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Spatial Structure as an Element of Motivation in Location- Based Games

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Abstract: Location-based games have emerged with the ubiquitous deployment of GPS-enabled devices. These games allow players to blend over the digital sphere with real-world whereabouts, implying that design choices made may affect the way players approach non-digital geographical spaces. This paper addresses scoring systems used to reward players for solving in-game tasks. We investigate how spatially structured scoring systems influence playing behaviours. The game we focus on is StreetComplete, an app that allows to collect and complement the OpenStreetMap database. We investigate indicators like walking speed, distance walked, and the game duration. Our results identify interesting effects spatial structure has on the game duration as well as the extent to which players are willing to explore an area geographically, hinting on interesting motivational elements of location-based games.

1 Introduction

Location-based games are characterised by a conflation of physical and digital spaces. They allow players to enrich camera views with additional information, to switch attention between digital and physical environments, and to situate and contextualise themselves on a scale beyond the immediate context. Popular examples of location-based games include Pokémon Go, Ingress, and more traditional Geocaching applications. In some cases, the entertainment factor of such games is combined with scientific purposes like data collection, turning games into so-called serious games. This is the case with apps like Kort and StreetComplete that allow users to playfully collect OpenStreetMap data. This way, location-based games can be useful devices for the targeted collection of missing geodata, and to augment or update existing repositories. This paper focuses on the latter type of serious games, and on how the spatial arrangement of digital gaming elements influences the playing behaviour in a real-world setting.

The gaming element we investigate is scoring systems attached to in-game tasks a player may have to solve (e.g. answering questions about geographic features). Spatial structure refers to non-random geographic patterns like clustering or dispersion. We compare the influence of such spatially systematic deployments of scores to spatially random setups. The knowledge gained is not only important for research, but also for game designers and players themselves. Game designers get hints and detailed insights into the effects of spatial patterns in scoring systems. This knowledge can be used to design games more efficiently. For players of location-based games, our

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results can be useful, as appropriately designed games allow players to better explore and learn local areas, improve their physical activity and thus positively influence the gaming experience.

2 Motivation and Objective

Location-based games utilise real world geographies as playing fields. Their game experience is thus strongly influenced by contextual spatial and non-spatial motivational factors. The attractiveness of an area, for instance, can have an impact on how extensive players explore a playing field (SCHEIDER & KIEFER 2018; WEBER 2017; HARTEVELD 2011). Similarly, the integrability of a location-based game with everyday life can support gaining new perspectives on otherwise routine places and activities (MATYAS 2011; MÄYRÄ & LANKOSKI 2009). Another closely related aspect is the degree to which a game is adapted to local conditions. The strong alignment of gaming elements with local geographical features that players may be familiar with often improves the gaming experience through evoking a so-called 'pride of place' (SCHLIEDER 2014; WILL 2013; COLEMAN et al. 2009). The geography of a given playing field clearly influences the motivational ability of a location-based game.

In this study, we investigate the influence of spatial patterning on the playing experience of location-based games. The focus is on scoring systems used to reward players for completing individual tasks during the game, such as annotating geographical features with attribute information. It is known that location-based games are affected by the physical and mental capabilities of players like their physical endurance, spatial cognition, and navigational capabilities (SCHLIEDER 2014; WILL 2013; JACOB & COELHO 2011). Our underlying hypothesis is therefore that players may (consciously or unconsciously) be affected by systematic structure found in the spatial distribution of scores attached to in-game tasks. The game we use in our investigations is a modified version of the open access application StreetComplete, and the tasks we look at are attached to actual OpenStreetMap features.

3 Literature Review

Location-based games take place in real geographic environments. Therefore, the geography of an area becomes an integral part of such games, including the related contextual factors (SCHLIEDER et al. 2006). Several factors that influence game behaviour are of an ambient nature. For example, it has been found that the time of day is important not only because a player's attention varies with it, but also because other characteristics, such as the buzz of streets, are strongly correlated with time (CARRIGY et al. 2010). Similarly, the actual physical and perceived conditions during the game have an impact on the motivation of players. Weather conditions are one example, but stress factors such as noisy environments (KNÖLL et al. 2014) and traffic-related air pollution are also important in evaluating the gaming experience. Some contextual factors are directly related to the morphology of a playing field. There is evidence that complex urban street layouts are demotivating, as they not only make it difficult for players to find their way around, but also to understand a local morphology (OLIVEIRA 2016, BEDÖ 2017). For similar reasons, the availability of prominent landmarks makes a difference, too (BESTGEN et al. 2017; RICHTER & WINTER 2014). Players can use them to orient themselves in potentially complex urban areas. This has an

