main stage, in the western part and the central area opportunities to get food or drinks. There exist four emergency exits: one to the south and west, two to the north. For later spatial analysis, it makes sense to classify the research area in different specified zones (dancing and stopover, bar, food, toilets and entrance) (see chapter 6).

5. Methodology

A mixed method approach, including psychophysiological monitoring, self evaluation questionnaires, subjective self-assessments as well as visualization techniques and spatial analyses, should meet the challenges specified before. The first challenge consists in providing valid physiological, geo-referenced data in a real-world environment (a). For physiological data acquisition the sensor wristband BMS Smartband was used, developed and manufactured by Bodymonitor Systems Gilching, Germany. It measures skin conductivity, skin temperature, outdoor temperature, triaxial acceleration and electrode contact pressure. The BMS Smartband enables to collect peripher-physiological data in real-time and location-independent (www.bodymonitor.de, 2015). The authors aim to identify stress reactions by the test people as precondition for feeling unsafe. Basic emotions reflecting stress are anger and fear (see chapter 2.2). These emotional reactions come along immediately with changes in the autonomic nervous system activity, which is reflected in specific physiological parameters (Kreibig, 2010). In consensus with researchers in emotion, a negative experience (anger or fear) is existent, when skin conductivity increases (Kreibig, 2010, pp.401/403) and shortly after that skin temperature decreases (Kreibig, 2010, pp.401/404). A well-known example is the cold sweat, resulting from fear. These findings were confirmed in a statistical validation study with the BMS Smartband. Here, it was ascertained that collected changes in skin conductivity (increase) and skin temperature (decrease), measured by sensors on the inner side of the wrist, during stress episodes are reproducible (Papastefanou, 2013). The theory behind this and the measurement device itself proves, that valid physiological data can be provided. In regard to the aspect of geo-referenced data, the GPS tracker G-Log 760 by TranSystem Inc. (www.transystem.com.tw) was used, which collects satellite signals every second. A later synchronization with the physiological data was hereby unproblematic.
Preparing and processing the resulting data for following analyses (challenge (b)) was carried out retrospectively. Especially the processing of the physiological data is a time-consuming work, which is absolutely indispensable if done properly. A necessary first step is data reduction to a one second signal, because of the sample rates (e.g. skin conductivity:ten samples/s (10Hz)). Added up in about five hours, 180.000 samples are received. The serial nature of ambulatory dat identification of the specific time points when abrupt and statistically significant level shifts occur that may be associated with psychological or other events (Wilhelm/Grossman, 2010, p.565). To avoid measurement artifacts, which can influence the overall structure of data, especially if changes in physiological data are considered, an early visual examination of the elevated raw data is essential. With the help of proper algorithms in appropriate software, the resulting data consists of gradient values for every second. The algorithms have been improved, compared to former studies, and a testing of different intensity levels of stress has taken place. As result, high intensity indications of emotional stress reactions with at least a duration of three seconds are focused in the present study. After analyzing certain physiological patterns defining a stress reaction (Bergner et al., 2011: pp.250/251) and identifying the time in which a stress reaction had occurred, this data is merged with the proper GPS coordinates (challenge (c)).

Figure 1: BMS Smartband (www.bodymonitor.de) & physiological patterns defining a stress reaction

Besides the psychophysiological monitoring approach, different questionnaires were applied. At the beginning as well as at the end of the study, the State Anxiety Inventory (STAI-S) , developed by Spielberger, Gorsuch and Lushene (1970, revised 1983), was used. The STAI-S is a psychological inventory based on a 4-point Likert scale with 20 questions on a self-report basis, concerning the relation between state anxiety/fear as characteristic in due consideration of situational influences and intra-psychological processes. The aim was a before and after comparison of changes in the test peoples mental state. In order to get a more precise image of the participant Five-Inventory-10 (BFI-10) (Rammstedt et al., 2012) was applied. The five personality tr openness to experience, conscientiousness, extraversion, agreeableness and neuroticism. Nowadays, it is the most established and accepted reference model for the description of personality (Rammstedt et al., 2012, p.7). Furthermore, a general questionnaire with questions to event affinity, perceived sense of safety and social basic data should give insights, if the participants represent the general characteristics and perceptions of the other event attendees at the Back to the Woods Open Air. The test people also had the chance to give self-assessment regarding stressing situations at the event via tape recorders.

