Chapter 10

Immersive Dynamics: Presence Experiences and Patterns of Attention

Michael Brill, Gudberg K. Jonsson, Magnus S. Magnusson, and Frank Schwab

Abstract

The present chapter addresses the application of T-Pattern Detection to video games research. By their nature as interactive media, games offer great degrees of freedom for their users which can result in very different gaming experiences; strictly speaking, no two sessions are the same. If researchers do not plan to solely rely on summative post-session measures, but also intend to investigate media-use processes in their temporal course, these challenges call for an analysis method which proves to be robust towards such inter-individual differences in the data. We discuss the use of T-Pattern Detection as a method which meets these challenges. We present an example study which merges summative questionnaire data and structural process analysis data in order to investigate the reception processes that underlie the reception phenomenon of presence.

Key words T-pattern, Structure, Game studies, Games, Gaming, Presence, Attention

1 Introduction

Media research in general addresses a wide range of media, especially in a modern information society. With constantly emerging new media capabilities, research has been facing new questions and new challenges. One of these novelties was the feature of interactivity which is one of the key-features of video games. Since pattern detection has already been used successfully for analyses of human interaction and of humans' reactions towards media, we argue that this method begs to be used for the analysis of humans' interaction with media, in this case video games. We will present a study in which a special kind of behavior of gamers, blinking, is analyzed and will demonstrate how pattern detection offers new possibilities for analysis and interpretation of data.

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1.1 Games as Interactive Media

Why do a myriad of people go to the movies and watch million-dollar blockbusters such as *Titanic* or *Lord of the Rings* over and over again? Why do users of an online game like *World of Warcraft* or racing games like *Need for Speed* spend countless hours visiting virtual worlds? What happens to our minds when we use media or play games on our computers, or are absorbed by an exciting book or movie [1]? Nowadays, in our so-called information age, the media have become a central part of our daily life. Current research shows that individuals spend an average of 4 h a day watching TV, 3 h a day listening to the radio, and almost 1.5 h a day browsing the Internet [2]. In face of this almost omnipresent media use, media psychology aims at describing and explaining behavior and experiences concerning the usage of mass and individual media [3]. Mass media include the press, radio, TV, and cinema, whereas individual media encompass landline telephones, mobile devices, and social network services and video games. In addition to learning and knowledge acquisition, the one focus of media psychology is to find an answer to the question why humans are willing to invest such a great amount of time and money into (media) entertainment and playful computer usage. One special aspect within this field is the phenomena which relate to the user's experience of the mediated environment. While there are several adjacent concepts dealing with this aspect using different stimuli media, we focus on the so-called presence experiences in the domain of video games.

Especially for the video games domain, interactivity is one key aspect of interest: Do video games compared to other media offer more immersion and presence, due to their interactive challenges? Do they make their users more aggressive because they let their users be active? So in fact, the key aspect of games—and also the one that ultimately led to the application of the T-Pattern Detection method in this example—is interactivity. In most studies the dependent variables are summative outcome measures like post-session questionnaires for presence or aggressiveness. Consequently, those outcome measures are used to assess effects of gaming, but don't focus on the process of gaming itself. A more fine-grained observation is delivered by studies incorporating objective measures for e.g. body posture [4, 5] or facial expressions [6]. In these studies, process measures are collected during a period of media use, are then summed up and compared across different experimental conditions. But strictly speaking, in these cases there is still an observation of behavior in its sum, not of the temporal process itself and its structural characteristics. At this point we suggest that one may gain valuable insights about the emergence of effects when considering the structural aspects of the user-media-interaction, as well. Patterns of user-media-interactions that unfold over the course of time could be used rather than cumulated parameters of isolated user behavior. As described by Magnusson [7], this approach follows the idea of identifying event structures in data rather than pure event frequencies or durations.

However, analysis gets more complicated when the subject's individual behavior in the course of time is of interest. Due to the high degrees of freedom and interactivity in modern video games, data may become more complex and may differ considerably among subjects. One tool to meet these analytic challenges is the method of T-Pattern Detection [8, 9].

1.2 T-Pattern Detection

The method of T-Pattern Detection is the connecting link of the researchers inside the MASI network. The algorithm has frequently been deployed for analysis of social interaction among animals and humans and there are numerous studies about this most natural form of interaction, be it for example in the context of psychotherapy settings [10] or human interaction with dogs and robots [11]. But the method's versatility allows it to be also used—besides many more applications—in similar contexts like reactions of humans towards classical media, for example which facial expressions occur during viewing of TV news [12].