influence, consciously or unconsciously, on how comfortable players of location-based games feel with real-world playing fields.
Location-based games have the advantage that they can be played literally anywhere and 'on the go'. This makes it easy for players to integrate these types of games into their everyday lives. One aspect of this integration, which has proved to be particularly positive in terms of the geoliteracy of the players, is the re-experience of seemingly familiar places (WEBER 2017; MATYAS 2011; MÄRYÄ & LANKOSKI 2010). This gives the players a new perspective on their own everyday activity spaces, which in turn enriches their everyday life with new experiences that they would not have had without location-based games. This re-experiencing of familiar places is supported by games that offer a broad distribution of game elements over an area (WEBER 2017; FRÄNTI et al. 2017; SCHLIEDER 2014; WIll 2013; CELINO et al. 2012). The wider the geographical distribution of the game elements, the stronger the positive influence a game can have on increasing the daily level of exercise, exploring an area and gaining new experiences. Furthermore, adapting the game elements to the local conditions of an area can further improve the game experience and thus motivate the players to play even more. Our research provides additional evidence for the importance of geography in location-based games. We shed light on the influence that a systematic geospatial pattern in scores can have on player behaviour.

4 Methodology

4.1 The game StreetComplete

The game we used for our research in this paper is StreetComplete. This game is developed by Tobias Zwick, a German software developer from Hamburg. StreetComplete is an open source application and therefore the code is freely available on Github[1]. The main goal of the app is to give also inexperienced OpenStreetMap users the opportunity to participate in the OpenStreetMap project. For this reason, the questions (called quests) that are asked during the game are relatively simple, such as dichotomous yes/no questions. New quest types are suggested by the wider OpenStreetMap and StreetComplete communities and are collected and discussed on Github. Once approved by the community, the quests are implemented by volunteers and automatically attached to current issues on the map, for example based on missing tags. StreetComplete is an open-ended game. This means that players do not work towards a specific goal, but rather altruistically collect or improve data. The only form of reward is a counter of already solved quests. This is an advantage for our study, as it ensures that none of our players (see Section 4.3) has previously used a more complex form of scoring in the context of StreetComplete. The fact that StreetComplete is open source has further allowed us to modify the game and tailor it to our needs. This has allowed us to introduce various forms of spatially structured scoring systems.

4.2 Spatially-Structured Scoring System

Our analysis is based on two trial groups of players. While the task locations were the same for both groups (uniformly distributed across the map to avoid visual clustering on the map), the scores attached to those locations differed with respect to their spatial patterning. One group of subjects played the game with a spatially randomised scoring system. That is, we generated scores on the range *[0, 100]* from a spatially autoregressive model with the spatial parameter adjusted to $\rho=0.01$.

Analogously, the spatially structured scores were generated from the same model but with $\rho=0.99$ leading to a strongly spatially autocorrelated scoring system. Figure 1 visualises both outlined scoring systems and how the tasks are distributed across the investigation area. The scores generated were not made visible on the map interface of the game to avoid introducing visual confounding factors. This way, we have been able to isolate the effect of spatially structured scores and to compare two groups of players under different spatial scenarios.

4.3 Subjects and Playing Field

Both scoring systems were deployed under controlled conditions. Our subjects comprised 40 geography students. This choice may limit the scope of the results to a specific target population, but it homogenises with respect to demographics and educational level, as well as technical proficiency. Those 40 subjects were randomly assigned to the two trial groups (20 each) playing the two different spatial scoring systems. The playing field is comprised of an urban area of 1.3 km² in size, located close to the centre of the city of Heidelberg (Fig. 2). The size chosen is motivated by findings from a prior study recommending 1.5 km² to be optimal for playing times of 30 to 60 min (SCHLIEDER 2014), a duration we considered appropriate to test our hypothesis. The area is diverse on a small scale comprising quiet zones like backyards but also busy roads. This allowed us to diminish the effect of subjects being more likely to move to pleasant parts of the area only.

4.4 Indicators of the Playing Behaviour

We have tested a range of parameters of the players' behaviours. All of those are indicators of the players' engagement and how motivated players remain during the game. Our indicators assessed include playing time, distance walked (normalised by playing time), variety of road types explored, numbers of tasks per minute solved, standard deviational ellipses, and a detour factor (ratio of shortest and trajectory-derived path, see Fig. 3). We investigated these indicators for significant mean differences between the two trial groups. Following Shapiro-Wilk tests, mean testing was performed using the non-parametric Mann-Whitney U test to account for non-normality. The only approximately normal variable is the numbers of tasks, which we tested by means of a t-test.