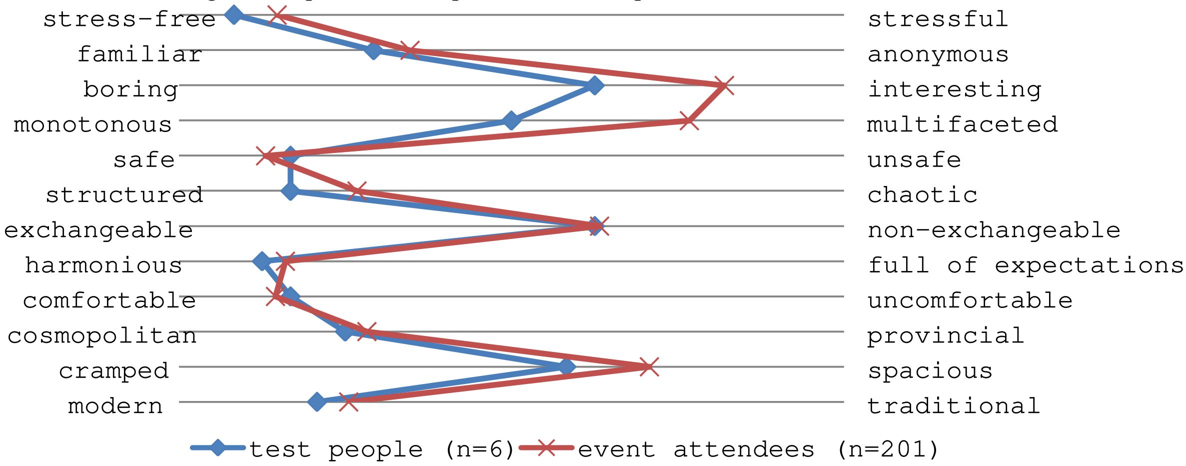
Within the context of this paper the authors utilize the GeoVisualizer application to visualize multivariate spatio-temporal physiological data from multiple users (challenge (d)). The GeoVisualizer application provides even non-visualization-experts interactive tools to produce meaningful visualizations based on state of the art techniques in order to provide a better insight in the underlying georeferenced data (Michel et al., 2013). GeoVisualizer is based on the Open-Source NASA World Wind SDK which provides a three-dimensional virtual globe and various plugins to import georeferenced data (e.g., Shapefile, GeoTiff, Web Map Service, Web Feature Service, Sensor Observation Service). The GeoVisualizer is implemented with the Java Web Start Technology, which allows starting the application on every computer connected to the Internet. Once installed, the GeoVisualizer application resides on the hard disk of the computer and can be also run in offline mode. However, if the computer is connected to the Internet a check for updates will be executed to ensure that the user always has the latest, up to date components.

Based on Nold s Bio Mapping , the approach of psychophysiological monitorin geo-referencing was tested and improved in different own studies, primarily in environmental planning context (e.g. accessibility and barrier-free design for impaired people (Bergner et al., 2011), impact of noise in urban areas (Bergner et al., 2012), orientation in open space (Exner et al., 2012) but also in other fields of research, like stress management of emergency rescue services (Steinitz et al., 2014)). This study is based on these insights and counts as the most up-to-date work by the authors.

6. Analysis and Discussion of Results/Findings

At the same time of the study, a general survey (n=201) with the visitors of the Back to the Woods Open Air took place within the research project MultikOSi (see chapter 2). Figure 2 shows the overall perception of the event by the event attendees as well as the test people in a semantic differential. The only difference is that the study test people experienced the event a bit more boring and monotonous. The chosen test people represent the general social structure (gender, age, social data) of the other event attendees. This is an important fact for the evaluation of the resulting data. The study test people pose no exception.

Figure 2: Open Air Perception of Test People and Event Attendees



The analyses of the test people questionnaires and data sets are carried out in a simple profile analysis, because an aggregation is inappropriate due to the small number of cases. To exemplify and discuss the results and findings, later visualizations are made available in simple profile analyses in comparison to an aggregation of all six test data sets.