Aside from these situations' common element—behavior occurs which can be analyzed with T-Pattern Detection—there are obviously different levels of possible interaction. In a social face-to-face situation, interaction is only limited by the social rules which determine what is appropriate to say, do and display. If instead of face-to-face communication a medium is used as a channel of communication, well-known additional constraints apply according to the medium's unique capabilities. As mentioned above, when watching TV or movies almost none of the recipient's actions alter the mediated content. Speaking of video games and their key-feature interactivity, they could be seen situated in between the noninteractive media and the perfectly interactive personal dyads. They allow a certain degree of interaction, however, not in such a broad spectrum and in such a natural way as human face-to-face interaction. In general, for single and multiplayer settings the interaction done via the game's controls is limited to certain actions and channels which have been incorporated by game designers.

So due to these media limitations, strictly speaking it would be inaccurate to describe for example the last study mentioned above, the observation of TV viewers' facial expressions, as an interactive situation. But this last example also shows that some behavior occurs despite the lack of a proper backchannel and thus without apparent (media-related) use: while in a dyad facial expressions can serve relational regulation or for illustration of spoken content [13], there is no obvious use for displaying joy, anger, or contempt while watching TV since it does not influence the TV program. So these recipient actions don't serve a purpose in the communication process, but when they can be seen as indicators for internal processes or as remnants of social interaction then they can be a valuable source of information for researchers.

2 Example Study

2.1 Background

In the presented study we used a racing video game to investigate an internal process during media use which is called the experience of presence. Presence is often referred to as the sense of "being there" or a "perceptual illusion of nonmediation" [14], i.e. during reception of media content the user becomes unaware of the fact that the content is brought to him/her by a medium. While there are several concepts of presence we focus on spatial presence and use the conceptualization by Wirth et al. [15]. They propose a two-stage model for presence experiences: On the first level, users need to focus their attention on the medium and create a mental model of the depicted situation, the spatial situation model. This leaves users with two rivaling mental models: one for the real environment and one for the mediated environment. Following the model, presence should occur on a second level if users choose the model from the mediated environment as their so-called primary ego-reference-frame. According to the model, there are two facets of spatial presence experiences: the users' feeling that their self is located in the mediated environment, and the users' feeling that their possible actions are determined by the mediated environment.

In our case, subjects were sitting in a darkened booth and were asked to play a modern racing game. The booth was equipped with a steering wheel for controls, surround sound, and a screen capable of stereoscopic 3D. According to the theory, the participants needed to build a spatial situation model of the simulated setting "car on the race track"; presence should have been experienced when they neglected the fact that they were sitting in a lab.

When it comes to measurement of the subjective presence experiences, the most common approach is to let users report their experiences in questionnaires. Depending on the conceptualization at hand, there is available a number of questionnaires. For our study we used the MEC-SPQ [16] by the same workgroup who proposed the presence model at hand. Because questionnaires as subjective measures are by design prone to subjective distortions such as memory effects, there have also been approaches to use objective indicators for presence experiences. They would have the advantage of being less prone to distortions and—in the best case—would be able to be recorded continuously without interrupting the media reception. In contrast, questionnaires can only sum up certain intervals of experiences after they took place. Approaches to objective measurement of presence include behavioral aspects [4, 5], brain-imaging methods [17], and measures for attention allocation [17].

In the latter, there is already the rationale of determining the degree to which subjects focus their attention on the stimulus by using eye movement. We would like to also follow this rationale by using eye blinks as indicators.

For our study we considered the so-called spontaneous eye blinks. While reactive eye blinks serve as protection of the eye, e.g. against close or approaching objects, the function of spontaneous eye blinks is seen in the moistening of the cornea [18]. One might think that this process occurs at random or is just determined by the eyes' level of humidity, but research findings show that there is more behind the ubiquitous closing of our eyes.

Nakano et al. [19] investigated the spontaneous eye blink rate during TV viewing. They first state that each blink means an inevitable loss of visual information. They thus hypothesized that blinking does not occur in a random manner but is somehow controlled to minimize loss of information. In their study, the researchers found that viewers of a comedy show tended to blink during certain breaks in the story telling, i.e. viewers inhibited their blinking when relevant story information was presented. This behavior did not occur during viewing of a non-story telling show or an audio story. More recent work by Nakano et al. [20] investigates possible functions of eye blinks in attention regulation.

A very similar direction is followed by the proposal of a two-component model for spontaneous eye blinks by Galley [18], in which blinking is seen as determined by two antagonist processes: on the one hand, excitatory processes that depend on arousal and increase spontaneous eye blink rate, and on the other hand inhibitory processes related to attention which can suppress blinking to a certain degree until it can be done safely. The proposal also claims that the inhibition could serve as a kind of optimizer of visual intake and avoid the loss of relevant visual information.