5 Results

A range of parameters did not differ significantly between the two trial groups (Tab. 1), but we were able to disclose two systematic differences. The group exposed to spatially structured scores played the game significantly longer than the control group (39 min vs 30 min, $p=0.02$). A second though slightly weaker result is that the group with spatially structured scores explored the area more extensively than the members of the control group did (detour factor of 5.02 vs 4.04, $p=0.09$, t-test). These results indicate that the ways in which scoring systems are laid out spatially could be an interesting way to tweak location-based games such that players remain motivated over time and space during the play.

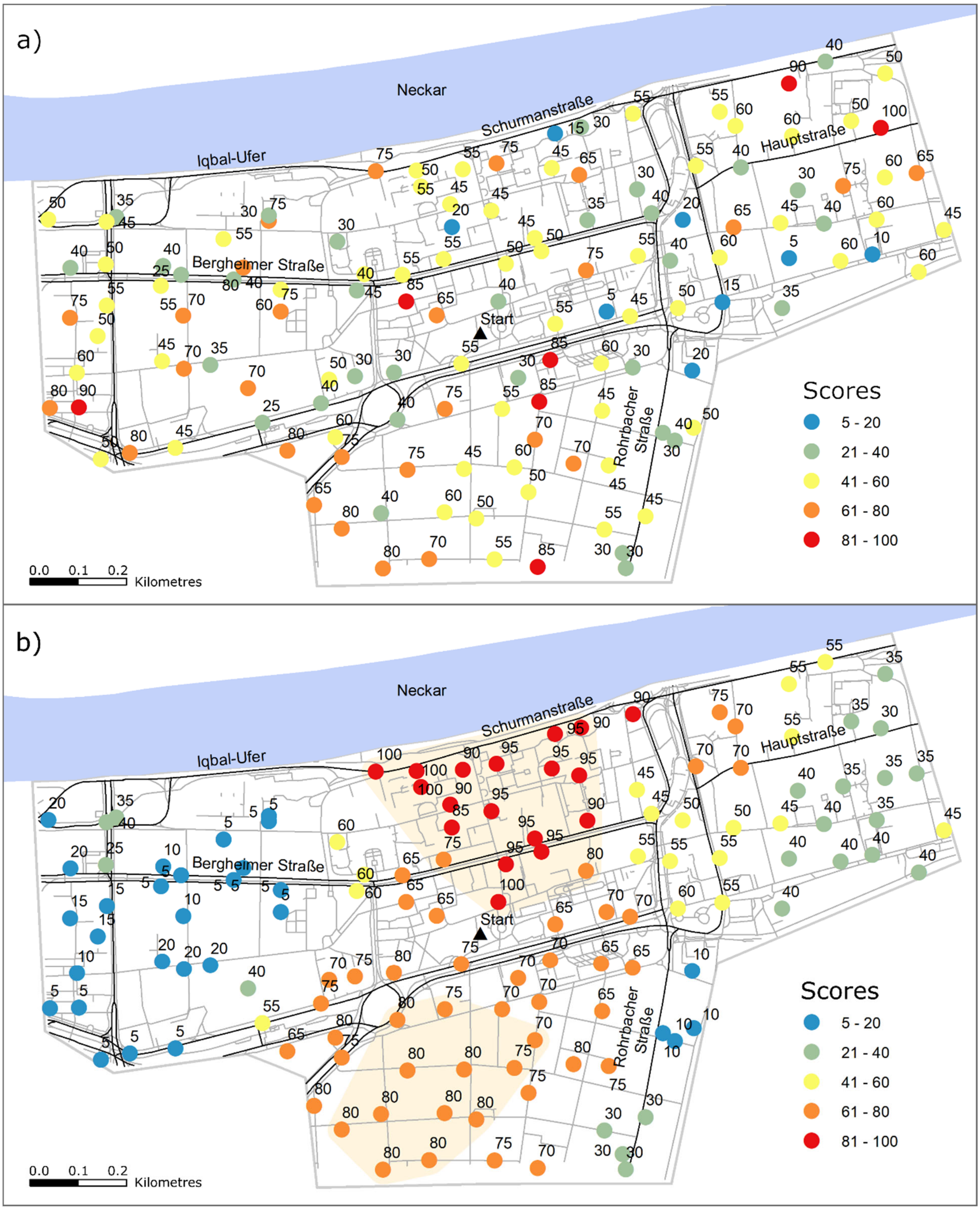

Fig. 1: Overview of the playing field. a) Endowed with a spatially random pattern of scores. b) Endowed with a spatially structured pattern of scores; clusters of the highest scores highlighted in orange. The background maps are based on OpenStreetMap data copyrighted by the OpenStreetMap contributors and available from https://www.openstreetmap.org.