6.1 Simple Profile Analyses Questionnaires and Psychophysiological Monitoring

The data of the six test people is anonymized and coded (e.g. HA29 represents one certain test person). The STAI-S shows that four of the test people (HA29, MA23, SA17, GA23) had a higher anxiety value at the end of the study in comparison to the beginning, whereas HA29 s anxiety value was significantly higher. The test people SE23 and EA09 had almost no change (Table 1). The increase of state anxiety is presumably connected with the abrupt break off of the Open Air because of the massive thunderstorm, which also ended the execution of the study.

Table 1: Results of State-Anxiety-Inventory (STAI-S)*

test person	study begin	study end	difference
HA29	42	65	+ 23
MA23	30	46	+ 16
SA17	29	40	+ 11
GA23	32	42	+ 10
SE23	40	39	- 1
EA09	42	39	- 3

* A resulting value of 20 means no anxiety, 80 the highest anxiety value.

The Big-Five-Inventory-10 (BFI-10) indicates that the test people are very different regarding their personality traits (Table 2). HA29 is more a conscientious type, but rather suspicious and less compassionate and cooperative. MA23 is characterized as a highly outgoing, energetic and compassionate, cooperative person, and less sensitive or nervous. SA17 has a tendency to be a conscientious type. GA23 is highly open to experiences, an inventive and curious person, like SE23. A tendency to extraversion and openness to experiences is shown by EA09. In case of neuroticism, none of the six test people has a high parameter value towards experiencing unpleasant emotions (like anger or anxiety/fear) easily.

Table 2: Results of Big-Five-Inventory-10 (BFI-10)*

test person	extraversion	neuroticism	openness	conscientiousness	agreeableness
HA29	3	3,5	3	4	2
MA23	5	2	3	4,5	2,5
SA17	3	2,5	3	4	3,5
GA23	3,5	3	5	3	3
SE23	3	3	4,5	3,5	3,5
EA09	4	2,5	4	2,5	3,5

* A resulting value of 1 means no parameter value, a value of 5 means highest parameter value (5-point-scale)

The psychophysiological monitoring results indicate a wide ranged percentage of being stressed between 2,00 % (HA29) and 13,00 % (SA17). The duration per stress event is nearly equal (between 4,3 and 4,9 seconds) with the exception of SA17 (7,7 seconds), who has also the highest percentage of being stressed (Table 3). The study had a duration about 3,5 to 4,5 hours. The self-assessments via tape recorder indicate that stress was experienced in dense crowds, especially while getting drinks or food. Here, the synchronized tape recorder data is reflected in the physiological indicated stress events.

Table 3: Results of psychophysiological monitoring   stress parameter values

test person	total time data set (in sec.)	number of stress events*	total time of stress events (in sec.)	average duration per stress event (in sec.)	Percentage test people were stressed
HA29	13324	57	266	**4,7**	**02,00%**
MA23	16507	190	851	**4,5**	**05,00%**
SA17	16484	439	2145	**7,7**	**13,00%**
GA23	13246	233	1069	**4,6**	**08,00%**
SE23	16498	170	738	**4,3**	**04,50%**
EA09	16462	256	1248	**4,9**	**07,50%**

* Minimum duration of three seconds

In the following, HA29 (least percentage of being stressed) and SA17 (highest percentage and highest average duration per stress event) are exemplarily analyzed in comparison to the quantitative questionnaires STAI-S and BFI-10.

According to STAI-S, HA29   s anxiety level clearly increased at the end of the study in comparison to the beginning, but had the lowest percentage of being stressed, continuously measured during the study. On the other hand, HA29 has only the slightest tendency to neuroticism (value 3,5). SA17 as the most stressed person during the event shows also an increase in anxiety level at the end, but no tendency to a high parameter value in neuroticism. As a result, no indication of an interdependency between the different dimensions (surveys and psychophysiological monitoring) can be found in the case study.