In an exploratory part and further analysis of the study we aimed at finding clues towards eye blinks as a continuous online-measure for presence experiences: Would players with different levels of presence apply their attention to the game in different ways? We used spontaneous eye blinks as an indicator for attentional processes and related them to post-session questionnaire measures of presence. The first step focused on intra-individual differences in blinking behavior: Since the racetrack consists of straight sections and curved sections, there is varying difficulty and thus varying demand for attention along the racetrack. We first derived the assumption from the described theoretical background that the rate of spontaneous eye blinks should be lower for the demanding curved sections when compared to the easier straight sections. In further analysis of the data we then considered the research question of whether participants reporting more or stronger presence experiences would fit their blinking behavior more distinctly to the racetrack's demands. This may serve as an indicator for being focused on the medium rather than on the real surroundings, a necessary condition for presence.

3 Methods

The whole study used two experimental factors: in the first factor we varied the mode of presentation, i.e. whether subjects played in regular 2D or with 3D glasses in stereoscopic 3D. For the second factor we varied the measurement of eye blinks via derivation of an electrooculogram by applying or not applying electrodes. We regarded this as necessary to control for the possibility that our method of measurement, electrodes, interfered with the measured construct of presence. Because both factors were fully crossed, four experimental conditions resulted. Participants were randomly assigned to these conditions. For analysis we could rely on the data of 48 subjects aged 19–45 ($M = 24.2$, $SD = 4.3$) with normal or corrected to normal vision.

The experimental sessions included six laps of training, followed by six laps of racing during which data was collected, all done on the same race track (see Fig. 1). After the gaming period we collected the post-session data including the presence questionnaire. As output we had several data sets for each participant, some of which are relevant for our present research question: the presence questionnaire ratings as a summarizing post-session measure, and the game's racing data and collected eye blinks as event time series data. Because racing and blinking data was recorded in sync, it was possible to determine when and where on the racetrack the subjects had blinked.

3.1 Summative Analysis: Frequencies and Questionnaire Data

To first create one artificial lap for each subject, the blinks from all six laps of each subject were condensed into one lap. These artificial laps from each subject were in turn condensed into one artificial lap including all blinks of all subjects. This way, the pooled distribution of blinks along the racetrack becomes visible (see Fig. 2); χ^2-tests were conducted to statistically test the distribution's equality. The first binning distinguished between straight sections versus curved sections, i.e. race track sections between corner entrance and corner exit. This first approach did not yield significant results ($\chi^2(1) = 1.806$, $p = 0.179$). For a second analysis

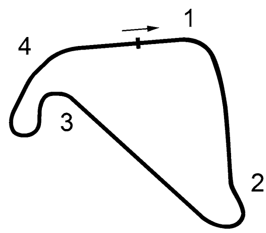

Fig. 1 Race track used in the study. *Numbers* indicate corner entries: 1 (at 6.5 % of race track), 2 (30.5 %), 3 (63.5 %), 4 (86 %)

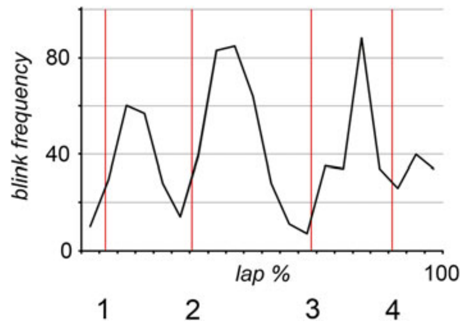

Fig. 2 Frequencies of all subjects' blinks for each section of race track. *Numbers* below indicate corner entries: 1 (at 6.5 % of race track), 2 (30.5 %), 3 (63.5 %), 4 (86 %)

we shifted the limits for curved sections forward to account for the fact that the entry area of a corner actually is more challenging than the corner exit. This layout led to a χ^2-test that showed a significant result ($\chi^2(1)=27.616$, $p<0.0001$). This confirms that the blinks are not distributed equally along the racetrack. Apparently, the spontaneous eye blink rate drops considerably in intervals around the curve entries. This may be explained by the fact that these intervals are the critical phases in which the users need to adjust speed and steering to properly pass the corner. The distribution suggests that, according to the theory, subjects try to avoid loss of visual information in these critical intervals: blinking is inhibited right before corners and is rather performed after the corners' apex.

For the assessment of inter-individual differences we first correlated individual blinking rates with presence experiences: if a reduced eye blink rate due to more focused attention leads to more presence experiences then there should be a significant negative correlation. Correlational analyses showed no significant correlation of eye blink rate to presence questionnaire data (scale "spatial presence—self-location": $r=0.284$, $p=0.190$; $N=23$; scale "spatial presence—possible actions": $r=.082$, $p=0.710$; $N=23$). In additional analyses of inter-individual differences we use the method of T-Pattern Detection to gain insights into the temporal structures of the interactive gaming process. We try to assess possible relations between blinking on the one hand and questionnaire based presence scores on the other hand. Additionally, the question is investigated if there is a relation between blinking and different performance levels of players measured by total racing time; e.g. low performing players may already be challenged by the controls, whereas high performing or experienced players can better focus on racing.