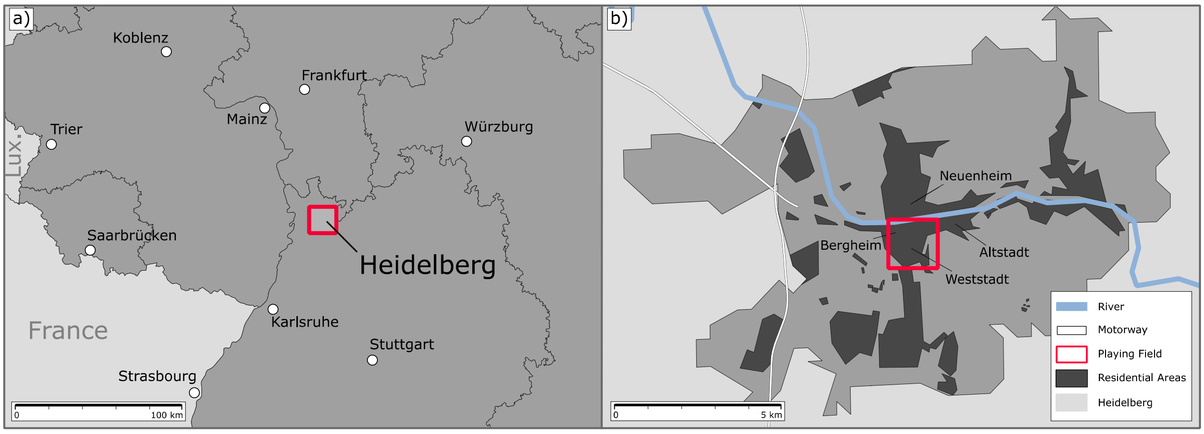

Fig. 2: Location and geographical context of the playing field. a) Location of Heidelberg in the wider context. b) Location of the playing field within the city of Heidelberg. The background maps are based on data from DIVA-GIS (HIJMANS et al. 2001) and OpenStreetMap data copyrighted by the OpenStreetMap contributors and available from https://www.openstreetmap.org.