6.2 Simple Profile and Aggregated Visualization

Figure 3 illustrates a two-dimensional stress heat map from all users who visited the Woods Open Air within the GeoVisualizer application. In addition, the visualization shows tracked GPS coordinates of test person HA29 by using three-dimensional pins. The head of the pins is colored according to its emotional state during stress (pink pins) or non-stress phases (cyan pins). Using the third dimension allows to compare and analyze the results of one test person with regard to the data of all test people, e.g. the tracked study participant did not spend time in the stress-hotspot area depicted in the lower right corner of Figure 3. In order to easily grasp the stress hotspots of the test person, the pins have been extruded more when a stress event was detected.

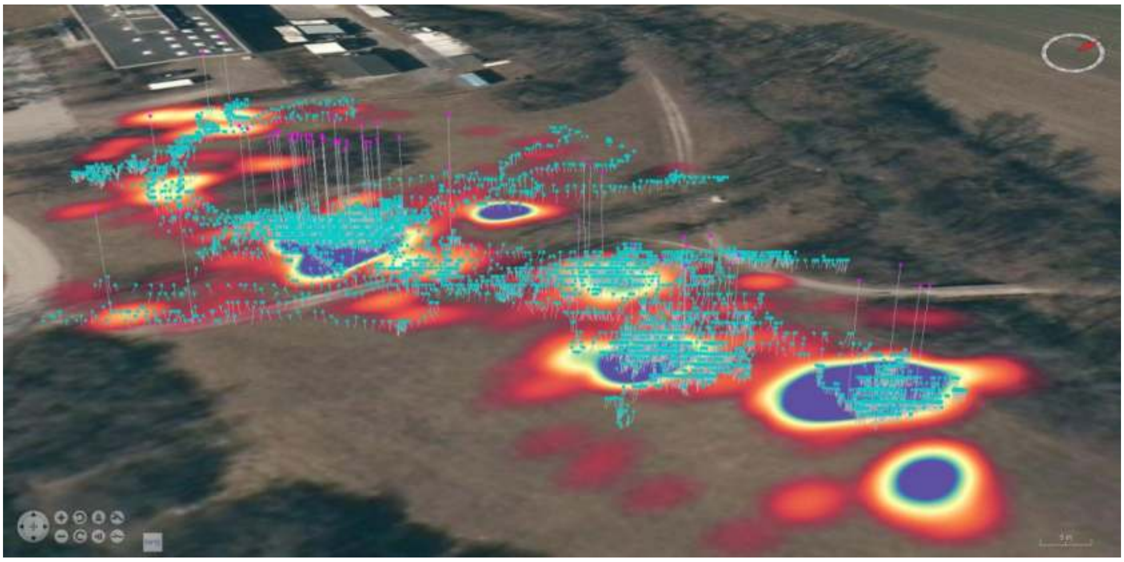


Figure 3: Visualization of the stress heatmap of all test people and the stress spots (pink pins) of test person HA29, using the GeoVisualizer

When especially interested in the relation of different attributes of spatio-temoporal time series, the two-dimensional visualization is not sufficient any more. As described above, 2D maps mostly use colours, contours or heatmaps to convey the information, e.g. river, terrain, land usage, etc. However, this kind of visual representation is limited by the number of colours that can be easily distinguished and perceived by planners and decision-makers. Furthermore, the amount of data items or layers can overlap in the visual display, whereupon information of layers beneath get lost. The GeoVisualizer application provides also a layer viewer for easy selection and comparison of the needed information.
As a consequence the usage of a third dimension is necessary in order to provide user-friendly and easily understandable visualizations. This would tackle the problems described previously. The GeoVisualizer application enables the user in a fast and easy way to feed the needed information in to the system and to get appropriate visualizations in an interactive open source tool. And as possible demonstrative, reduced to elementary functions information tool it is helpful to process the many different information channels an environmental planner as well as an event planner have to consider.
In case of the presented study, the visualizations helped to identify the most crucial areas where stress was experienced by the test people. As seen in Figure 4, the authors made the decision to exemplarily visualize and analyze an aggregated stress heatmap of all study participants, as it would have been

done if a higher number of test people had been available. As result, especially the food and drink zones as well as the dancing area are documented with a high density of stress events. On-site observations have shown, that in these areas dense crowds were present. The queuing also triggered many stress events (tape recordings). Open to discussion are the stress events in the dance floor area. Furthermore, the toilet area was very stressful for the study participants. This fact was confirmed by the participants and other event attendees. Queuing and the condition of the toilets itself were problematic.