3.2 Structural Analysis: T-Pattern Detection

As described above, Galley's proposal [18] suggests that for such critical intervals blinks are more likely to be inhibited and may rather occur afterwards when the situation allows a certain loss of visual information. Our data of intra-individual distributions of spontaneous eye blinks supported this notion. As a more sensitive and process oriented method of analysis we applied T-Pattern Detection to our data: Because blinks can be done more hazard-free in the end of corners when the participants accelerate towards the straight sections, there should be identifiable patterns that incorporate both events of "passing the corner exit" and "blinking." In preparation of this approach data was recoded and two extreme outliers in blinking frequency were excluded from further analyses. Data were then imported into the THEME T-pattern Detection software.

Subjects were categorized into two groups along the median of their scores on the scale "spatial presence—self-location." Thus event patterns of subjects who reported lower presence experiences could be compared to subjects who reported higher presence experiences. A χ^2-test showed a significant difference among the two very heterogeneous groups with regard to blink numbers ($\chi^2(1) = 9.03$, $p < 0.005$), so in our limited sample participants who reported more presence experiences had also been blinking more during the race. The search parameters were set for detection of T-Patterns in the individual subject files and included THEME's "burst detection" to detect rapidly timed events. Only two types of events were specified for the search: "passing the curve exit" and "blinking", so an example for a possible pattern would be that a blink follows within a critical time interval after the player has left the corner. A level of significance of $p = 0.005$ was chosen for both general patterns and burst detection; furthermore patterns were only considered when they occurred at least three times in a subject's data set. For the low presence group a total of 62 patterns, for the high presence group a total of 139 patterns were detected. Another χ^2-test was conducted to test the difference for its statistical significance. Under the assumption that a larger number of blinks also allows more patterns, the expected values for the χ^2-test were estimated from the previously found distribution of eye blinks between the two groups. Under these premises the test yielded a significant result ($\chi^2(1) = 12.67$, $p < 0.001$).

The two groups were split again along the median of their total racing time, dividing the participants into four groups. In this 2×2 split it appears that the number of blinks is distributed rather equally among slower and faster drivers and that there appears to be some difference between low- and high-presence players (see Table 1). These numbers are again used to estimate the numbers of expected T-Patterns for each cell. In the numbers of patterns detected by the THEME software there are apparently slight differences for slow players (low-presence: 52 pattern occurrences,

Table 1
Number of eye blinks in median-split groups

	Low presence	High presence
Fast racing time	113	154
Slow racing time	116	144

Table 2
Number of pattern occurrences in median-split groups

	Low presence	High presence
Fast racing time	10	91
Slow racing time	52	48

high presence: 48 pattern occurrences), but apparently remarkable differences for the faster players: In the group of faster players, in sum 10 pattern occurrences had been identified for the low-presence group, whereas a sum of 91 pattern occurrences had been identified for high-presence players (see Table 2). A χ^2-test was conducted to compare the observed number of pattern occurrences with the blink-number-based expected numbers and showed a significant result ($\chi^2(3)=45.03$, $p<0.001$).

With due care because of limited sample size, large inter-personal differences in eye blink frequency and our explorative approach, some findings can be derived for informing hypotheses in future studies. First, the finding of more pattern occurrences in eye blinks of more present players is in line with the assumption that players who feel more present may orient their blinking behavior more towards the game's demands. Second, THEME extends an invitation for further research into the differences in blinking behavior between the faster and the slower race drivers which may contribute to research about the influence of expertise; this will have to be addressed again with appropriate sample sizes.

4 Conclusion

We tried to use spontaneous eye blinking behavior as an observable indicator of unobservable cognitive processes. The rationale was to determine the degree to which subjects focus their attention on the virtual world by using blinking behavior and relate this to established questionnaire measures of presence. Regarding frequency and distribution of blinks, the participants showed differential blink distributions along the race track; since this distribution falls in line with theoretical assumptions on attention allocation, this may be a result of the players' attentional processes that take place when using the virtual race track. Beyond that, we used the T-Pattern analysis of THEME to investigate structural aspects in the event-time-series of blinking and racing events. These patterns were in turn used for further analyses and uncovered previously unnoticeable relations in the data. Presence literature supposes attention to be a necessary, but not sufficient prerequisite for presence experiences [15], so this analysis alone does not lead to ultimate insights on the formation of presence. Nevertheless, the example shows that T-Pattern Detection offers the chance to get a deeper insight into the mental processing of interactive media. The phenomena within the research fields of immersion, presence, or transportation are not yet fully understood and are mostly addressed with questionnaires on a summative, attributional level of description. T-Pattern Detection enhances the researcher's possibilities and offers a chance to depict the dynamics of the events that let us get immersed in mediated environments.

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