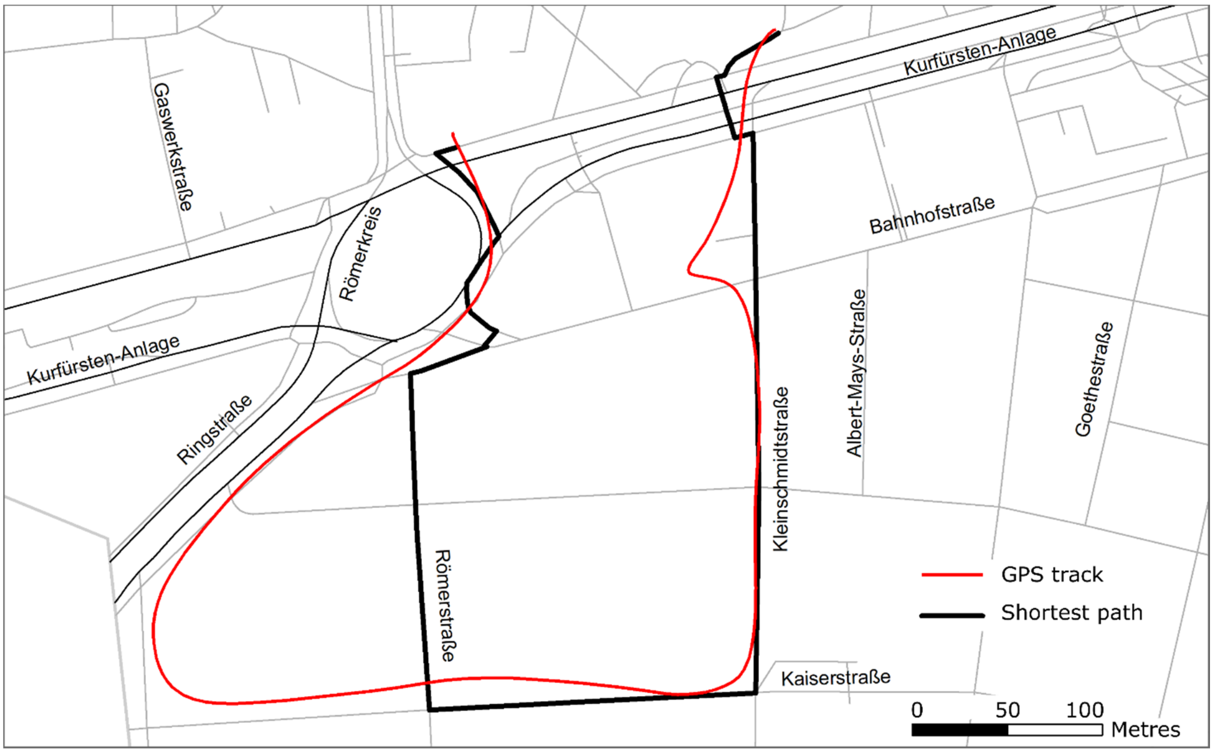

Fig. 3: Illustration of the detour factor as the ratio of the lengths of the GPS tracks and the shortest paths passing through all tasks visited. The background map is based on OpenStreetMap data copyrighted by the OpenStreetMap contributors and available from https://www.openstreetmap.org.

Interpreting our results in more detail reveals that some of them are not only statistically significant but also notable with respect to their effect strengths. The players exposed to spatially structured scores on average played the game longer than the control group. In addition, the same group added the whole length of a shortest path distance to their distance walked according to our assessed detour factors. Considering also the other indicators that do not differ significantly in a statistical sense (which may be an effect of the limited numbers of participants in the groups) reveals that the players exposed to a spatially structured scoring system consistently solved more tasks, walked slower and longer distances on average, and traversed a higher diversity of different road types. The results obtained are thus highly indicative of an interesting relation between the players' motivation and the spatial layout of the game.

The parameter that differed most statistically and in terms of the absolute mean deviation is the duration of play. This is an important result because the game StreetComplete is unlimited in time and players could end the game at any time. The fact that the players from the experimental group played the game almost 33% longer than the players who were presented with the spatially random point system *ceteris paribus* is therefore a strong indication of a systematic influence of the spatial structure in the scores on the motivational aspects of the game. The random allocation of game versions to the players additionally supports this finding, since no obvious distortions result from the investigation structure. This result is significant beyond the case of location-based games. It supports the previous evidence that shows how important it is for players to be able to understand a game in order to be and keep motivated (LEE et al. 2017). Our results add a geographical dimension in the form of spatial structure.

Another very important parameter that was tested is the detour factor. As with the duration of the game, this parameter varied significantly and strongly between the two groups. While the longer game duration indicates a general tendency towards higher game motivation, the detour factor provides information about the motivation of the players not only to play the game but also to explore the field. Compared to the control group, the players in the trial group added the length of an entire "optimal" shortest path to their trajectories. This not only shows how important a comprehensible point system is for the effective design of location-based games, but also points to the relevance of geographically rewarding areas in general and beyond the present context, for example regarding quality of stay. Players from the experimental group have become more involved in the playing field, which, transferred to cases beyond playing, shows that they might also be more likely to explore areas if there are incentives to do so. The results obtained here are thus also of importance for urban planners and related researchers and practitioners.

Tab. 1: Mean values and their differences between the indicators calculated for the two trial groups. Statistical significance is flagged for confidence levels $\alpha=0.10$ (*) and $\alpha=0.05$ (**).

Parameter	Group with spatial pattern	Randomised control group	p-value
Playing time [*min*]	39.20	30.20	0.02**
Normalised distance walked [*m*]	2587	1954	0.46
Walking speed [*m/s*]	0.92	0.99	0.40
Area: standard deviational ellipse [km^2]	0.114	0.102	0.86
Variety of road types traversed [*%*]	79	72	0.29
Tasks solved [*1/min*]	17.80	12.55	0.38
Detour factor	5.02	4.04	0.09*

6 Conclusions

Based on our results obtained, we conclude that a spatially comprehensible layout is likely to support higher levels of motivation with location-based games. In this sense, our results support and add to prior results achieved in non-spatial settings demonstrating the importance of traceable scoring systems that players can make sense of (either consciously or subconsciously) (LEE et al. 2017). Future research should investigate other types of spatial structures in scoring systems to identify optimal layouts for game designs. Further, other gamification elements beyond scoring systems may be tested for spatial effects in similar ways. This way, it will be possible to optimise location-based games and to better utilise them for research purposes such as data collection. Also, research in the nexus of gamification and spatial analysis may contribute to the revealing of interesting, general psycho-geographic mechanisms.

Notes

[1] https://github.com/westnordost/StreetComplete

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