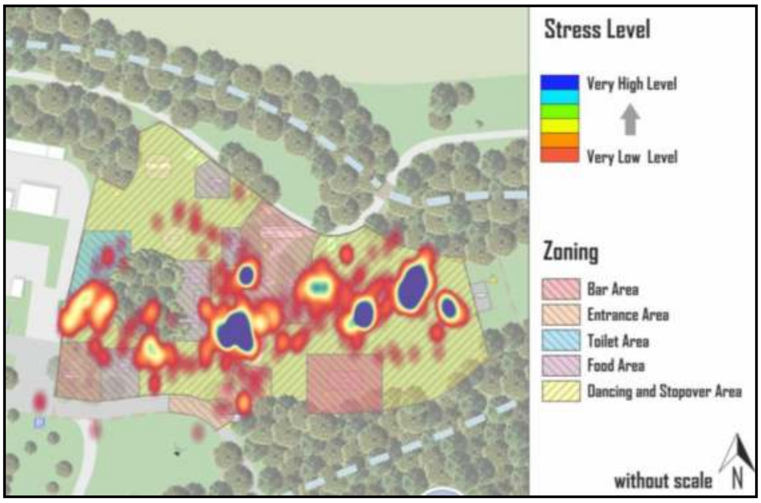


Figure 4: Aggregated heatmap and zoning of the event area

7. Conclusions

User-generated emotion data in the context of environmental as well as event planning shows very high potentials in delivering completely new insights into perception and experience of humans in their immediate environment. If visualized in an adequate, easy to handle and information reduced way, this data offers new perspectives across disciplines. The here presented study has met the methodical challenges, defined in the beginning. But the point of the matter is that the results, concerning this study and the mentioned former studies, are only exemplary. A lot of interdisciplinary basic research has yet to be done. Especially the identification beyond doubt of stress inducing stimuli is the biggest challenge for further studies. Data extracted from questionnaires, self-assessment, the location and visualizations can help to understand to which stimuli people are exposed. At this point, the authors basically recommend a higher number of test people, an exact defined target group or object of investigation, observations on-site, more data of the study participants personality tra not to forget, the evaluation of experts in the specific field of research. Still, there is gap between continuously, objectively measured indications of emotions by psychophysiological monitoring and retrospective recall, self-assessment methods and quantitative questionnaires which face each other and have their individual short-comings. A mixed-method approach turns out to be reasonable. Also the application of other sensor data, like crowd sensors, can help to get more objective data of the immediate environment. The analyses and validation of the gathered data is still highly complex and not completely to be automated. At this moment, the authors regard it as a high risk to give recommendations for decision-makers based on user-generated emotion data.

The experiences made at the Back to the Woods Open Air were valuable though very special, because of the abrupt end of the study due to the incoming thunderstorm. The data gathered up to that point already gave specific involved groups of players indications where problematic hotspots could be in the future. On-site observations have supported the fact, that queuing, dense crowds and the toilet situation is not only stressful for the event attendees, but also a matter of safety aspects. The study will be repeated in 2015, adding participating observations of the test people.

8. Acknowledgements

The research at hand is part of the research project Support Systems for Urban Events Integration for Openness and Safety (MultikOSi) , research programme Research for Civil 2012 - 2017 , topic Urban Safety and Security , funded by the German Federal Education and Research.

9. References

- Aigner, W.; Miksch, S.; Schumann, H.; Tominski, C., 2011. Visualization of Time-Oriented Data.
- ART+COM, 1994. TerraVision. Available at: http://artcom.de/de/project/terravision/ [Accessed 13 May 2015].
- Bergner, B: S.; Zeile, P.; Papastefanou, G.; Rech, W.; Streich B., 2011. Emotional Barrier-GIS A new Approach to Integrate Barrier-Free Planning in Urban Planning Processes. In: Schrenk, M.; Popovich, V.; Zeile, P. (eds.): Proccedings REAL CORP 2011. Schwechat, pp.247-257.
- Bergner, B. S.; Exner, J.-P.; Zeile, P.; Rumberg, M., 2012. Sensing the City How to identify recreational benefits of urban green areas with the help of sensor technologies. In: Schrenk, M.; Popovich, V.; Zeile, P. (eds.): Proccedings REAL CORP 2012. Schwechat, pp. 737 746.
- Diener, E.; Suh, E.; Oishi, S., 1997. Recent Findings on Subjective Well-Being. In: Indian Journal of Clinical Psychology, 24(1), pp.25-41.
- Drews, B.; Wacke, G.; Vogel, K.; Martens, W., 1986. Gefahrenabwehr. Allgemeines Polizeirecht (Ordnungsrecht) der Bundes und der Länder. Köln, Berlin, Bonn, München: Heymanns Verlag.
- Ekman, P. and Friesen, W. V., 1971. Constants across cultures in the face and emotion. In: Journal of personality and social psychology, 17(2), pp.124-129.
- Exner J-P, Bergner BS, Zeile P, Broschart D, 2012. Humansensorik in der räumlichen Planung. In: Strobl J, Blaschke T, Griesebner G. (eds.): Angewandte Geoinformatik 2012. Beiträge zum 24. AGIT-Symposium Salzburg. Berlin: Wichmann, pp.690 699.
- Fischer, J., 2009. Subjective Well-Being as Welfare Measure: Concepts and Methodology. Paris: OECD. Available at: http://mpra.ub.uni-muenchen.de/16619/1/MPRA_paper_16619.pdf [Accessed 16 May 2015].
- Floeting, H. and Seidel-Schulze, A., 2012. Urbane Sicherheit eine Gemeinschaftsaufgabe vieler Akteure. In: Schrenk, M.; Popovich, V V.; Zeile, P.; Elisei, P. (eds.): Proceedings REAL CORP 2012. Schwechat, pp.1055-1062.
- Francis, B. and Pritchard, J., 1997. Visualisation of historical events using Lexis pencils. Advisory Group on Computer Graphics.
- Forlines, C. and Wittenburg, K., 2010. Wakame: Sense Making of Multi-Dimensional Spatial-Temporal Data. In: ACM (ed.):Proceedings of the International Conference on Advanced Visual Interfaces, pp.33-40.
- Getz, D., 2012. Event Studies. Theory, Research & Policy for Planned Events, London/NY: Routledge.
- Gebhardt, W. , 2008. Gemeinschaften ohne Gemeinschaft. Über situative Event-Vergemeinschaftungen, in Hitzler;Honer;Pfadenhauer (eds.): Posttraditionelle Gemeinschaften. Wiesbaden: VS Verlag, pp. 202-213.
- Guo, D.; Chen, J.; MacEachren, A. M.; Liao, K., 2006. A Visualization System for Space-Time and Multivariate Patterns (VIS-STAMP). In: IEEE Transactions on Visualization and Computer Graphics, 12(6), pp. 1461 1474.
- Häußermann, H. and Siebel, W., 1987. Neue Urbanität. Berlin: Suhrkamp Verlag.
- Hessian Ministry of the Interior and Sport (ed), 2013. Leitfaden Sicherheit bei Gro veranstaltungen .
- Hope, S. , 2009. Socially Engaged Art The Conscience of Urban Development. In: Nold, C. (ed.): Emotional Cartography Technologies of the Self. London, pp.68-82. Available at: http://emotionalcartography.net/EmotionalCartography.pdf [Accessed 13 May 2015].
- Kahnemann, D. and Krueger, A. B., 2006.Developments in the Measurement of Subjective Well-Being. In: Journal of Economic Perspectives 20(1), pp.3-24.
- Kreibig, S. D., 2010. Autonomic nervous system activity in emotion: A review. In: Biological Psychology 84(3), pp.394-421.

- Lazarus, R. S. & Launier , R., 1978. Stress-related transactions between person and environment. In: Pervin, L. A.; Lewis, M. (eds.): Perspectives in interactional psychology. New York. Plenum, pp. 287-327.
- Lazarus, R. S., 1993. From Psychological Stress to the Emotions: A history of Changing Outlooks. In: Annual Reviews Psychology 44(1), pp.1-21.
- Lynch, K., 1960. The image of the City. Cambridge MA: MIT Press.
- Michel, F.; Steffen, D.; Bergner, B. S.; Exner, J.-P.; Zeile, P., 2013. A new Approach in the Visualization of Georeferenced Sensor Data in Spatial Planning. In Schrenk, M.; Popovich, V. V.; Zeile, P; Elisei, P.(eds.): Proceedings REAL CORP 2013, pp.17 24.
- NASA, 2013. The World Wind SDK. Available at: http://goworldwind.org [Accessed 02 May 2015]
- Nold, C. (ed.): Emotional Cartography Technologies of the Self. London. Available at: http://emotionalcartography.net/EmotionalCartography.pdf [Accessed 13 May 2015].
- Papastefanou, G., 2009. Ambulatorisches Assessment: Eine Methode (auch) für die empirische Sozialforschung. In: Weichbold, M.; Bacher, J.; Wolf, C. (eds.): Umfrageforschung: Herausforderungen und Grenzen. Wiesbaden: VS Verlag, pp. 443-468.
- Papastefanou, G., 2013: Experimentelle Validierung eines Sensor-Armbandes zur mobilen Messung physiologischer Stress- Reaktionen. In: GESIS (ed.): Tech Rep 7, pp.5 14. Available at: http://www.gesis.org/fileadmin/upload/forschung/publikationen/gesis_reihen/gesis_methodenberichte/2013/TechnicalReport_2013-07.pdf [Accessed 26 April 2015].
- Pohl, R. F., 2004. Cognitive Illusions. A Handbook on Fallacies and Biases in Thinking, Judgement, and Memory. New York: Psychology Press.
- Rammstedt, B.; Kemper, C. J.; Klein, M. C.; Beierlein, C.; Kovaleva, A., 2012. Eine kurze Skala zur Messung der fünf Dimensionen der Persönlichkeit: Big-Five-Inventory-10 (BFI-10). In GESIS (ed.): Working Papers 22.
- Redelmeier, D. A. and Kahnemann, D., 1996. Patients memories of painful medical treatments: real-time and restrospective evaluations oft wo minimally invasive procedures. Pain 66 (1), pp.3-8.
- Renn, O., 2010. Sicherheit, Risiko und Vertrauen. In: Winzer,P. ;Schnieder, E. ;Bach, F-W. (eds.): Sicherheitsforschung Chancen und Perpektiven. Berlin: Springer, pp.163-183.
- Reuter, V.; Bergner, B. S.; Spellerberg, A., 2012. Pedestrian Evacuation Planning for Major Events a New Approach Combining Planning Aspects and Human Factors. In: Schrenk, M.; Popovich, V. V.; Zeile, P. (eds.): Proceedings REAL CORP 2012, Schwechat, pp.571-579.
- Selye, H., 1976: Stress in health and disease. London: Butterworths.
- Spielberger, C. D.; Gorsuch, R. L.; Lushene, R. E., 1970. Manual for the State-Trait Anxiety Inventory. Palo Alto: Consulting Psychologist Press.
- Steinitz, D.; Carius-Düssel, C.; Bergner, B. S.; Papastefanou, G.; Schultz, M., 2014. Verbesserung des Stressmanagements von Einsatzkräften Empirische Studie zur Wirksamkeit eines Handlungsleitfadens. In: Notfall + Rettungsmedizin 17(5). Berlin, Heidelberg: Springer Verlag, pp.432-439.
- Stephenson, N., 1992. Snow Crash. Bantam Spectra.
- Tominski, C.; Schulze-Wollgast, P.; Schumann, H., 2005. 3d information visualization for time dependent data on maps. In: Information Visualisation (ed): Proc. 9th International Conference on IEEE pp.175-181.
- Wilhelm, F.; Grossman, P., 2010. Emotions beyond the laboratory: Theoretical fundaments, study design, and analytic strategies for advanced ambulatory assessment. In: Biological Psychology 84, pp.552-569.
- Ziegleder, D.; Kudlacek, D.; Fischer, T., 2011: Zur Wahrnehmung von Sicherheit durch die Bevölkerung Erkenntnisse und Konsequenzen aus der kriminologisch-sozialwissenschaftlichen Forschung. Forschungsforum Öffentliche Sicherheit, Sicherheit (5).